L HUSON & ASSOCIATES

REPORT

REVIEW

Lal Lal Wind Farm
Planning Permit Amendment
August 2016

CLIENT:

Mrs H McMahon on behalf of the Lal Lal Environment Protection Association (LLEPA)

Job No LHA403
October 2016

L HUSON & ASSOCIATES PTY LTD

Consulting Scientists in Acoustics

PO Box 290
WOODEND
VIC 3442

Tel. 0416 143 716

Email: office@huson.com.au

ABN 57 094 096 992

REVIEW

Lal Lal Wind Farm Planning Permit Amendment

EXECUTIVE SUMMARY

I have reviewed the documentation provided to support an amendment to the Lal Lal Wind Farm planning permit with regard to acoustics. My conclusions outlined in the following are similar to those outlined in an earlier report LHA403rep dated December 2015.

I support a revision to the current noise conditions contained in planning permit number PL-SP/05/0461, dated 30 April 2009, for the Lal Lal Wind Farm to reflect recent planning guidelines that refer to the 2010 version of New Zealand Standard 6808:2010 *Acoustics – Wind farm noise.* However, I do not support the extensive changes proposed by WestWind Energy.

I do not consider that the candidate wind turbine used in the new wind farm layout will achieve compliance with the required noise limits at some dwellings surrounding the Lal Lal Wind Farm. The use of G=0.5 in the noise modelling is inappropriate and the justification for its use by Marshall Day Acoustics (MDA) is found to be lacking with the references actually supporting the use of G=0 in ISO9613.2.

The NZS6808 requirements are lacking in prescription of certain modelling parameters that can significantly alter predicted sound levels. The noise modelling completed by MDA has followed the NZS6808 noise modelling requirements using optimistic model parameters. With more representative noise model inputs ISO9613 will demonstrate non-compliance with the 40 dB(A) target suggested by MDA.

The noise model used to prepare data for the MDA report does not account for site conditions such as inflow turbulence from other upwind turbines. These effects can increase sound emissions from wind turbines to an extent largely determined by the proximity of the wind turbines to each other.

A larger rotor diameter (up to 140m) for a new candidate wind turbine would normally require an increase in spacing between wind turbines to minimise this adverse effect. The proposed new layout retains the same wind turbine spacing described in the current planning permit that was based on a wind turbine having an 82m diameter rotor. The result for the new proposed Senvion 3.2M114 wind turbine will be a decrease in efficiency of the wind farm and an increase in noise emissions, even though test results (always measured to minimise inflow turbulence during testing) show that the sound power of the smaller and the proposed larger wind turbines are similar.

If a high noise amenity is demonstrated through objective measurements, as provided for in NZS6808:2010, then the noise model results in the MDA report demonstrate that predicted noise levels are non-compliant with high amenity noise level targets for some dwellings.

I do not recommend major changes to the existing permit conditions. The draft permit changes in the JACOBS report are extensive and reduce the effective controls for noise that were originally coined to protect the amenity of nearby residents. I recommend that permit condition

24 be retained with only a minor modification to the date and title for NZS6808, reflecting the 2010 version.

An updated Noise Compliance Testing Plan is required that does not diminish the permit conditions.

I recommend that permit conditions be altered to include the model licence condition 14 from the Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria, November 2015 to replace the current permit condition 23, yet still retain the requirement to assess compliance within 20m of any dwelling.

I do not give any weight to wind turbine noise guarantees and suggest that it is preferable to rely upon conditions that require robust assessment against licensed noise limits. Different sound power test results for the same wind turbine model have been used in MDA noise models and this adds further doubt to the reliability of candidate sound power levels used in noise modelling. Turbulence Intensity (TI) can increase sound emissions and an increase in TI is inevitable for a larger wind turbine on the same turbine array footprint.

Ancillary equipment can operate below cut-in wind speed at the Lal Lal Wind Farm that is not covered by the NZS6808 standards. I therefore recommend that a target night time noise limit from any ancillary equipment below cut-in be conditioned at a maximum sound level of 32 dB(A) Leq in accordance with EPA Victoria standard industrial noise assessment practices and that this noise target be adjusted for tonal and impulsive characteristics.

A current Noise Compliance Testing Plan for the Lal Lal Wind Farm has been reviewed and it shows that some of the current permit conditions are compromised. Recommendations are suggested to update this document such that it reflects any altered permit conditions and noise modelling for the final choice of wind turbine. It is further recommended that an alternative assessment of wind speed at wind turbines closest to dwellings be made when preparing any noise/wind speed scatter charts in compliance testing.

Declaration
I William Leslie Huson, hereby declare that I have been provided with the Planning Panels Victoria - Guide to Expert Evidence, that that I have read the Guide and that this report has been prepared in accordance with that Guide.

Prepared by

31 October 2016

W Les Huson BSc MSc CPhys MInstP MIoA MAAS MEIANZ
CV included as Appendix A

TABLE OF CONTENTS

INTRODUCTION

I have been commissioned by Mrs H McMahon on behalf of the Lal Lal Environment Protection Association (Client) to review, with regard to noise, an application by WestWind Energy Pty Ltd to amend planning permit number PL-SP/05/0461, dated 30 April 2009, for the Lal Lal Wind Farm (Project). This report has been prepared by William Leslie Huson.

An earlier Planning Permit Amendment was reviewed in 2015 and this is included in Appendix B. This report is supplemental to that report (LHA403rep) and addresses an amended Lal Lal Wind Farm Planning Permit Amendment report that has been prepared by JACOBS, dated 15 August 2016, (JACOBS) and which includes documents prepared by others.

MDA 2008 REPORT

The original noise report prepared by Marshall Day Acoustics (MDA) for Lal Lal in 2008 showed noise modelling results for both the simplified NZS6808 noise propagation model, which does not include either a ground absorption or barrier attenuation factor in the calculations, and compares those results to ISO9613.2 calculation results that include ground absorption and barrier effects.

MDA show the resulting predicted sound levels for dwellings around the Lal Lal wind farm site in Table 3 of their report 001 R01 2007344 dated 5 Feb 2008. The candidate wind turbine had a maximum sound power level of 104 dB(A) at and above a wind speed at 10m of 8m/s.

The difference between the two noise modelling options used show that the simple NZS6808 results were 2 dB higher than the results using ISO9613.2. It should be noted that MDA used an average air absorption attenuation rate of 0.004 dB/m rather than use octave band air absorption values that can be found in ISO9613.1 or a value of 0.005 dB/m average used as an example in NZS6808:1998.

In 2008 MDA chose to use the NZS6808:1998 results to promote conservatism in the results.

MDA 2015 REPORT

I prepared a review for my Client (included in Appendix B of this document) and provide the following additional comments.

In 2015 MDA used a candidate wind turbine with a sound power level of 105.2 dB(A) at a 10m high wind speed of 8m/s. The MDA report 002 2015386ML dated 11 Sept 2015 (MDA 2015) explains in the Introduction that the noise assessment was completed in accordance with NZS6808:2010 and the method described in Appendix D1 of this standard has been used. It should be noted that this appendix is an Informative (for information only) part of the standard, not Normative (must be used). In fact, any alternative noise model may be used with justification. Section D2 of the standard provides an alternative method to use within ISO9613.2 under certain circumstances. This Alternative method is similar (but not the same) as the process used in equation 1 in NZS6808:1998 where no barrier effects are considered. The major difference in the use of D2 in NZS6808:2010 to the method of equation 1 in

NZS6808:1998 is the inclusion of a ground absorption factor where it is assumed that the ground near the turbines and near the receiver is generally porous and uncompacted.

The MDA 2015 report has an inconsistency in the sound power levels used in noise modelling from Figure 2 to that documented in Appendix F. Furthermore, reference has been made to a sound power level at 8 m/s hub height in section 2.2.2 whereas the manufacturer's data for the Senvion 3.2M114 refers to sound power at wind speeds reference to 10m AGL.

MDA 2016 REPORT

The JACOBS Amended Application dated 15 August 2016 includes another noise modelling report by MDA in the form of a letter 'Lt 001 2016307ML Lal Lal Wind Farm Revised wind farm noise predictions' (MDA 2016) dated 12 August 2016.

The MDA 2016 report lists sound power data and spectrum data for the Senvion 3.2M114. I have not been provided with the source documents for this or the other candidate wind turbines referenced by MDA. I have compared the sound power data and spectrum values for the latest 3.2M114 wind turbine from the MDA 2016 report and their MDA 2015 report.

The following table lists the sound power data used by MDA in their noise modelling in MDA 2015 and MDA 2016 for the same Senvion wind turbine type 3.2M114.

SENVION 3.2M114	Octave Band Sound Power Levels - LwA dB 63Hz	125Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz	8000Hz
MDA 2016	86.4	93.6	97.7	99.8	100.1	95.8	89.9	78
MDA 2015	83.5	91.7	98.1	100.2	98.3	97.0	92.5	89.3

There are differences in some octave bands of up to 11.3 dB for the same wind turbine model. Senvion have advised MDA of the probable sound power and spectrum shape for the 3.4M122 and 3.4M140 wind turbines and noise models have been run using that data.

Given that there is such a variation in sound power data derived from testing using IEC61400-11 for the same 3.2MM114 wind turbine I have no confidence in the sound power data used in noise modelling for the other two candidate wind turbines that have yet to be measured.

The MDA 2016 report on page 6 under the heading **Tonality** refers to work by Zwicker and Fastl in their book Psycho-acoustics from 2007. I have this book and cannot find any reference to corroborate the statement in the MDA 2016 report that "$\Delta L_{a,k}$ = -2 dB is approximately the audibility threshold for a tone" and "Where $\Delta L_{a,k}$ < 0 dB, the tone, while perhaps audible, is generally unlikely to cause significant issues."

With no test results for two of the candidate wind turbines it is impossible to assess tonality at this stage. It is also questionable if the tonality results quoted in the MDA 2016 report for the 3.2M114 are applicable to both test results for this wind turbine, considering the differences shown in the table above.

The MDA 2016 report has again used a G=0.5 value in their ISO9613-2 noise models and my comments that relate to the MDA 2015 report also apply to the MDA 2016 report in this regard; the noise model is being used inappropriately and predicted sound levels are typically underestimated by between 3 dB and 4 dB.

WIND TURBINE SIZE VARIATION

I understand that the Panel must decide on the issue of the change in size and capacity of the candidate wind turbine generator to be used in the Lal Lal wind farm project and not on the adequacy of the original decision of a Panel in 2009. To this end it would seem most appropriate to compare apples with apples, rather than one noise model to a different one when determining the acoustic impact of the proposed change in wind turbine generator size.

In the simplest of terms the new candidate wind turbine has a sound power output of up to 105.5 dB(A) compared to the original candidate wind turbine that had a sound power output of 104 dB(A). There are only minor changes to the wind turbine layout so it would be expected that the changes will result in an increase in sound pressure level, when using similar noise models, of 1.5 dB. The use of a noise model described by equation 1 in NZS6808:1998 is also compliant with NZS6808:2010. There is justification for this older noise model since we can compare like with like.

A previously unconsidered effect of wake induced turbulence on noise emissions should be considered by the Panel since this is a consequence of the change in wind turbine size required by the Applicant. Again, there is adequate justification in the application of NZS6808:2010, and indeed NZS6808:1998, to account for previously unconsidered site effects (e.g. TI) when assessing any change in the scale of the Lal Lal wind farm.

Even though there may be a significant underestimate of the original noise modelling of 2008 or that of 2015 and 2016 by MDA it may be of no consequence to the matter before the Panel unless the underestimates are exaggerated by the proposed wind turbine size changes.

I note that the noise prediction in the current Noise Compliance Testing Plan uses the simpler NZS6808:1998 Equation 1 calculation method and notes that an average absorption coefficient of 0.005 dB/m, used as an example in the standard, may be too high and that an absorption coefficient of 0.004 dB/m has been used to improve noise prediction accuracy.

It is worth noting that the use of an air absorption coefficient of 0.004 dB/m is also too high for an average value for the 3.2M114 Senvion wind turbine under consideration. A larger wind turbine has a noise spectrum that tends to be more dominant at lower frequencies compared to the smaller candidate wind turbines currently permitted for Lal Lal.

Observation of the sound power frequency spectrum for the 3.2M114 in the MDA 2015 report shows that the 500 Hz octave band has the highest sound power. The air absorption coefficient at 500 Hz is 0.00193 dB/m for the temperature and relative humidity used in modelling. The change to a larger candidate wind turbine would warrant a lower average air absorption value than 0.004 dB/m, which was originally used in a noise model using Equation 1 from NZS6808:1998 in the MDA 2008 report. This change will increase the comparative accuracy of the predicted noise levels for the larger wind turbines if the same noise model is used.

SOUND POWER DATA

I have long held the view that "A number of variables such as: turbulence, wind shear, inflow angle and air density may differ at an installed site compared to the idealised sound power measurement results obtained using IEC 61400-11. These effects can alter the sound power level of a WTG and should be considered in the noise model." This extract is from a peer reviewed paper I presented at the joint Australian and New Zealand Acoustics 2006 conference titled "Review of the application of NZS6808 to wind farms in Australia".

A paper recently published by the Institute of Physics[1] quantifies the effect on time-averaged sound pressure levels, for a typical 2.75 MW single wind turbine having an 80 m rotor diameter, by changing wind shear and inflow turbulence [turbulence intensity (TI)]. The results show that for both upwind and downwind sound propagation the sound pressure level at 700m for a TI of 3% and 10% produced a difference of between 8dB and 9dB (increase from 3% to 10% TI increases the sound level up to 9 dB). The increase in sound pressure level from 0% TI to 10% TI is greater at 11dB to 12 dB. The paper states in the conclusion: *"First of all, higher ambient turbulence intensity results in increased sound source power levels, particularly at the low frequency content (31.5 Hz - 300 Hz). This directly affects the far field noise (up to 2500 m), as the atmospheric absorption is negligible for this frequency range. To the authors' knowledge none of the noise mapping tools take into account the increased source levels due to ambient or wake induced turbulence. Neither the standards demand turbulence dependent noise curves. We believe that this can be one of the reasons for inaccurate far field noise predictions."*

The Amendment Application dated 15 August 2016 is for an increase in allowable wind turbine size to accommodate a rotor diameter of 140m, without any change in the wind turbine spacing. This will increase wake induced turbulence intensity within the site. This effect has not been considered in the MDA reports and ISO9613-2 modelling, where sound power derived from measurements using IEC61400-11 has been used in which TI is required to be minimised for the measurements.

Another consequence in increasing the size of the Lal Lal wind turbines is that the wind shear across the rotor will increase. The second point from the conclusions in the IoP paper[1] is: "*Second of all, it is observed that under low incoming turbulence the wind shear has significant effect on downwind propagation*" and that: "*Further investigation of the SPL modulation due to wake deficit showed that particularly the low incoming turbulence levels (0 % and 3 %) result in increased spectral energy of the low acoustic frequency content over wide spread propagation distances. This can lead to beating noise at far field*."

The ISO9613-2 noise propagation model has proven to be an acceptable noise model if it is used within its design constraints. Acoustic consultants working for wind farm developers invariably use a single source for each turbine located at hub height (sometimes the sound source is located at maximum rotor height). Unfortunately, wind turbines are complex sound sources that do not readily conform to the stated limitations of ISO9613-2. For example, a wind turbine emits sound for each blade, approximately 85% from the hub towards the tip, in a cyclic manner and there are wake and turbulence effects that influence sound propagation.

There are effectively three rotating sound sources for each wind turbine and standard propagation models such as ISO9613.2 are generally used for wind farms using a single point

[1] Barlas, E. Zhu, W. J. Shen, W. Z. Andersen, S. J. "Wind Turbine Noise Propagation Modelling: An Unsteady Approach" Journal of Physics: Conference Series 753 (2016) 022003 (TORQUE 2016)
Available at: *iopscience.iop.org/article/10.1088/1742-6596/753/2/022003/pdf*

source per turbine without inclusion of a directivity correction term that is available in the ISO9613.2 method.

The addition of a directivity correction to account for TI and wake effects could improve the accuracy of ISO9613.2 when applied to a wind farm. For situations where the wind farm is located in a flat region and where wind turbines are in a line then TI will not be relevant perpendicular to the line of turbines so long as there is adequate spacing between turbines in the line. TI influences on power and sound output become most relevant when the wind blows along a row of wind turbines.

Unfortunately, the Lal Lal wind farm layout will suffer from TI effects in all wind directions.

Wind turbine manufacturers are knowledgeable about the effects of wake induced and site affected inflow turbulence on the sound emissions and performance of their wind turbines. It is customary to first request the minimum turbine spacing that the manufacturer is willing to provide a guarantee for, in terms of power output and sound emissions. In this instance, the turbine locations are fixed in the current permit so a written comment on the suitability of the suggested candidate wind turbines could be provided by Senvion in respect of guarantees.

It should be noted that a wind turbine of a given name such as a Senvion MM92 or 3.2M114 can have many variants and can have different blades or gearboxes fitted that can influence sound power output.

ANCILLARY EQUIPMENT

Different wind turbine designs are available where the switch gear and hydraulic equipment can be housed within the tower or external in a separate enclosure.

An energised wind turbine waiting for sufficient wind to 'cut-in' will have equipment operating yaw drives, transformers and fans and this equipment does not get masked by changes in wind speed below cut-in. The NZS6808 wind turbine assessment methodology is only applicable to the operating wind turbine in which case ancillary operating equipment could fall within the sound power testing described in IEC61400-11. However, below cut-in it would be appropriate to assess noise emissions from ancillary equipment housed internally and/or externally to the tower using standard EPA Victoria industrial noise guidelines rather than use NZS6808.

An EPA VIC assessment has been made by MDA for the construction activities where a target night time noise limit of 32 dB(A) Leq is suggested. I therefore recommend that a target night time noise limit from any ancillary equipment below cut-in be conditioned at a maximum sound level of 32 dB(A) and be in accordance with standard practice where this noise target be adjusted for tonal and impulsive characteristics.

JACOBS RESPONSE TO OBJECTORS

My original report was a peer review of the MDA 2015 report. MDA has provided comment on my peer review in a letter compiled as Appendix E into a larger document by Jacobs dated 6 May 2016 titled 'Lal Lal Wind Farm – Response to Objectors'.

I provide the following comments in reply to the MDA letter reference 'Lt004 2015386ML – Moorabool Wind Farm – Response to Huson peer review' dated 13 April 2016 on the subject of Lal Lal Wind Farm (Response).

HIGH AMENITY

I acknowledge that changes made to the Planning Guidelines for wind farm developments now includes a reference to consideration of deliberations by the Panel for the Cherry Tree wind farm hearing and that in that case a farming area was not considered an area of 'high amenity' as defined in NZS6808:2010. However, it may be appropriate for the Panel to consider the merits of applying such an assessment to all wind farms in other local council areas noting that the Planning Guidelines are not mandatory and that 'high amenity' could be addressed on a case by case basis. After all, the planning designation of Farming Zone is there to protect farming operations, not the promotion of other industrial land uses such as power generation.

I have been provided with a copy of the Noise Compliance Testing Plan, report 001 R02 2010178 dated 12 Aug 2010 that was prepared by MDA. This report has noise limits approved for construction activities that were set in accordance with the EPA Victoria Guidelines N3/89. The report states: "*We have reviewed the background noise levels measured for the noise impact assessment of the Lal Lal Wind Farm and concluded that the minimum noise limits of the N3/89 Guidelines should be applied*."

Despite being in a Farming Zone, construction noise limits are set at 37 dB(A) in the evening and 32 dB(A) at night (measured as Leq). It seems illogical to set evening and night time construction noise limits lower than wind farm noise limits when this industrial noise source will operate 24 hours per day. The 37 dB(A), Leq evening construction noise limit would equate to a 35 dB(A) L90 noise limit from the 'high amenity' category in NZS6808:2010.

HOST NOISE LIMITS

Host noise limits are suggested by MDA to be based upon a UK guideline from 1997 and it is suggested that this is consistent with a draft guideline in Australia dated 2010. However, as explained in my initial submission, the 2010 Australian guideline issued by EPHC refers to 45 dB(A) Leq and not 45 dB(A) L90. The suggestion that the recommendation in the old ETSU-R-97 from the UK is consistent with the Australian Commonwealth guideline is incorrect and the Australian guideline states: *"Minimum noise level limits of more than 45dB LAeq at a receiver are not considered suitable without provision for noise insulation of the dwelling and a suitable protected outdoor living area."* MDA are proposing a noise limit of 47 dB(A) Leq for Hosts (which is equivalent to 45 dB(A) L90).

TONALITY

My comments on the inadequacy of a tonal guarantee from a wind turbine manufacturer in accordance with measurements using IEC61400-11 remains a concern.

SOUND POWER LEVELS

The MDA Response suggests that the oral presentation by Eric Sloth[2] could differ from the information on his presentation slides. I am unconvinced by this proposition and refer to other additional supporting evidence shown above in this supplemental submission.
I am also unconvinced by the assumption of MDA that the Sloth presentation is diminished by subsequent versions of IEC61400-11, or; the use of 10m high wind speeds compared to hub height wind speeds since there is a simple mathematical correction that MDA has often used in

[2] Erik Sloth, et al, Problems related to the use of the existing noise measurement standards when predicting noise from wind turbines and wind farms, AUSWEA Conference, 2004

their own reports for wind farm developments that has been retained in all versions of IEC61400-11.

GROUND FACTOR

The Response in respect of the use of different ground attenuation factors in noise models using ISO9613.2 puts forward two references in support of the use of G=0.5 (half absorbent or porous and half reflective ground).

The Bullmore[3] reference data does not support the use of G=0.5 in noise modelling of wind farms. The measurements presented are compared to noise models using ISO9613.2 for three wind farms where G=0 and G=0.5 were used in the model parameters. The first site (A) was problematic and minimal results are shown and no conclusions are drawn. The paper notes for this site that it "*is located on a relatively high plateau characterised by moderately undulating terrain and minimal vegetation*." As such, the ISO9613.2 ground effect calculation method would not apply since it states in section 7.3.1 of the standard that "*This method of calculating the ground effect is applicable only to ground which is approximately flat, either horizontally or with a constant slope.*"

The other two sites (B and C) are considered appropriate to apply ISO9613.2. Site B had ground such that G=0 was representative and in the results shown in Figure 3b there is agreement between measurement and predicted sound levels within the bounds of measurement uncertainty.

The third site C had a mixed ground absorption represented in the noise model by G=0.5 for the source, middle and receiver intervening ground. At distances typical of the nearest dwelling to a wind turbine at Lal Lal (820m) the paper shows in Figure 6b that the predictions underestimate the measured sound level by approximately 2 dB in the wind speed range of 8m/s to 11 m/s (at 10m AGL). This chart unfortunately suffers from an error in the noise modelling where a receiver height of 4m has been used rather than a receiver height of 1.5m that was used to take the sound level measurements. The implication of this error is that a noise model having the correct height for the prediction of 1.5m rather than 4m in conditions where G=0.5 will show lower predicted noise levels by approximately 1.8 dB. Thus this paper shows a significant underestimate of predicted noise level compared to measured sound levels of approximately 4 dB (2dB + 1.8 dB) when using G=0.5. This is precisely the point I have made in my original submission.

Contrary to the submission in the MDA Reports that G=0.5 should be used for noise modelling of wind farms in Australia, it is clear that the Bullmore paper referenced actually demonstrates that G=0 is more appropriate.

Another paper that was referenced to support the use of G=0.5 for wind farm noise models in Australia is by Delaire[4]. Unfortunately, the analysis method employed uses background sound levels compared to background sound levels plus wind farm noise. The measurement results are questionable, rendering them of little use in assessing the accuracy of ISO9613.2 or

---

[3] Bullmore, Adcock, Jiggins & Cand – *Wind Farm Noise Predictions and Comparisons with Measurements*; Presented at the Third International Meeting on Wind Turbine Noise in Aalborg, Denmark June 2009

[4] Delaire, Griffin, & Walsh – *Comparison of predicted wind farm noise emission and measured post-construction noise levels at the Portland Wind Energy Project in Victoria, Australia*; Presented at the Fourth International Meeting on Wind Turbine Noise in Rome, April 2011.

NZS6808:1998 type noise modelling. This background noise issue was addressed by Delaire[5] himself who showed significant variation in background noise level results on a location by location and seasonal basis with background results varying by up to 15 dB. Furthermore, measurements reported by Delaire[5] used equipment that was unsuitable by today's standards. The IoA Good Practice Guide No. 1 from 2014 states in section 2.4.8:

"The use of 'standard' windscreens with a diameter of (typically) less than 100mm should be avoided because there is a serious risk that measurements using this type of windscreen will be corrupted by wind-induced noise at the microphone. Measurements using standard windscreens can only be considered reliable where the measurement location is sheltered and there is evidence that local wind speeds at microphone height did not exceed 5 m/s during the survey period."

Unfortunately, the same instrumentation was used for the Lal Lal background measurements which have been used to set target noise conditions in the 2008 MDA assessment report Rp 001 R01 20007344.

The MDA Response states that the ISO9613.2 version applied in their analysis is a modified version of that standard. The ISO9613.2 standard assesses ground absorption in three zones between the sound source and a receiver. The total ground absorption correction (Agr) is derived from formulae considering the ground absorption within 30 times the source height (As), within 30 times the receiver height (Ar) and a middle section between As and Ar called Am. Agr = As + Ar + Am. If As overlaps Ar then Am = 0.

Although not stated in the MDA noise modelling report Rp 002 2015386ML, I presume that the G=0.5 value was applied to calculate As, Ar and Am.

It is worth noting that As can be based on G=0.5 in some circumstances and that Ar can be based on G=0. ISO9613.2 explains that G=0 represents "*Hard ground, which includes paving, water, ice, concrete and all other surfaces having a low porosity. Tamped ground, for example, as often occurs around industrial sites, can be considered hard*." Since the receiver height used for noise modelling is 1.5 m then the distance from a dwelling to the wind farm that should be considered for ground absorption in Ar is 45m (30 x 1,5). In situations where a driveway or paved patio area surrounds a dwelling then G=0 would apply in calculating Ar, even if there was mixed porous ground beyond.

I have calculated the effect of G=0.5 for As and G=0 for Ar for dwelling K34aa. The difference is an increase of 3 dB compared to a situation where G=0.5 is used to calculate both As and Ar.

I reiterate; the use of G=0.5 universally for wind farm developments in Australia is not recommended and will underestimate the acoustic impact upon surrounding dwellings.

NOISE COMPLIANCE TESTING PLAN

The current Noise Compliance Testing Plan is based on NZS6808:1998 and refers to particular planning conditions of the current planning permit for the Lal Lal Wind Farm. A new Noise Compliance Testing Plan must be prepared to address proposed changes to the planning permit.

[5] Delaire, & Walsh - *A Comparison of Background Noise Levels Collected at the Portland Wind Energy Project in Victoria, Australia*; Presented at the Third International Meeting on Wind Turbine Noise in Aalborg, Denmark, June 2009.

Reference is made in the Noise Compliance Testing Plan to correcting operational compliance noise levels with background trend data.

Considering that the original background data was collected using instrumentation and techniques known now to be suspect it is recommended that a new set of background measurements be completed prior to commencement of construction and that in the event that the correlation coefficient minimum of 0.5 not be obtained that an on/off testing program be devised in the updated Noise Compliance Testing Plan.

Currently, an on/off testing plan is deferred in the Noise Compliance Testing Plan. It is my opinion that such a testing plan should be included in an updated Noise Compliance Testing Plan.

The current Noise Compliance Testing Plan diminishes the rigor of the original permit conditions in that it allows for data to be used in the compliance assessment that would be disallowed within the current permit conditions (e.g. condition 24e(i) for R^2). An alternative wind direction range has also been approved in the Noise Compliance Testing Plan contrary to condition 24f.

The assessment of special audible characteristics (SAC) is suggested in the Noise Compliance Testing Plan to be done subjectively and only if considered applicable will objective measurements be made. This is contrary to the intent of condition 24(h) which provides for each and every 10-minute measurement sample to be corrected for SAC in the compliance assessment. Modern sound level monitoring equipment allows for simultaneous recording from which objective measurements can be made.

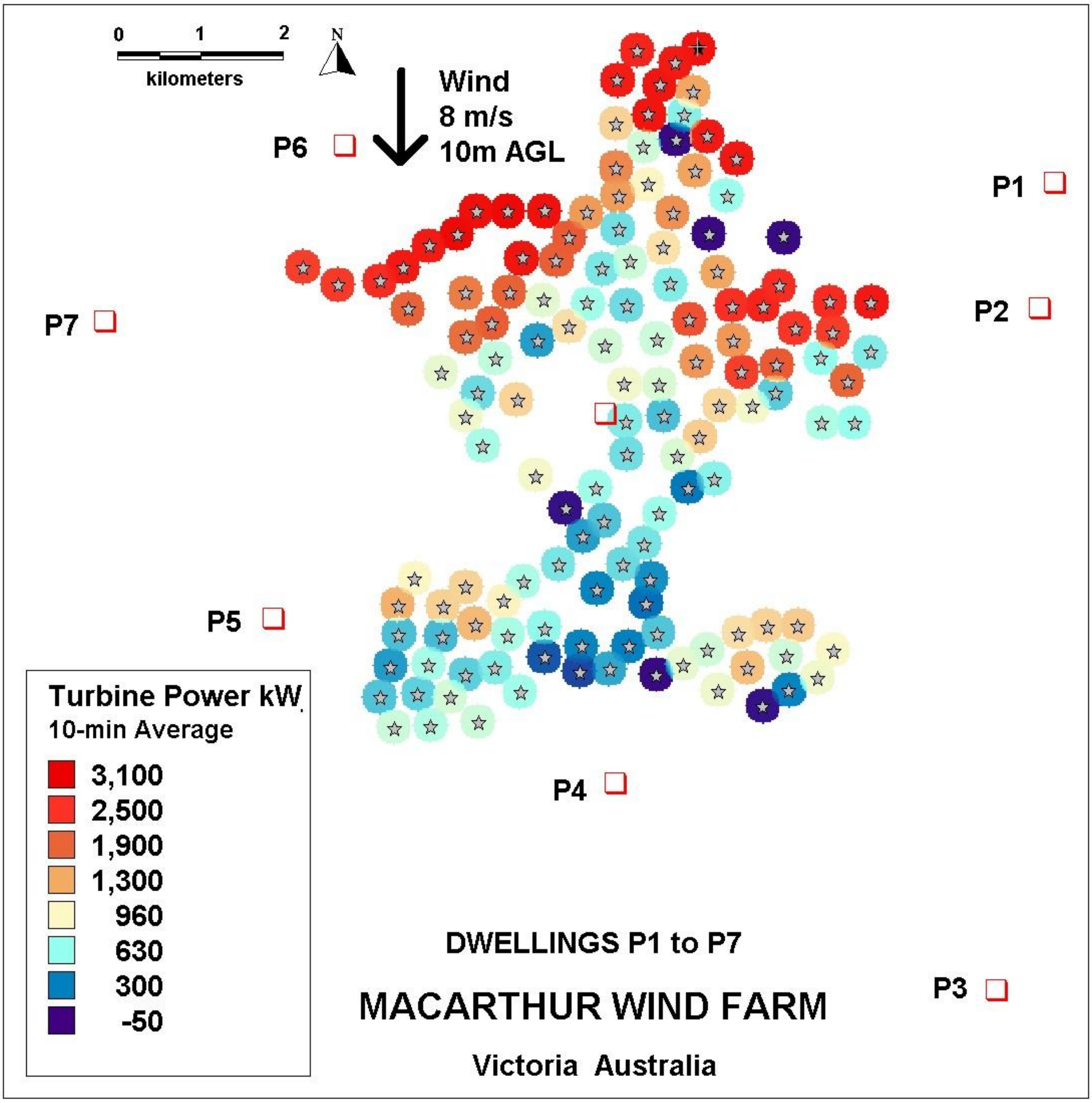
A qualified acoustical consultant cannot attend each monitoring site and subjectively assess all conditions that may give rise to SACs. However, they could take automated unattended regular recordings.

A 10-minute listening of sound from the wind farm when deploying, maintaining or retrieving measurement equipment is allowed in the current Noise Compliance Testing Plan but this will not pick up irregular SAC events at night.

A new noise prediction assessment is required for the updated Noise Compliance Testing Plan using the data for the particular wind turbines that will be constructed.

It has been demonstrated at the Macarthur Wind Farm that wind turbine wake turbulence can influence site anemometer results after the wind farm is constructed. This will also be the case for the Lal Lal Wind Farm. At the Macarthur Wind Farm a method was derived to use only wind presented external to the wind turbine array be used in preparing the compliance noise scatter charts. Unfortunately, this methodology is seriously flawed and results will tend to be skewed artificially in favour of easier to comply noise targets to the benefit of the wind farm operator and detriment of nearby residents.

The following figure is from a single 10-minute sample of power output at the Macarthur Wind Farm to show how power output varies across the wind turbine array, as it would for the two Lal Lal sections. Sound output increases with increasing wind speed across any individual wind turbine. This figure shows the shielding effect caused by wake turbulence.



In this situation a wind approaching the wind farm from the north at 8 m/s would be applied in the scatter chart for noise at P4. However, the noise received at P4 is dominated by sound from the wind turbines closest to that location, not those experiencing the 8 m/s wind on the northern edge over 6 km away. The single point entered on the scatter chart will be placed erroneously on the chart such that it would appear that high wind speeds produce lower sound levels at the P4 dwelling. With many such points it would appear that lower sound levels are produced by the wind farm from the compliance scatter chart.

This type of assessment should not be allowed and a method in the Noise Compliance Testing Plan should describe an alternative measurement arrangement where an estimate of the wind speed across the wind turbines closest to the dwellings is required for input on any wind speed / noise scatter chart for compliance testing.

An estimate of the wind speed at hub height for each of the wind turbines contributing the most noise at a particular nearby dwelling can be obtained from the power curve for the wind turbine model. This will improve the compliance assessment accuracy.

APPENDIX A

NAME AND ADDRESS OF EXPERT

William Leslie Huson
PO Box 290
WOODEND
VIC 3442

QUALIFICATIONS

BSc (Hons) Applied Physics, UK 1975

MSc Noise and Vibration Studies, Institute of Sound and Vibration Research, Southampton, UK 1977

PROFESSIONAL AFFILIATIONS

Chartered Physicist, UK

Member of the Institute of Physics, UK

Member of the Institute of Acoustics, UK

Member of the Australian Acoustical Society

Member of the Environment Institute of Australia and New Zealand

Member of the AV003 and AV004 acoustics working groups for Standards Australia

Australian representative for the International Institute of Noise Control Engineers (I-INCE) Technical Study Group 5 A GLOBALAPPROACH TO NOISE CONTROL POLICY (Now disbanded after completion of the scope of work defining this group – see http://www.i-ince.org/data/iince061.pdf)

My company, L Huson & Associates Pty Ltd, is a member firm of the Association of Australian Acoustical Consultants and the Association of Noise Consultants (UK)

EXPERIENCE

Since graduating I have been involved in a number of scientific areas of research and development. My early experience was in constructing a microwave device to measure the temperature of plasma inside a nuclear fusion experimentation device at the UKAEA, Culham Laboratory in the UK. I then worked in research and development of thermal imaging devices prior to completing my Masters in Sound and Vibration Studies. My work since then (1977) has been primarily associated with acoustics and vibration both terrestrial and underwater.

For the past 25 years I have worked in Australia as a noise and vibration consultant and have operated through my own consultancy firm for the past 19 years. I am experienced in modelling acoustic propagation from a variety of sources such as railways, roads, aircraft, underwater ordnance, pile driving, blasting and numerous types of industry.

Of particular relevance to the evidence provided here is the work I completed for the Toora Wind Farm which involved detailed analysis of pre and post construction noise data using NZS6808 1998 to check compliance with license conditions. My experiences in the analysis of wind farm noise data led to a paper that was presented at the joint Australia and New Zealand Acoustics conference in 2006 titled "Review of the Application of NZS6808 to wind farms in Australia." This paper highlighted the sources of error that were implicit and allowed in the NZS6808, 1998 standard. The latest version of the NZS6808 standard (2010) addresses a number, but not all, of the data analysis error concerns described in my paper. Over the past three years I have been independently gathering sound data in the audible and infrasound parts of the acoustic spectrum at numerous wind farms in Australia, the UK and Ireland. A summary of some of this research work on infrasound was presented in a peer reviewed paper earlier this year: Huson, W. Les."Stationary wind turbine infrasound emissions and propagation loss measurements." 6th International Conference on Wind Turbine Noise, Glasgow 20-23 April 2015.

APPENDIX B

L HUSON & ASSOCIATES

REPORT

REVIEW

Lal Lal Wind Farm
Planning Permit Amendment
October 2015

CLIENT:

Mrs H McMahon

Job No LHA403
December 2015

L HUSON & ASSOCIATES PTY LTD

Consulting Scientists in Acoustics

PO Box 290
WOODEND
VIC 3442

Tel. 0416 143 716

Email: office@huson.com.au

ABN 57 094 096 992

REVIEW

Lal Lal Wind Farm Planning Permit Amendment

EXECUTIVE SUMMARY

We have reviewed the documentation provided to support an amendment to the Lal Lal Wind Farm planning permit with regard to acoustics.

We support a revision to the current noise conditions contained in planning permit number PL-SP/05/0461, dated 30 April 2009, for the Lal Lal Wind Farm to reflect recent planning guidelines that refer to the 2010 version of New Zealand Standard 6808:2010 *Acoustics – Wind farm noise.* However, we do not support the extensive changes proposed by WestWind Energy.

We do not consider that the candidate wind turbine used in the new wind farm layout will achieve compliance with the required noise limits at some dwellings surrounding the Lal Lal Wind Farm.

The NZS6808 requirements are lacking in prescription of certain modelling parameters that can significantly alter predicted sound levels. The noise modelling completed by Marshall Day Acoustics (MDA) has followed the NZS6808 noise modelling requirements using optimistic model parameters. With more representative noise model inputs ISO9613 will demonstrate non-compliance with the 40 dB(A) target suggested by MDA.

The noise model used to prepare data for the MDA report does not account for site conditions such as inflow turbulence from other upwind turbines. These effects can increase sound emissions from wind turbines to an extent largely determined by the proximity of the wind turbines to each other.

A larger rotor diameter (114m) for a new candidate wind turbine would normally require an increase in spacing between wind turbines to minimise this adverse effect. The proposed new layout retains the same wind turbine spacing described in the current planning permit that was based on a wind turbine having an 82m diameter rotor. The result for the new proposed Senvion 3.2M114 wind turbine will be a decrease in efficiency of the wind farm and an increase in noise emissions, even though test results (always measured to minimise inflow turbulence during testing) show that the sound power of the smaller and the proposed larger wind turbines are similar.

If a high noise amenity is demonstrated through objective measurements, as provided for in NZS6808:2010, then the noise model results in the MDA report demonstrate that predicted noise levels are non-compliant with high amenity noise level targets for some dwellings.

We do not recommend major changes to the existing permit conditions. The draft permit changes in the JACOBS report are extensive and reduce the effective controls for noise that were originally coined to protect the amenity of nearby residents. We recommend that permit condition 24 be retained with only a minor modification to the date and title for NZS6808, reflecting the 2010 version.

We recommend that permit conditions be altered to include the model licence condition 14 from the Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria, November 2015 to replace the current permit condition 23, yet still retain the requirement to assess compliance within 20m of any dwelling.

We do not give any weight to wind turbine noise guarantees and suggest that it is preferable to rely upon conditions that require robust assessment against licensed noise limits.

Prepared by

W Les Huson BSc MSc CPhys MInstP MIoA MAAS MEIANZ

TABLE OF CONTENTS

INTRODUCTION

L Huson & Associates Pty Ltd has been commissioned by Mrs H McMahon to review, with regard to noise, an application by WestWind Energy Pty Ltd to amend planning permit number PL-SP/05/0461, dated 30 April 2009, for the Lal Lal Wind Farm (Project).

The Lal Lal Wind Farm Planning Permit Amendment report has been prepared by JACOBS, dated October 2015, (JACOBS) and includes attachments prepared by others. Section 5.3.1 of the JACOBS report refers to Acoustics in section 5.3.1 and this in turn refers to Attachment E: Marshall Day assessment against NZS 6808:2010 (MDA report).

AMENDMENT OBJECTIVES

The JACOBS report provides a rationale for the proposed changes to the planning permit for the Project "to reflect changes which have occurred to the planning scheme and the guidelines." The recent change to the planning scheme and guidelines, with regard to noise assessment, is the use of NZS6808:2010 in lieu of NZS6808:1998 and this would require an amendment to the planning permit which specifies the use of NZS6808:1998.

The MDA report has a single objective stated in its introduction to detail "the results of a noise assessment for the Lal Lal Wind Farm in accordance with the New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* as required by the Victorian Government's *Policy and planning guidelines for development of wind energy facilities in Victoria* dated June 2015." We note that the latest guideline is dated November 2015 but that there is no difference between the July and November revisions in the requirement to use NZS6808:2010.

NOISE SENSITIVE LOCATIONS

The MDA report notes that WestWind Energy has supplied them with noise sensitive dwellings surrounding and within the proposed Lal Lal wind farm development. A brief overview of the area has located two additional noise sensitive locations in the form of a dwelling at 238476 E 5818187 S and a monastery that has accommodation at 762709 E 581419 S. These two additional sensitive locations are approximately 1000m from the nearest wind turbine within the proposed layout of the new Lal Lal wind farm proposal. The MDA report has not assessed the noise impact at these locations in the tables provided.

NOISE LIMITS

The MDA report seeks to set target noise limits for the Project with reference to the Victorian guidelines for wind farms, which in turn refers to NZS 6808:2010.

The primary reference for wind farm noise is the Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria, November 2015 (PPGWEF). The PPGWEF refers to the draft National Wind Farm Development Guidelines (July 2010), as amended, for further guidance.

The MDA REPORT has elected a baseline noise target limit of 40 db LA90 for dwellings not subject to noise agreements with the Project developers. The MDA REPORT has elected not to set a lower baseline target noise level of 35 dB LA90 that would be suitable for a high amenity noise area.

We disagree with the arguments in the JACOBS and MDA reports against allowing the area to be designated a high amenity noise area. The PPGWEF refers to limits suggested in NZS6808:2010 and there is an objective assessment of high amenity noise areas in section 5 for areas where low background sound levels are common.

Background noise measurements in 2008 and 2010, that are referenced in the MDA report, were taken using equipment that has limitations regarding the lower linearity limit to which the noise loggers used comply with IEC61672. The noise loggers used by MDA in 2008, such as the Environmental Noise Loggers Type EL-215 and EL-316, only comply with the required acoustics standards down to 30 dB(A). Such devices are not suitable to assess a high amenity noise area or to set target noise limits for the Project. We note from the Lal Lal Wind Farm Panel Report (February 2009) that poor correlation of background sound level to wind speed was apparent in the results and that the Panel recommended certain prescribed correlation values to be achieved for compliance testing and this forms part of the current permit conditions. The proposed draft revised conditions has removed these permit requirements.

It would be appropriate to require an objective assessment of high amenity noise areas surrounding the Project. If measurements, using appropriate equipment capable of measuring low sound levels with linearity down to 22 dB(A) or below, show a dwelling to be in a high amenity noise area then the base target noise limit for this area should be set at 35 dB(A) L90, not 40 dB(A) L90. This would be best described in an amended permit condition such as that described in model license condition 14 of the PPGWEF.

COMPLIANCE ASSESSMENT

The proposed draft revised conditions in the JACOBS report has cherry picked some of the model license conditions in the PPGWEF. For example, model noise condition 15 Noise Compliance Assessment has had part (c) removed in the JACOBS report so that the six monthly compliance checking is not required. We believe that this model condition is a good idea since it will give advanced warning of any non-compliance issues that may arise and can provide for cheaper remediation / amelioration works that may become problematic if found after full commissioning. An extension to this may also be advantageous to allow testing of the first wind turbines against any guaranteed sound power levels.

HOST NOISE LIMITS

The MDA report has referenced ETSU-R-97 from the UK instead of the Australian draft National Wind Farm Development Guidelines recommended by the PPGWEF for advice on setting appropriate noise limit relaxations for residents entering into an agreement with the Project developers. As there is alternative Australian advice available in the PPGWEF, ETSU-R-97 should not be used. However, we note that the Panel report from February 2009 recommended that there be no noise conditions set for dwellings within the area covered by the Project but that the Australian draft National Wind Farm Development Guidelines post date the Panel report and that provision for a host noise limit agreement would be an appropriate update in an amended planning permit. The MDA report suggests that an appropriate baseline noise limit for such an agreement should be 45 dB LA90, however the draft National Wind Farm Development Guidelines state:

> The Guidelines recommend that where stakeholders are involved in a proposed development and they agree to a relaxed set of noise level limits to apply at their property/properties, the minimum noise level limit may be increased by a suitable margin, for example 5dB. Minimum noise level limits of more than 45dB LAeq at a receiver are not considered suitable without provision for noise insulation of the dwelling and a suitable protected outdoor living area.

If the baseline target were to be for areas requiring a high amenity noise limit of 35 dB LA90 then the relaxed agreement of 40 dB LA90 may be more appropriate for host dwellings. Furthermore, the recommended agreement relaxation base noise limit in the MDA report is 45 dB LA90, not LAeq. The 45 dB LA90 noise level is equivalent to 47 dB LAeq which is not considered suitable without noise insulation of the dwelling and protection of outdoor living areas.

NOISE PREDICTIONS

NOISE MODEL

Without an understanding of the uncertainty of measurement and limitations of equipment and models, apparently detailed technical analysis work can provide misleading conclusions.

The MDA report has used ISO9613 to predict noise levels surrounding the Project site. Reference has been made to a report by Bass, Bullmore and Sloth (1998) suggesting that this report "found that the ISO 9613-2:1996 model provided a robust representation of upper noise levels which may occur in practice, and provided a closer agreement between predicted and measured noise levels than alternative standards such as CONCAWE and ENM. Specifically, the report indicated the ISO 9613-2:1996 method generally tends to marginally over predict noise levels expected in practice." This statement is misleading. The Bass, Bullmore and Sloth report (Joule study) advised the use of an alternative model in preference to ISO9613.

It is generally accepted that ISO9613 is a poor model to use for predicting wind farm sound levels and that it requires a number of adjustments before reasonably accurate results can be obtained and only in these circumstances may an accuracy of +/-4dB be achieved. This fact was accepted by the author of the MDA report in questioning for the Panel investigations reported in February 2009 for the Lal Lal Wind Farm. ISO9613-2 lists the accuracy of the model to be +/- 3dB at distances up to 1000m for a source height no higher than 30m.

The author of the MDA report is quoted in the Panel Report on page 83 from February 2009 as saying:

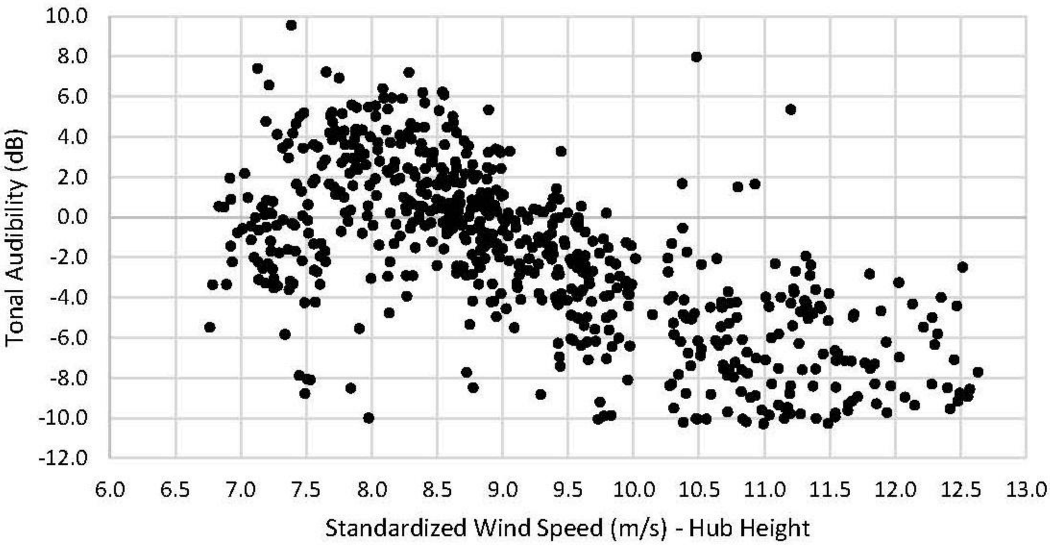
> "*Although the South Australian EPA minimum noise limit is 35dBA, the method used to predict noise emissions, typically ISO9613-2 is considered to be less conservative than the simple prediction method required by the NZ Standard. Therefore, while the SA EPA Guidelines minimum noise limit is lower than that in the NZ Standard, it is expected that predicted noise levels would also be lower using the SA EPA Guidelines.*"

We agree that ISO9613-2 is not as conservative as the model referenced for use in the NZS6808:1998 assessment methodology. In fact, any other noise model may be used when applying NZS6808 and the simpler noise model described in the 1998 version of NZS6808 will give more conservative (higher) predicted sound levels. The author of the MDA report acknowledges that ISO9613 is not a conservative model, contrary to the suggestion in his report for this application.

CANDIDATE WIND TURBINE

The new Lal Lal wind farm layout includes a candidate wind turbine (Senvion 33.2M114) to be used for each wind turbine location. MDA have used the candidate wind turbine to assess noise impacts from the development. WestWind Energy have not yet confirmed the particular wind turbine that may be used in the development and this should be remembered when considering references to guaranteed noise emissions and tonality that are referred to in the MDA report. The form of any guarantee can have significance to the noise experienced at nearby noise sensitive locations. Jozwiak[1] has compared different revisions of IEC 61400-11 *Wind Turbines – Part 11: Acoustic noise measurement techniques* and with regard to tonality assessment reported that:

> "While the sound pressure level measured from a turbine remains relatively steady at a given standardized wind speed, tonal audibility can vary quite significantly. Figure 5 depicts the calculated tonal audibility (as per Edition 3.0) for a select wind turbine. The variation for a given wind speed easily exceeds 5 dB between the min and max values. Although only one sample set is depicted, the findings are fairly consistent for majority of tests completed and whether Edition 2.1 or Edition 3.0 is utilized.



> *Figure 5 – Tonal audibility of all data points vs wind speed from a sample data set, as per Edition 3.0*
>
> The difference in minimum sample size between Edition 2.1 and Edition 3.0 is small, 12 vs 10 respectively. Edition 3.0, however, utilizes more representative wind speed data (as noted in Section 2.4) which ultimately provides a more accurate indication of the tonal audibility at a given wind speed.
>
> Further, if the analysis is expanded to a larger sample set Edition 2.1 remains capped at 12 data points while Edition 3.0 accounts for the larger sampling. Given the variation typically observed in the tonal audibility results a larger sample set is likely to give a

[1] Jozwiak, R., Munro, A., Halstead, D.,Denison, A. 2015 " Field comparison of IEC 61400-11 Wind turbines - Part11: Acoustic noise measurement techniques: Edition 3.0 and Edition 2.1" 6th International Conference on Wind Turbine Noise, Glasgow

> more consistent result with Edition 3.0, where Edition 2.1 is more akin to playing the lottery."

A guarantee of compliance to earlier versions of IEC 61400-11, or the latest version with small sample size, is of little value if the assessment of tonality is "more akin to playing the lottery". We have no confidence that such a guarantee proposed in the MDA report will achieve the objective of ensuring the absence of tonal special audible characteristics in practice. Furthermore, IEC 61400-11 effectively averages the tonal audibility test results and even if the test result shows no tonal audibility it does not provide a guarantee that tonality will not occur when, from Jozwiak referenced above; "the variation for a given wind speed easily exceeds 5 dB between the min and max values."

SOUND POWER DATA

Input data to the ISO9613 noise model has been suggested for a candidate wind turbine (Senvion 3.2M114). The sound power data for this particular wind turbine has been included in the noise model from a test report reference SD-3.2-WT.PC.00-B-D-EN *Power Curve & Sound Power Level 3.2M114 [50Hz]*.

Sound power levels for wind turbines are measured in accordance with IEC61400-11. These sound power levels are used in a noise model such as that used in the MDA report. Inaccuracies from the IEC61400-11 measurements translate into uncertainties in model predictions. The generally accepted uncertainty with the IEC61400-11 measurement is 2 dB for controlled conditions such as minimal inflow turbulence to the rotor. However, the MDA report shows that a 1dB margin was used, as required by Senvion for guaranteed power levels, to account for uncertainties.

Sloth[2], a Vestas wind turbine manufacturer and installation employee and co-author of the Joule study, suggested that IEC61400-11 "is a fairly good tool for verification of warranties, but not a good tool for predicting noise at imission points where people actually can get annoyed". Sloth also suggests that if the ISO9613-2 noise model is used then hard terrain (G=0) should be used and that installed sound power results from measurements using IEC61400-11 should be corrected for actual inflow angles, actual air density, actual wind shear and actual turbulence intensity, each being known to influence the sound emission of a wind turbine.

Sound power test data for a wind turbine is measured having regard to minimising inflow turbulence to the rotor (turbulence intensity). Increased inflow turbulence will increase sound power and this effect is described in Annex C of IEC 61400-11 v2.1 as follows: "Turbulence is a natural part of the wind environment, and as it passes through the rotor disk, it causes unsteady pressures on the blades that radiate noise. Studies suggest that at high power levels or wind speeds, noise due to inflow turbulence can become the dominant source of aerodynamic noise emission from a wind turbine." In a real wind farm turbulence is generated by each wind turbine. The location of each wind turbine and the spacings between then influence the amount of turbulence at awind farm site (site effects).

The Basic Aspects for siting of Wind Farms is described in the following from Suzlon Energy: http://www.wwindea.org/technology/ch02/en/2_4_1.html.

This reference is included in the Appendix and it contains the following:

[2] Erik Sloth, et al, Problems related to the use of the existing noise measurement standards when predicting noise from wind turbines and wind farms, AUSWEA Conference, 2004

> "We have to distinguish between two different sources of turbulence. Turbulence is generated by terrain features – which is referred to as ambient turbulence intensity - as well as by neighbouring wind turbines – which referred to as induced turbulence (Figure 1). Sources of ambient turbulence are for example forests, hills, cliffs or thermal effects. Thus ambient turbulence can be reduced by avoiding critical terrain features. But the wake-induced turbulence has far more impact than the ambient turbulence intensity /2/.
>
> Decreasing the spacing increases the turbulence induced by the wakes of neighbouring wind turbines meaning that there are limits to how close you can space the turbines.
>
> As a general rule the distance between wind turbines in prevailing wind direction should be a minimum of the equivalent of five rotor diameters. The spacing inside a row perpendicular to the main wind direction should be a minimum of three rotor diameters."

The larger rotor diameter of 114m for the new wind turbine translates to a minimum spacing of 570m compared to a minimum spacing of 410m that was used for the original wind farm turbine layout. The larger 114m diameter rotor proposed will contravene the minimum spacing of turbines suggested by Suzlon Energy which has extensive experience in wind farm design. The sound power data used for the MDA report is very optimistic.

GROUND ABSORPTION

The MDA report references good practice guidelines from the UK for a justification to use G=0.5. Given the climate in the UK, it would be reasonable to use a 50/50 mixed ground terrain value of G=0.5 for an ISO9613 noise model in the UK. However, in Victoria this model input parameter is not considered appropriate. For example, the South Australian EPA wind farm noise models are required to use G=0 if ISO9613 is used.

The ISO9613 noise model will predict typically 4 dB extra noise at imission points around the Project site if G=0 is used in the noise model instead of the G=0.5 value used in the MDA report.

The implications of this minor correction to the noise model in the MDA report are significant when compliance margin levels of 0dB to 3.8dB are predicted for eleven dwellings in Table 3. This margin is applicable to a base noise target limit of 40 dB LA90 as suggested in the MDA report. However, for a high noise amenity area, that may be appropriate for dwellings surrounding the Project, the base noise level target of 35 dB LA90 will be exceeded, even without correction for the ground absorption factor.

Considering a high noise amenity area may be applicable for some dwellings and the correction in the noise model to include G=0, we expect that noise non-compliance will result for at least eleven dwellings. The predicted sound levels at the dwellings requiring noise agreements (e.g. J17aa) with the Project developers will also be higher and may not comply with the agreement noise targets.

PANEL REPORT FOR THE LAL LAL WIND FARM 2009

It is useful to reflect on the deliberations and recommendations by the Panel in the Lal Lal Wind Farm planning proceedings.

In considering the planning guideline for the use of NZS6808 the Panel stated (page 79):

We interpret the WEF Guidelines requirement for compliance with the NZ6808:1998 noise limits as creating two separate requirements:

- a pre-construction noise assessment that supports a reasonable expectation that the NZ6808:1998 limits can and will be complied with; and
- post-construction compliance with NZ6808:1998 noise limits.

At this point, the first of these requirements is under consideration while the second will be dealt within Chapter 5.4 of this report. For the purpose of the current discussion it must be assumed that an adequate compliance monitoring and enforcement regime will be established and implemented. The question at hand is whether compliance can be reasonably expected.

If the assessment clearly predicts non-compliance then the Proposal must be considered unacceptable, however if compliance is predicted and not achieved in practice then the cost of the modifications required to achieve compliance, which could be substantial, will be borne by the WEF operator.

Although we have doubts that the proposed candidate wind turbine and new layout for this Project will meet the proposed (non-high amenity area) noise limits, the assessment by MDA has applied an assessment in accordance with NZS6808:2010 (NZS6808:2010 does not prescribe noise modelling parameters or uncertainty corrections). If the Lal Lal Wind Farm owners subsequently find that noise at surrounding dwellings exceed the noise limits suggested in NZS6808:2010 (for non-high amenity areas and for those areas that may be determined to be classed as having a high noise amenity) then that is a risk for the developers, owners or operators of the wind farm.

Regarding any proposed (indicative/candidate) wind turbine the Panel report states (pages 89,90):

> At this point in time there is no way of determining what the sound power level of the turbine ultimately selected will be.
> The assessment provided supports a reasonable expectation of compliance if the indicative turbine is used. We do not agree with Mr Delaire that additional predictions should be required if the indicative turbine is not ultimately selected. The use of a different turbine, which would not be precluded, would be subject to the same performance requirement in terms of noise, and the WEF operator would be foolish to install generators that are predicted to exceed the prescribed noise limits. While we expect that such an assessment would be conducted, since it would be in the interest of the Proponent, there is no need to make it a permit requirement - the permit will require compliance with the limits.

In respect of non-compliance, the Panel has stated on page 91 that:

- any exceedance of the limit should be considered as a breach of the condition and we see no reason to allow the limit to be exceeded for 10% of the time. The limits are aimed at protection from sleep disturbance and effectively allowing sleep disturbance for 10% of the time is inappropriate.

The Panel considered the background measurement reports of MDA and noise model predictions and stated on page 82 that:

> While we consider the data used is acceptable for the purpose of the assessment, we have serious doubts as to the adequacy of that data for the purposes of setting of limits and compliance testing. These concerns are discussed later in this report.
> Overall we believe that the noise assessment provides an adequate response to the requirements of the planning scheme and supports a reasonable expectation of compliance with the appropriate limits. We emphasise that it is the actual noise from the WEF that is the critical concern, rather than predicted noise levels, and set out a rigorous process to ensure compliance with the appropriate limits is achieved.
> If, despite the expert evidence and the confidence expressed in the Proponent's submissions, the predicted noise levels presented in support of the Application prove to be under estimates, the WEF operator will need to take whatever action is necessary to comply with the standard. Thus, any risks associated with inaccurate modelling at the assessment stage rest with the WEF operator, not the residents.

We note that the existing permit in condition 24 describes the rigorous process recommended by the Panel in 2009 to ensure compliance. However, the proposed revision of condition 24 simply removes this rigour and effectively negates the deliberations and recommendations of the Panel in 2009 that formed the conditions of the current approval.

Similarly, the new proposed revised condition 23 removes the requirement to assess noise compliance within 20m of each dwelling and for all time and night time separately. A similar condition to the existing 20m permit requirement is in place for the Macarthur Wind Farm.

ASSOCIATED REPORTS

We understand that a noise compliance testing plan has been prepared in accordance with the existing planning conditions and that this, after endorsement by the Minister for Planning, becomes part of the current permit. We have not reviewed this document but expect that it will need revision in the event of any changes to reflect the use of NZS6808:2010.

We have reviewed a compliance report for the Macarthur Wind Farm and note that problems arise when determining wind speed from site anemometers due to wind turbine induced turbulence. This effect needs to be considered in any revision of a noise compliance testing plan.

APPENDIX

(http://www.wwindea.org/technology/ch02/en/2_4_1.html)

Siting of Wind Farms: Basic Aspects

When searching the internet for the definition of the word “layout” I came across following:

Layout in word processing and desktop publishing refers to the arrangement of text and graphics. The layout of a document can determine which points are emphasised and whether the document is aesthetically pleasing. While no computer program can substitute for a professional layout artist, a powerful desktop publishing tool can make it easier to lay out professional looking documents (source: www.webopedia.com)

In principle the same is valid for wind farm planning: The term layout in wind industry is used for choosing optimal locations for wind turbines. Tools like flow models help to identify the best positions, but cannot replace the engineer making the final decision by balancing interests.

So what is that engineering experience, what factors influence the decision?

Jessica Rautenstrauch, wind energy consultant from Anemos, Germany, at work. © Paul Langrock (www.unendlich-viel-energie.de)

Wind resource

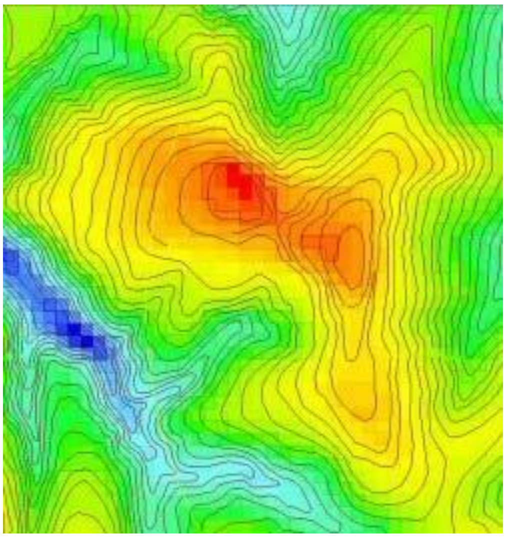
The wind resource is the most obvious factor to concentrate on when choosing a wind turbine location. We have a wide range of options to determine the wind resource of the site. The quality of the tools varies significantly and so does their price.

Common sense is a good starting point. Nature itself helps to guide us to suitable sites. Flagging of trees – permanent flagging and not the temporary bending in the wind – shows us the prevailing wind direction and is a good indicator for the strength of the wind.

However because of the uncertainty involved, using common sense as the only tool is of course insufficient. For any bankable estimate of the energy yield on-site wind speed measurements are required. The number of measurement masts required for a specific site depends next to the size of the project mainly on the complexity of the terrain. The measurement height should be minimum 2/3 of the expected future hub height. An increase in measurement height beyond this leads to a reduction of the uncertainty in the energy estimate. The measurement period must be one year or more to avoid any seasonal bias. Since the wind speed varies also inter-annually typically up to +/-12% a long-term correction is highly recommended.

The measured wind regime is extrapolated across the site to derive a resource map of the site using different flow models /4, 5/. A wind map like the one in Graph 1 can then be used to identify the windiest locations.

However additionally technical constraints should be taken into account when developing a layout /3/. A number of site specific wind load parameters can be extracted from the wind speed measurement. They are used to optimize the technical suitability of the chosen layout and the wind turbine type for the site specific wind regime.



Graph 1: Example Wind Resource Map. The colours denote the energy content of the wind, red high and blue low energy content.

Technical restrictions

Wind turbines are designed for specific conditions. During the construction and design phase assumptions are made about the wind climate that the wind turbines will be exposed to. In rough terms: For very complex sites with high wind speeds "heavy-duty" versions of wind turbines are available, which are sturdier but also more costly. Low wind speed sites in flat terrain do not put so high demands on the on the wind turbine structure, hence the construction can be more light-weight and hence cheaper. The different turbines have been classified by the IEC, class 1 being the highest wind speed class. The following table is a simplified summary of the IEC classification /1/.

IEC class	I	II	III	IV
V_{ave} (m/s) annual average wind speed at hub height	10	8.5	7.5	5
V_{ref} (m/s) 50-year maximum 10-minute wind speed	50	42.5	37.5	30

Table 1: IEC classes

But not only the wind speed but also other parameters play a role and have to be checked, when developing a layout for a specific turbine.
One of the most important parameters is the turbulence intensity. Turbulence intensity quantifies how much the wind varies typically within 10 minutes. Because the fatigue loads of a number of major components in a wind turbine are mainly caused by turbulence, the knowledge of how turbulent a site is of crucial importance.

We have to distinguish between two different sources of turbulence. Turbulence is generated by terrain features – which is referred to as ambient turbulence intensity - as well as by neighbouring wind turbines – which referred to as induced turbulence (Figure 1). Sources of ambient turbulence are for example forests, hills, cliffs or thermal effects. Thus ambient turbulence can be reduced by avoiding critical terrain features. But the wake-induced turbulence has far more impact than the ambient turbulence intensity /2/. Decreasing the spacing increases the turbulence induced by the wakes of neighbouring wind turbines meaning that there are limits to how close you can space the turbines. As a general rule the distance between wind turbines in prevailing wind direction should be a minimum of the equivalent of five rotor diameters. The spacing inside a row perpendicular to the main wind direction should be a minimum of three rotor diameters.

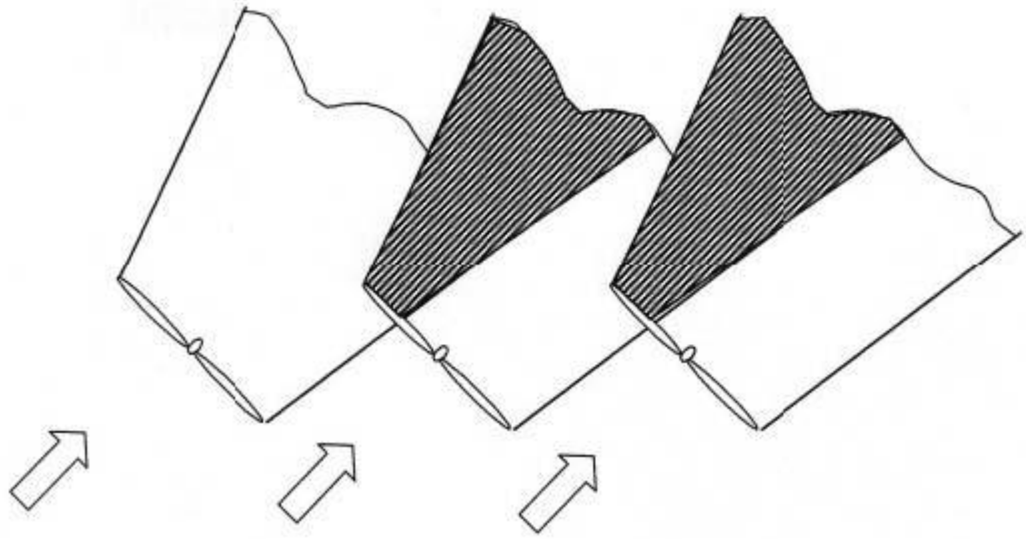


Figure 1: Shadowing in wind farm

If a layout is too close the resulting fatigue loads might be too high. In order to then ensure the lifetime of the main components wind sector management might have to be applied, meaning that some wind turbines might have to be switched off when they are operating in the wake of the neighbouring wind turbine.
Another parameter which has to be checked when developing a layout is the flow inclination, velocity tilt or in-flow angle. When wind turbines are to be placed on steep slopes or cliffs the wind might hit the rotor not perpendicular but at an angle. This angle is related to the terrain slope. With increasing height above ground level the effect of the terrain slope is normally reduced such that the terrain slope is only of indicative use to estimate the velocity tilt. A large in-flow angle will not only reduce the energy production but will also lead to an increased level of fatigue of some of the mayor components.

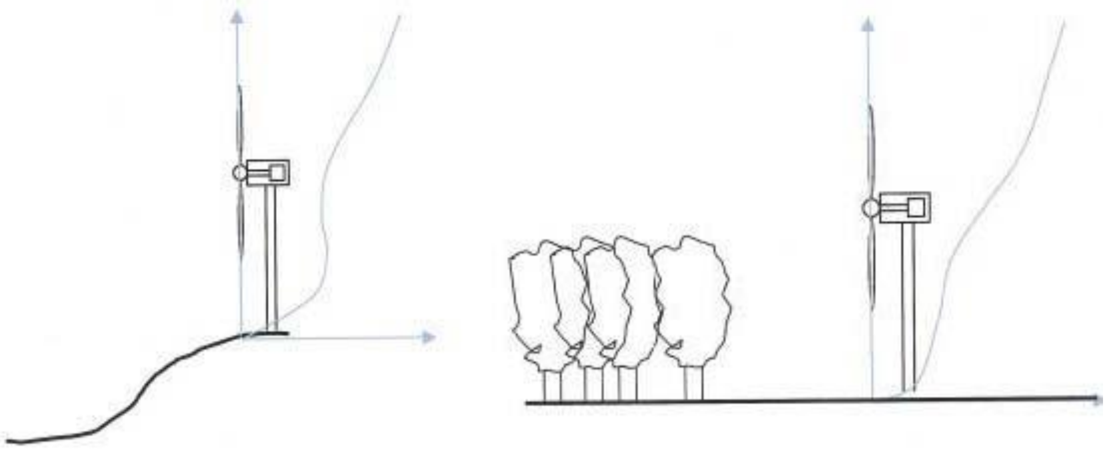


Figure 2: Distorted wind profile at steep slope (left) and behind a forest (right)

Furthermore a steep slope might cause a negative gradient across some parts of the rotor (Figure 2).

Normally the wind speed increases with increasing height. In flat terrain the wind speed increases logarithmically with height. In complex terrain the wind profile is not a simple increase and additionally a separation of the flow might occur, leading to heavily increased turbulence. The resulting wind speed gradients across the rotor lead to high fatigue loads particularly on the yaw system.

Obstacles like forest can have a similar effect on the wind profile and should be thus avoided.

Planning constraints

Next to the wind resource and technical considerations a good layout should also take planning constraints into account. The visual impact is course the most obvious. A layout that follows the shape of the terrain rather than straight rows of wind turbines appears to be less intrusive. Noise is another important parameter to take into account. Next to noise also the impact due to flicker at the nearest inhabited houses should be estimated. The accepted levels vary from country to country.

Electro-magnetic interference can cause problems. Hence placing wind turbines in a transmission corridor should be avoided.

Some areas on site might have to be excluded from development due to other factors related to fauna, flora and archaeology.

Jessica Rautenstrauch, wind energy consultant from Anemos, Germany, at work. © Paul Langrock (www.unendlich-viel-energie.de)

Summary

A large number of parameters have to be taken into account when developing a layout. Some work can be done using tools, but in the end the balance between financial, technical and planning constraints can be best done by an experiences engineer.

Literature

/1/ IEC 61400-1, Ed.2 – Wind Turbine Generator Systems – Part 1: Safety Requirements, FDIS 998 /2/ S. Frandsen, St.; L. Thøgersen, L.;: Integrated Fatigue Loading for Wind Turbines in Wind Farms by Combining Ambient Turbulence and Wakes; Wind Engineering, Vol. 23 No. 6, 1999 /3/ K. Kaiser, W. Langreder: Site Specific Wind Parameter and their Effect on Mechanical Loads, Proceedings EWEC, Copenhagen, 2001 /4/ E.rik L. Petersen, N. G. Mortensen, L. Landberg, J. Højstrup and H. Frank: (, Wind Power Meteorology Part I: Climate and Turbulence, Wind Energy, 1, 25-45 (1998), Risø-I-1206, 1997 /5/ E. L. Petersen, N. G. Mortensen, L. Landberg, J. Højstrup and H. Frank: Wind Power Meteorology Part II: Siting and Models, Wind Energy, 1, 55-72 (1998)

Wiebke Langreder
Suzlon Energy: www.suzlon.com