Expert Witness Statement of William Leslie Huson

In the matter of the Stockyard Hill Wind Farm

Application to Amend Planning Permit PL-SP/05/0548

Expert retained by:

Stockyard Hill Community Guardians, and;

Sarah and Phillip Hawker

NAME AND ADDRESS OF EXPERT

William Leslie Huson
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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 26 years I have worked in Australia as a noise and vibration consultant and have operated through my own consultancy firm for the past 20 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 uncertainty 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 in 2015: Huson, W. Les."Stationary wind turbine infrasound emissions and propagation loss measurements." 6th International Conference on Wind Turbine Noise, Glasgow 20-23 April 2015. An additional paper was presented at the 6th International Conference on Wind Turbine Noise: "Constraints imposed by and limitations of IEC 61672 for the measurement of wind farm sound emissions".

In 2010 I provided Expert assistance to the Panel in the matter of the Stockyard Hill wind farm on behalf of Lowell Pty Ltd.

OTHER CONTRIBUTORS TO THIS REPORT

1 None

SCOPE OF THIS REPORT

2 I have been commissioned by Sarah and Phillip Hawker and the Stockyard Hill Community Guardians, to prepare a review of the noise aspects of the Stockyard Hill Wind Farm Application to Amend Planning Permit PL-SP/05/0548 (Application) updated August 2016 prepared by JACOBS. A noise report prepared by SONUS was included as Appendix G of the Application.

3 Sarah and Phillip Hawker have also requested that I assess any relevant noise impacts upon their property and those surrounding them.

4 I have compiled all of my review material into one report for the benefit of the Panel since there would otherwise be unnecessary duplication.

5 As part of my assessment, I have also reviewed the Stockyard Hill Wind Farm Peer Review dated 11 May 2016 prepared by Marshall Day Acoustics (MDA) on behalf of Stockyard Hill Wind Farm Pty Ltd which is included in the Application as Appendix R.

6 In a letter dated 11 November 2016 to Submitters from Planning Panels Victoria:

> "As stressed by the Chair at the Directions Hearing it is important to recognise that the wind farm permit (Pyrenees Planning Scheme PL-SP/05/0548) is an amendment to an existing permit, not a new application. Submissions from all parties including the applicant should focus on changes from the existing approved project rather than undertaking a 'first principles' review."

7 My interpretation of this requirement is that the extant permit conditions prevail in the assessment of the proposed amendments and that the extensive work completed by the Panel that determined those permit conditions is not under a 'first principles' review.

8 With regard to acoustics, the relevant changes are the relaxation of hub height and blade length restrictions, together with a new wind turbine layout.

9 The original application was for a wind farm containing 252 wind turbines. During the panel hearing of 2010 a total of 29 wind turbines were removed from the original application and the Panel decided that a further 56 of the wind turbines should also be removed, as described in the extant permit. The permit also required six of the wind turbines to be resited from the original layout.

10 The extant permit includes the following condition:

> *2. The use and development as shown on the endorsed plans must not be altered or modified without the written consent of the Minister for Planning, except that:*
>
> *• no application can be made for consent to modify those matters*

specified in Condition 4; and

• the micro-siting of wind turbines and overhead powerlines, access tracks and underground cabling as defined below, does not require consent and will be viewed as generally in accordance with the endorsed plans.

11 The specifications in Condition 4, which can have an acoustics influence, requires the following:

SPECIFICATIONS

4. The wind energy facility must meet the following requirements:

a) the wind energy facility must comprise no more than 157 wind turbines;

b) the overall maximum height of the wind turbines (to the tip of the rotor blade when vertical) must not exceed 132 metres above natural ground level;

c) wind turbines must be mounted on a tubular tower with a height of no greater than 80 metres;

d) each wind turbine is to have not more than three rotor blades, with each blade having a length of no greater than 52 metres;

12 It would appear from the first bullet point of Condition 2 that no application can be made to modify the specifications described in Condition 4. I am not versed in the intricacies of planning law so there must be some legal reason why this current Application is allowed to be made, when Condition 2 appears to disallow such an application. I am unsure if the conditions take precedence over section 97I(1) of the Planning and Environment Act 1987.

13 The extant permit also requires:

DEVELOPMENT PLANS

1. Before the development starts, development plans must be prepared to the satisfaction of the Minister for Planning.....

f) details of the model and capacity of the wind turbines to be installed.

NOISE MODELLING

23. Before the development starts a noise modelling plan must be prepared to the satisfaction of the Minister for Planning meeting the following requirements:

25. Should the modelling required above not be done with the turbine finally selected for the wind energy facility that modelling must be repeated once the final turbine type is selected and resubmitted to the Minister for approval.

14 To my knowledge, a noise modelling plan, noise compliance testing plan (including provision for an on/off testing plan) and an active noise management plan, all being subject to approval by the Minister for Planning, have not yet been prepared and approved. Furthermore, a particular turbine model has not yet been chosen.

15 The Application appears to be a new application for a wind farm on the Stockyard Hill Wind Farm (SHWF) designated land, rather than a minor modification to those elements of the extant permit that can be altered with the approval of the Minister.

16 The Application may be considered premature since it is a current requirement before construction to have approved a Noise Modelling Plan and apply that to the particular wind turbine model proposed to be built (in accordance with the permit).

17 There are numerous ways to review the Application.

a) If the Application is, in effect, a new application then there is no need to consider the extant permit and the Application should be presented as a new application with the requirements to impose the latest planning guidelines.

b) If the Application is allowed in law to alter Condition 4 requirements of the permit then the remaining permit conditions may still prevail and such things as the assessment of Background noise in accordance with the approved Background Noise Monitoring Plan of 2011, the preparation of a noise modelling plan, noise compliance testing plan (including provision for an on/off testing plan) and an active noise management plan, all being subject to approval by the Minister for Planning, are required.

c) If the Application is not allowed to alter the approved wind turbine dimensions of Condition 4 (a, b, c, d), then only the effect of changing wind turbine locations may need to be reviewed.

d) If the Application requests modification of certain permit conditions and these changes are permitted in law, then the reasons must be justified in the Application and those reasons reviewed prior to being allowed.

e) If any condition of the extant permit, suggested to be changed in the Application, is authorised, is it a requirement in law to change the permit to reflect newer noise standards? If so, then the implications of such changes need to be reviewed.

18 Many of the options for review are dependent upon what is considered lawful planning practice, for which I am not qualified to provide expert opinion. Accordingly, this review simply assesses the change in noise from a proposed new layout using larger wind turbines as it may affect noise sensitive locations around the SHWF site and the justifications provided, if any, to alter extant noise conditions.

19 I have also reviewed the approved Background Noise Measurement Plan prepared by SONUS dated October 2011 and permit PL-SP/05/0548.

20 This review includes the changes with regard to noise assessment and compliance that may arise in relation to the assessment of noise from the use of NZS6808:2010 in lieu of NZS6808:1998 and the use of the latest (January 2016 edition) of the Policy and Planning Guidelines for development of wind energy facilities in Victoria (PPGWEF).

21 My guiding principal in this assessment, with regard to permit condition changes, is to determine whether those changes diminish any intended protections provided by the extant permit. After all, this amendment is not supposed to be a 'first principles' review that may undermine planning panel recommendations from 2010.

GENERAL COMMENTS

22 The SONUS Report for this Application compares predicted sound levels for dwellings using CONCAWE for three alternative proposed candidate wind turbines with capacities over 3MW, with revised layout, to earlier noise predictions for the currently approved layout using a candidate Senvion MM92 wind turbine.

23 The SONUS report in the Application shows that there is both a reduction in predicted sound level and increase in predicted sound level at different dwellings surrounding the SHWF.

24 Wind turbine layout is important to ensure efficient harvesting of power from the wind and to minimise increase in sound from wind turbines that become subject to inflow turbulence and wake effects due to other wind turbines and any obstacles or terrain undulations in the SHWF site (site effects).

25 It should be noted that a wind turbine of a given name such as a Senvion MM92 or 3.4M140 can have many variants and can have different blades or gearboxes fitted that can influence sound power output. Any particular wind turbine chosen for construction must be properly identified with regard to its variant and the corresponding test results for that variant must be used in the final noise model that is required prior to construction.

26 Standards for compatibility of a wind turbine in different average wind resource are allocated to various Classes using IEC61400-1:

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

27 In addition, there are sub-classes A, B, where A is for areas having 'higher' turbulence (TI=18% measured at 15m AGL) and B is for areas having 'lower' turbulence (TI =16% measured at 15m AGL)

28 CLASSES FOR 3.X SENVION MODELS

3.4M104	up to IEC IB
3.4M114	up to IEC IIA
3.2M114VG	up to IEC IIA
3.0M122	IEC IIIA
3.2M122	IEC IIIA
3.4M140	IEC IIIA

29 I note that the extant permit compliant Senvion MM92 is certified to IEC IIA for an 80 m hub height.

30 Because average wind speed increases with height, the 110m hub height suggested in the Amendment for the Senvion 3.4M140, used by SONUS as a candidate wind turbine, may not be rated for use at the Stockyard Hill wind farm where the Class IEC IIIA may not comply with the maximum average annual wind speed at 110m hub height.

31 The Senvion website does not show certification to Class IEC IIA for the 3.4M140 wind turbine. If the same applies to the other two candidate wind turbines proposed then they may also be unsuitable for use on the Stockyard Hill wind farm site.

AMENDED WIND TURBINE LAYOUT

32 It is customary in the design of a wind farm to take account of the distances between wind turbines to minimise noise emissions and to maximise efficiency. An outline of such design considerations can be found in 'NSW Wind Energy Handbook 2002': Sustainable Energy Development Authority of NSW (SEDA).

33 From page 53 of the SEDA document:

"A wind-farm layout must take into account that turbines have substantial 'wakes', which interfere with each other depending on wind direction and spacing. The general rule of thumb for spacing (the '5r-8r rule') is five times rotor diameter abreast and eight times rotor diameter downwind. '

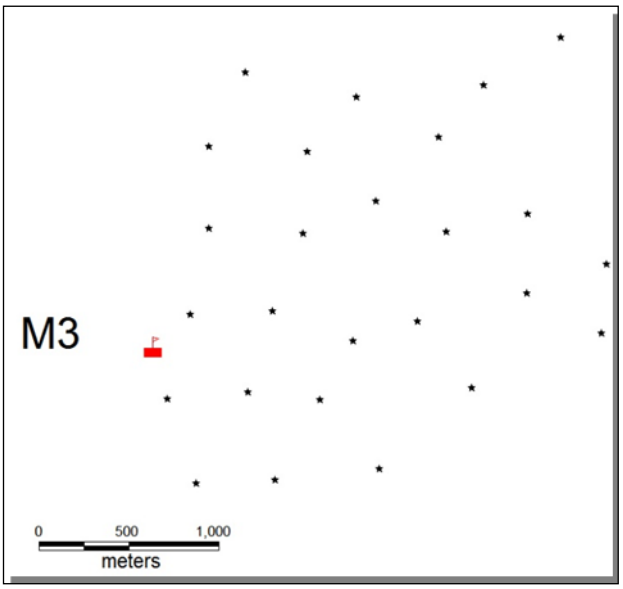
34 Appendix B of IEC61400-11 explains that wind turbulence will become the dominant sound source at higher wind speeds and that the tests should minimise and optionally report these effects.

35 The average minimum spacing between turbine towers for the currently approved wind turbine layout and the Amended layout I have calculated to be 535 m and 581 m respectively.

36 On average, the amended turbine layout increases the spacing between turbine towers by 46 m. However, to assess the effect upon wake generated turbulence we must consider the change in the multiples of D that these spacings represent. Using 92.5 m as the rotor diameter, D, for the extant permit the multiple of rotor diameters is 5.8 (5.8D), which is greater than the multiple of rotor diameters (142 m) for the Amended layout of 4.2 (4.2D).

37 The Application will increase wind turbine wake turbulence that will increase noise emissions, will decrease the efficiency of the wind farm and is a spacing less than that recommended as the minimum by SEDA.

38 Wind data from measurements at the WF2 anemometer mast at Stockyard Hill has been analysed to determine the current TI at 80m for wind speeds above 3m/s (cut-in). The mean TI from 6232 10-minute samples is 9.57%. For comparison to a situation where a similar anemometer mast is affected by wake turbulence I compared the TI obtained from an anemometer (M3) 84m high at the Macarthur wind farm that uses Vestas V112 3MW wind turbines. The geographic relationship of the M3 mast to nearby wind turbines is shown below with turbine locations marked with stars.



39 The average TI measured at M3 from 1658 10-minute samples with wind direction limited between 30 degrees and 150 degrees above 3m/s is 16 %. However, in the 60 degree wind direction a TI maximum of 52% is observed directly downwind of the nearest wind turbine.

40 This effect has not been considered in the SONUS modelling, where sound power derived from estimates, rather than measurements from the candidate turbines, have been provided by three wind turbine manufacturers (purported to comply with IEC61400-11) where TI is required to be minimised for the measurements.

41 I hold 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".

42 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 an inflow 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."*

43 The Application is for an increase in allowable wind turbine size and power generating capacity to accommodate a rotor diameter of 142m , with some change in the wind turbine spacing and an increase of allowable hub height to 110 m. As explained above, this will increase wake induced turbulence intensity within the site. This effect has not been considered in the SONUS report and CONCAWE modelling.

44 Another consequence in increasing the size of the Stockyard Hill wind turbines is that 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*."

[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*

45 Unfortunately, wind turbines are complex sound sources that do not readily conform to the simple noise models such as CONCAWE or 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 and special audible characteristics (SAC).

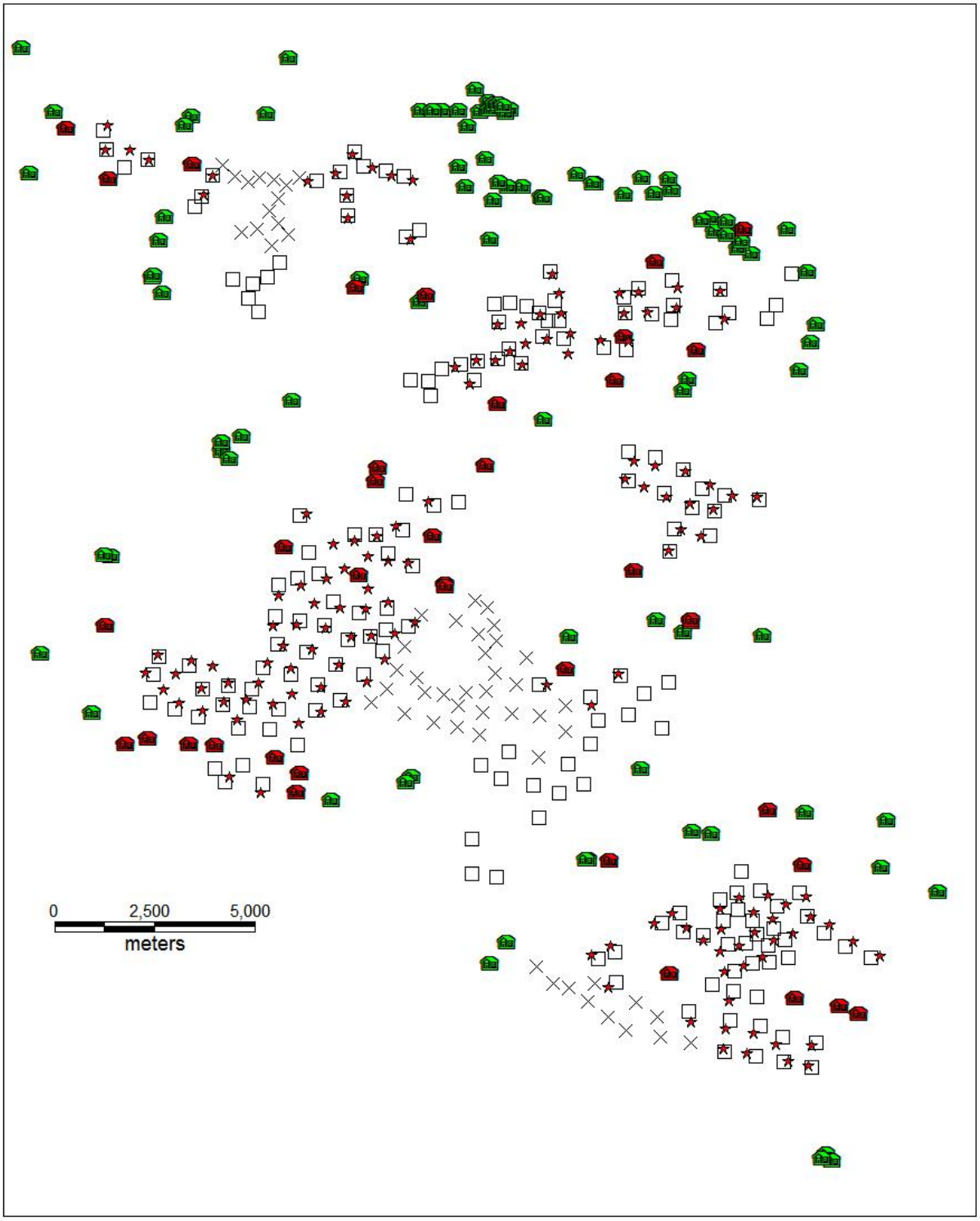
46 There are effectively three rotating sound sources for each wind turbine and standard propagation models generally used for wind farms use a static single point source per turbine without inclusion of other correction terms.

47 The addition of a sound power correction to account for TI and wake effects can improve the accuracy of a noise model 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 electrical power and sound output become most relevant when the wind blows along a row of wind turbines, or if the turbines in a row are located on a ridge line and site effects can influence inflow wind perpendicular to the row. The Appendix shows some of these effects described by Wiebke Langreda of Suzlon Energy.

48 The following is a figure showing the various layouts proposed for the Stockyard Hill wind farm.

49 Unfortunately, the Stockyard Hill wind farm layout can suffer from wake effects upon adjoining turbines in all wind directions.

50 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 extant permit and Application so a written comment on the suitability of the suggested candidate wind turbines could be provided by any prospective manufacturer in respect of guarantees because increased wake turbulence can enhance fatigue loads leading to increased maintenance costs and poor longevity.



KEY

HOSTS

NON-HOST DWELLINGS

ORIGINAL APPLICATION TURBINES (242 turbines)

AMENDMENT TURBINE LOCATION

SPECIFIC TURBINES REMOVED IN PERMIT (+29 others not shown)

SPECIAL AUDIBLE CHARACTERISTICS

51 Tonal noise has not been assessed for the wind turbines because there has yet to be a particular turbine type chosen. Any wind turbine chosen for the SHWF must be tested and a noise model prepared to the satisfaction of the administering authority to ensure that there are no tonal noise emissions. The assessment method for assessing tones from wind turbine generators can be found in NZS6808:2010 and the objective methods described can be included in the noise compliance testing plan.

52 I do not recommend a condition that allows a subjective assessment of special audible characteristics (SAC) such as tonality or amplitude modulation. Unlike the NZS6808:1998 version, the current NZS6808:2010 provides objective assessment methods to assess SAC that can be utilised during compliance testing or complaint investigations.

53 The final SHWF developers/owners/operators after the construction stage must recognise that non-compliance can have serious implications and may lead to the prompt removal of one or more wind turbines.

COMPLIANCE AUDITING

54 It would appear reasonable to have a condition requiring the engagement of an environmental auditor, appointed under the Environment Protection Act 1970, as suggested in the Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria. However, the requirements for acceptance as an Environmental Auditor under the provisions of the VIC EPA requires a team of professionals who may not have the skills in acoustics to assess the complex issues associated with wind farm noise.

55 In the interests of openness to the Community it may be appropriate to publish any Compliance Assessment Report and make available the raw data, such as noise measurements, SCADA and anemometer mast data from the wind farm during any survey period, to allow for any independent review to be completed.

56 If any independent review identifies problems with a compliance assessment report then an authority such as the VIC EPA may be called in to mediate and request correction. It is unreasonable to expect that a Minister or their Office would have specialised acoustic knowledge to determine the validity of a compliance assessment.

57 A similar problem arises when it is the responsibility of a Minister to approve any plan, such as a Noise Compliance Testing Plan. In a similar approach, it would be advisable to publish any draft Compliance testing method and to invite independent review prior to its approval.

NOISE LEVEL TARGETS

58 The SONUS Report seeks to set target noise limits for the Project with reference to NZS6808:2010. The new targets are based upon LA90 statistics rather than LA95 statistics.

59 I see no practical need to change the extant permit in this regard because most other wind farm permits in Victoria adhere to the LA95 limits from NZS6808:1998.

60 The primary reference for wind farm noise is the Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria, January 2016 (PPGWEF). The PPGWEF refers to the draft National Wind Farm Development Guidelines (July 2010), as amended, for further guidance.

61 Application of the 2010 version of NZS6808 now requires the assessment of high amenity noise areas that the 1998 version neglected.

62 The extant permit refers to NZS6808:2010 in part and there is scope to include references to include more prescriptive advice and objective assessment methodologies that is available in the 2010 version, within the various plans that are required to be prepared in the extant permit. For example, reference is already made in the approved background noise measurement plan to NZS6808:2010.

63 SONUS, MDA and JACOBS submit that the area around the SHWF does not warrant high acoustic amenity status. If this is the case, in my opinion, there is no need to change any of the extant permit conditions because the additional information from NZS6808:2010 can be included in the yet to be prepared plans.

64 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.

65 SONUS 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, citing extracts from a Panel decision for the Cherry Tree Wind Farm. The MDA peer review also refers to the Cherry Tree Decision but contends that the SONUS assessment of high amenity areas based on the predicted 35 dB(A), Leq noise contour should be for a hub height higher than 6m/s suggested by SONUS.

66 With respect to the wind speed to be used in predicting the 35 dB(A) contour I agree with the MDA peer review.

67 In a decision from The Sisters Wind Farm Pty Ltd v Moyne SC [2010] VCAT 719 (27 April 2010) the Panel decided that if the NZS6808:2010 version were applied to that wind farm then a high acoustic amenity would apply in that farming area which is located in a similar locale and is in a similar environment to the SHWF.

68 The Sisters VCAT decision was successfully appealed on the basis that it was unlawful to apply later standards and guidelines to an application for planning approval made before those changes occurred.

69 Since that time the law has changed and a similar appeal made today would not be successful.

70 I acknowledge that recent changes made to the Planning Guidelines in Victoria 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 more pertinent recent relevant considerations from Commissioners in New Zealand in this regard.

71 The more recent relevant interpretations of high amenity areas in New Zealand referenced under the NZS6808:2010 standard is available since the Cherry Tree hearing, the SONUS report, the Application and the MDA peer review.

72 The Cherry Tree Decision wrestled with the difficult issue of applying a New Zealand standard that references New Zealand planning and Resource Management laws. However, there has recently (22 August 2016) been a Decision of the Hearing Commissioners in New Zealand regarding the application of NZS6808:2010 in relation to the Resource Management Act 1991 and the issue of high amenity areas, amongst other matters[2]. Discussion on the classification of high amenity area starts on page 71 at paragraph 372.

73 Although I am not a Planner or Lawyer it is my opinion that the evidence of Mr Lloyd was preferred who explained that the objective assessment of high amenity areas in NZS6808:2010 provided an in-built safety valve to set base target noise levels. With regard to Mr Halstead's opinion regarding the issue of the Plan noise limits (40 dB(A)) in the following extract from the decision I have added an underline to what I believe is a pertinent view of the New Zealand Commissioners related to this Application that may inform the Panel:

"375) NZS 6808:2010 5.3.1 suggests that the windfarm noise limit is appropriate at most noise sensitive locations, but:

> **'In special circumstances at some noise sensitive locations a more stringent noise limit may be justified to afford a greater degree of protection during evening and night time. A high amenity noise limit should be considered where a plan promotes a higher degree of protection of amenity related to the sound environment of a particular area, for example [where night time noise limits are more stringent than 40dBLaeq(15min) or 40dBA L10]**

[2] Palmerston North City Council. Proposed Plan change 15 A-H under Part 1 Schedule 1 Resource Management Act 1991. Decision of the Hearing Commissioners, 22 August 2016
Available at: www.pncc.govt.nz/media/3129221/pc15-commissioners-decision.pdf

376) Mr Halstead's point is that this criterion is simply not satisfied in relation to these areas, particularly in relation to Plan noise limits. However, we think that this approach wrongly conflates the criterion with the example. In our view the Plan does intend the Rural Residential areas to have high amenity. It is an approach based on experience. The unfortunate fact is that the Council has spent a great of time dealing with noise issues from windfarms. Indeed, a view that seems to underlie some arguments from both the Council and the REG submitters is that there is a degree of wariness, if not reluctance, to enable further windfarm development in the City

377) So we do not accept Mr Halstead's contention that 'many if not most of the properties within the defined areas do not fit the criteria'. On the contrary, the areas within the definition are both residential and generally well removed from external sources of noise from highways, industry and so on. While Rural areas can be notoriously noisy at times, the kind of noise and its duration is different from that associated with windfarms.

378) We therefore reject the request to delete this definition."

74 In a recent panel hearing for the Mortlake South wind farm Ms Quigley informed me that the decision[2] from the New Zealand decision has been appealed, although, I was not informed on what grounds.

75 SONUS describe the results of background noise levels taken at numerous dwellings around the SHWEF and it is clear that the background levels are consistently very low (below 24 dB(A), the lower linearity range of the instrument used) and the objective assessment test of section C5.3.1(e) would support the justification of a high amenity for this area. Accordingly, I am of the opinion that the base target noise limit for this area in accordance with the objective sound level criteria in NZS6808:2010 should be set at 35 dB(A) L90, not 40 dB(A) L90.

76 The SONUS 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".

77 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 will in my opinion be more appropriate.

Furthermore, the recommended agreement for a relaxed base noise limit in the SONUS Report is 45 dB LA90, not LAeq. The extant permit specifies a target of 45 dB(A) LA95.

78 If NZS6808:2010 is to be applied, 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.

BACKGROUND NOISE

79 Background noise measurements used to set proposed noise limits for nearby residents in the original MDA surveys were found to be lacking and a new set of background noise data was required to be taken before any construction of the SHWF commenced. To this end, a noise measurement plan was to be approved by the Minister that would satisfy the permit conditions. A Background Noise Monitoring Plan was prepared by SONUS and, after minor modification to insist on the use of Class 1/ Type 1 sound level measurement equipment (as per the permit), it was approved.

80 Background measurements were then completed in 2012, although the survey presented as a report within the SONUS reports described in Appendix Q of the Application was non-compliant with the approved Background Noise Monitoring Plan that requires the analysis of data into wind direction quadrants and Day and Night, as required in the permit.

81 The MDA peer review has not assessed the background noise survey (page 8 of the review).

NOISE PREDICTIONS

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

83 The original work by MDA that supported the initial successful application for the permitted SHWF was based upon predictive noise modelling using ISO9613-1 for air absorption values and Equation 1 described in NZS6808:1998. The same noise model was used for reference in the approved background noise measurement plan prepared by SONUS in 2011.

84 It appears that the noise related parts of the Application are effectively starting afresh with a new noise impact assessment since most extant permit conditions are being ignored.

85 The SONUS report in Appendix Q also uses a different noise prediction model, rather than the one used for the approved wind farm.

86 It is known that different noise models produce different results for similar input parameters and SONUS have stated that the CONCAWE method they used is better than the ISO9613-2

noise model, used as an example in NZS6808:2010, because the ISO9613-2 model requires additional modifications to the standard to make it applicable to wind farms.

87 However, the original Marshall Day Acoustics report used the model of Equation 1 in NZS6808:1998 with a slight modification to improve its accuracy using air absorption factors and sound power levels in octave bands. Such an approach is still an accepted noise model in NZS6808:2010 and is not the ISO9613-2 method found in NZS6808:2010 that SONUS believe to be inappropriate.

88 Given that Equation 1 in NZS6808:1998, with a slight modification to improve its accuracy using air absorption factors and sound power levels in octave bands, was used in the original assessment upon which the permit was granted for the SHWF it would in my opinion be the most appropriate noise model to use for any new wind farm variation. Furthermore, the approved background noise measurement plan prepared by SONUS also relied on this model.

89 The same noise model should in my opinion be specified for use in a repeat of noise predictions for the wind turbine model chosen for construction.

90 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 SONUS Report and MDA peer review. Uncertainties 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.

91 The MDA peer review suggests that an additional 1dB(A) or 2 dB(A) be added to the SONUS predictions to account for uncertainty related to the IEC61400-11 measurement method (page 9) and I agree that this is appropriate in addition to a correction that should be applied to account for the increased TI due to wakes from adjoining wind turbines.

92 I suggest that an additional 2 dB(A) be applied to the overall A-weighted sound power levels used in the noise modelling for the size of wind turbine in the extant permit.

93 If octave band sound power levels are used in the model then a correction higher than 2 dB(A) would be appropriate in the frequency range at and below 300Hz for the size and scale of wind turbine currently approved.

94 However, due to the increased wind shear and TI that will be caused by the larger wind turbines described in the Application, the correction to sound power levels derived from IEC61400-11 to account for increased wind shear and TI of the larger wind turbines should be 4 dB(A) overall or 7 dB(A) added to each one third or octave band at 315 Hz and lower frequency.

95 Sloth(2004)[3], 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".

96 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. This type of correction is allowed in NZS6808 and can be incorporated using simple corrections into any of the noise models compliant with NZS6808 (1998 and 2010).

97 The MDA Peer review prefers the use of ISO9613-2 in contrast to SONUS. SONUS explains why ISO9613-2 it is less preferred than CONCAWE. In fact, all noise models are acceptable in both iterations of NZS6808, and obviously, so was the noise model that MDA originally used to inform the Panel for the SHWF back in 2010.

98 The differences in noise model results shown in the MDA peer review simply reflect the incorrect use of a ground absorption factor (G) used in ISO9613-2 where MDA prefer to use G=0.5, rather than G=0. However, in Victoria I do not consider G=0.5 to be appropriate and the South Australian EPA guidelines for wind farm noise assessment agree with me that G=0 should be used when applying ISO9613-2.

99 The MDA per review cites a number of references to support the use of G=0.5. However, when examined more closely, those references actually support G=0 in noise modelling using ISO9613-2.

100 As the Application uses CONCAWE I will not expand on the detail of why the MDA references do not support their use of G=0.5.

101 I have calculated the predicted sound level for five dwellings to show the effect on the results from CONCAWE used by SONUS and the NZS6808 Equation 1 model used by MDA in the original assessment (this is not ISO9613-2). The results in dB(A) are shown in the following table using the example Senvion M3.4-140 at 9m/s hub height wind speed used by SONUS in the Application for model input:

[3] 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

Dwelling	NZS6808 with oct abs	CONCAWE by SONUS
B054	30	27
B066	33	32
B058	40	40
B122	35	36
B366	35	35

102 The results show good agreement after rounding to the nearest dB, except for dwelling B054 and I recommend that SONUS review the results for this dwelling.

103 The sound power levels used in the example comparison above are those yet to be corrected for the uncertainty value of +2 dB(A) suggested by MDA and myself and the addition of an extra +4 dB(A) factor to account for TI from wakes and wind shear of the larger turbines in the Application. Additional corrections to account for more parameters suggested by Sloth (2004) that are known to increase sound power output can also be applied.

104 After corrections for only two or the correction items, and assuming that actual test results confirm the sound power levels used, the predicted sound levels at the dwellings increase by 6 dB(A). Considering that B058 is a host, the predictions produce a marginally non-compliant outcome for three of the dwellings listed if the compliance targets remain at 40 dB(A) for non-host and 45 dB(A) for hosts. Compliance with a 40 dB(A) base noise target is found for B054 and B066.

105 However, in the event that high acoustic amenity is demonstrated then the predicted sound levels for B066, Bo54, B058, B122 and B366 are non-compliant.

106 The dwellings shown to be within a predicted sound level contour of 35 dB(A) or warrant a background noise assessment and possibly compliance checking post construction.

107 A revised assessment of the dwellings falling within the predicted 35 dB(A) noise contour is required to ensure that all relevant dwellings requiring a background survey have been correctly determined. However, this assessment is best done after a particular wind turbine variety has been chosen for construction.

108 The implications of these minor corrections to the noise model are significant when compliance margins are small. I note that the sound power levels provided by the manufacturers (without test results) for the larger 3+ MW wind turbines are similar, if not lower than those for the Senvion MM92 2MW wind turbine.

109 Compliance to a base noise target limit of 40 dB LA90 or LA95, as suggested in the SONUS Report could be achieved at most dwellings if there was confidence in the sound power level input to the noise model.

110 If, after testing the chosen wind turbine model destined for construction reveals higher sound power levels than the MM92 Senvion model, then non-compliance for a number of dwellings will be assured.

111 The predicted sound levels at the dwellings having noise agreements with the SHWF developers will also be higher and may not comply with the agreement noise targets.

COMPLIANCE TESTING

112 A noise compliance testing plan has yet to be prepared and approved. Such a plan will be dependent upon the outcome of this Application, however NZS6808:2010 outlines a methodology for such testing. I have recently reviewed a compliance assessment approach using on/off testing from the UK. The testing was done by setting all of the wind turbines on a wind farm to turn on and off at predetermined times throughout monitoring at noise sensitive locations.

113 Considering that the SONUS background noise monitoring report provides no background data for dwellings outside an optimistically predicted noise contour of 35 dB(A), it is likely that many more dwellings will require a compliance assessment if the Application is approved. Even more dwellings could require background and compliance testing if the wind turbine chosen for construction has higher sound power levels.

114 The compliance testing methodology from the UK (Green Cat Renewables) allows a compliance assessment and background set of measurements to be completed at the same time. This is done by setting the controls of the wind farm to periodically shut off and on the turbines across the wind farm each hour. The data gathered can then be sorted into on and off times to assess noise compliance.

115 Any wind farm is designed to allow for such start and stop conditions and the corresponding effect on grid supply. If such operational changes are problematic then the wind farm is not fit for purpose.

116 If the Application is approved or refused I recommend a compliance test methodology requiring such on/off testing to test compliance be included in a Noise Compliance Testing Plan, as already provisioned in NZS6808:2010 and referenced in the extant permit within condition 27.

117 Condition 27 already refers to NZS6808:2010, yet JACOBS are suggesting deletion of this condition. I do not believe that the simplistic statement by JACOBS, in support of its deletion, regarding more contemporary conditions is valid. In my opinion this condition should remain.

WIND SPEED DATA

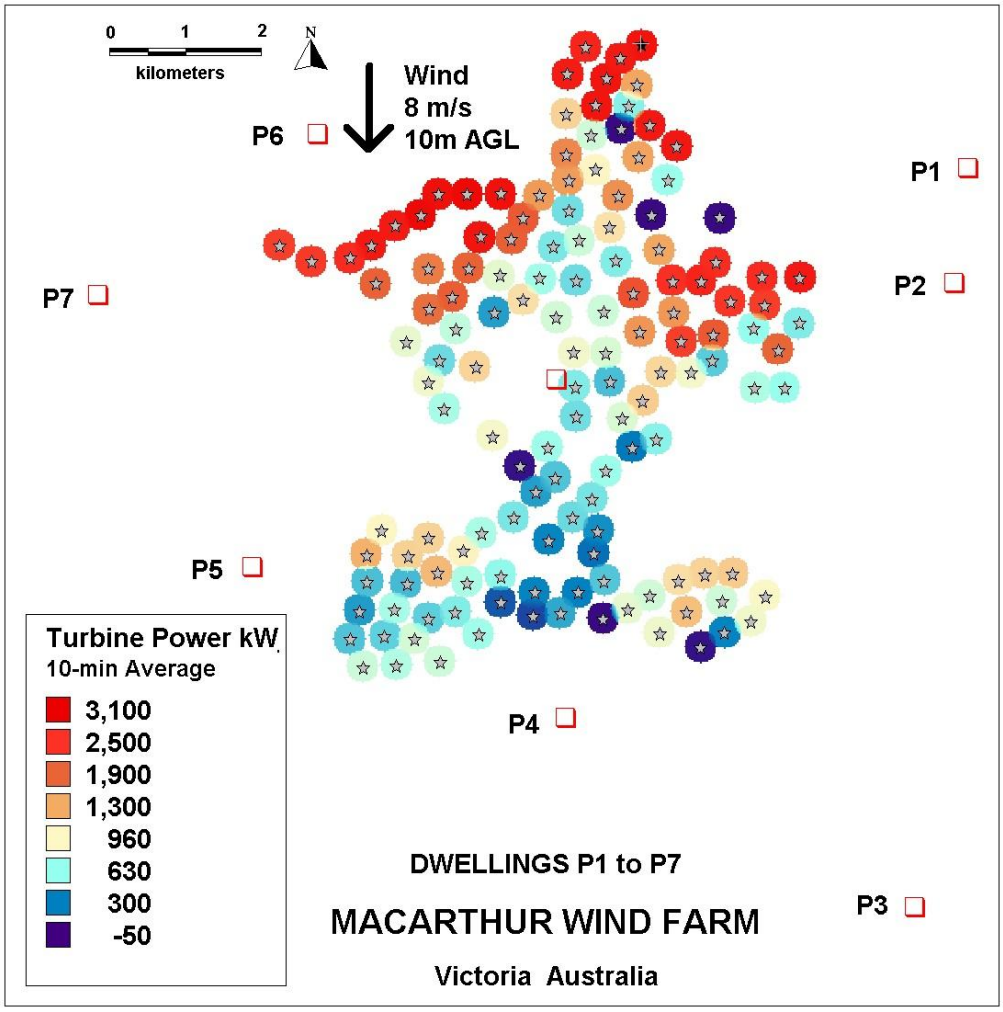
118 The SHWFis a large wind farm containing more wind turbines than the Macarthur Wind Farm.

119 It was found that the anemometers at the Macarthur Wind Farm were producing corrupted results after construction of the wind turbines due to the turbulence caused by the wakes from rotating blades. This eventuality has been addressed in the extant permit in condition 20(c).

120 With six anemometer masts around the Macarthur Wind Farm it was found that under certain wind directions the anemometers downwind of the wind turbines provided corrupted data. Gross errors arise in the scatter chart analysis when a wind blows across the wind farm to a receiver location unless wind speed data representative of turbines closest to the particular dwelling under investigation is used.

121 It is not appropriate to use wind speed data approaching the other side of a wind farm many km away for compliance testing at dwellings downwind of the turbines.

122 This image shows the effect of wakes at Macarthur on wind turbine power.



123 It is a requirement of the extant permit that anemometer masts at hub height be installed such that they are not influenced by wind turbine wakes. If this is not accomplished the wake influenced wind speeds can have adverse implications in compliance testing where accurate wind speed is required to produce reliable compliance scatter charts.

124 Each wind turbine has its own anemometer mounted on the nacelle. By default, the output is close to hub height, as required in the application of NZS6808. It is also possible to assess the TI for each wind turbine from these anemometers.

125 When testing noise compliance at a particular noise sensitive location, the wind speed data to use in a scatter chart must be obtained from the nearest wind turbines to the survey location. It may be necessary to take an average of wind speed data from, say, the five nearest wind turbines. In my opinion, this type of approach should be explored in a noise compliance testing plan.

126 Hub height wind speeds are required in NZS6808:2010 and the extant permit.

CONDITIONS

Condition 18

127 It is suggested by SONUS that condition 18(d) be removed because of the possibility of limited data sets stating that this is an impractical requirement. However, the approved background noise measurement plan prepared by SONUS describes a practical measurement and analysis methodology to comply with the condition. Lack of data in certain wind speed ranges can introduce greater uncertainty in results for the setting of noise targets at dwellings from background sound level measurements suggested in NZS6808:2010 (and the 1998 version) and the lack of data in a measurement exercise is dependent on nature to provide wind speeds covering the appropriate wind farm operating range. The extant conditions compensate for the requirement to assess noise in different wind quadrants by requiring a minimum of 4000 data points. If nature provides a limited data set then additional monitoring could be specified in the relevant background or compliance plans. The requirement for any such additional testing is informed by an appropriate analysis of uncertainty that is required in the extant permit but which is sought to be deleted in the Application.

128 The JACOBS report states on page 44: "The definition and calculation of uncertainty for background noise is not provided by any Standard or Jurisdiction in Australia." This is an interesting, narrow and a misleading statement since the PPGWEF refers to NZS6808:2010 and the 'Informative' Appendix C states: "It is good practice to state the uncertainty and confidence level for all sound levels determined in accordance with this Standard. Uncertainty should be determined in accordance with the procedures in Craven and Kerry (2001)". The Craven and Kerry reference is deficient in the assessment of uncertainty from low sample numbers but that can be obtained from Huson[4].

129 SONUS suggest that condition 18(e) does not provide adequate objectivity in the application of a penalty for special audible characteristics (SAC). However, a noise compliance testing plan has yet to be prepared and such a plan provides ample opportunity to refer to contemporary guidance from planning and there is no need to delete this condition.

[4] Huson, W Les, "Review of the application of NZS6808 to wind farms in Australia"., L Huson & Associates Pty Ltd, Victoria, Australia, published in proceedings of Acoustics 2006, Joint Conference of the NZ and Australia Acoustical Societies, Christchurch, November 2006.

130 With regard to SAC, the Planning Guidelines of Jan 2016 stipulates the following justification to alter the lower noise limit of 40 dB LA90(10min) in section 14b(ii): (underline added)

> ii. where special audible characteristics, including tonality, impulsive sound or amplitude modulation occur, <u>the noise limit will be modified</u> by applying a penalty of up to + 6 dB L90 in accordance with section 5.4 of the Standard;

131 This is in contrast to NZS6808:2010 which suggests that any SAC penalty is added to individual measurement results of operating wind farm noise, rather than the noise limit. I support the approach of PPGWEF, where it is the noise limit that is penalised, because SAC can be most noticeable and intrusive under certain circumstances and may, for example, last for many hours at night but not for the whole day. Adding a penalty to individual samples where SAC is observed for, say, 10% of evenings or nights will effectively dilute the penalty with little to no overall penalty being applied when a trend line average is drawn through more than a thousand samples.

132 The planning guideline does not alter the determination of the amount of penalty to apply (up to +6 dB LA90) in accordance with section 5.4 of NZS6808:2010, only to what the penalty is to be applied (the noise limit).

Condition 20

133 The effect of wake induced errors that can arise at a wind measurement mast is covered in the extant condition 20(c). The JACOBS report seeks to remove this condition by assuming that it relates only to a background noise survey that was completed in 2012, and that that survey was compliant with these conditions. However, this condition also refers to compliance issues after wind farm construction for compliance testing. Furthermore, the background survey completed in 2012 and reported on in Appendix Q of the Application did not comply with most of these conditions (anemometer measurements not taken at the new proposed hub height, no separation into Day and Night and wind direction quartiles, no estimate of uncertainty provided of the background noise measurements). The removal of condition 20 is unjustified.

Condition 19

134 Similarly, the JACOBS report suggests the removal of condition 19 on the basis that a background survey has been completed in 2012. However, the approved background noise monitoring plan was approved for the extant permitted wind turbine layout and hub height. It is not known if the new layout will have any adverse wind turbulence corruption effects on the anemometer masts used for the background survey or if the wind farm will be constructed

in stages by whatever entity finally owns the rights to construct the wind farm in the future (it is common for approved wind farms to be sold prior to construction).

135 It may become a requirement to prepare another background noise monitoring plan if construction is staged. Furthermore, the permitted wind farm was approved in 2010 and has yet to be constructed and the background survey data is already 5 years old. If the wind farm, in whatever final form it takes, is not constructed for another 7 years then one could question the validity and relevance of previously approved 12 year old background measurements. The removal of condition 19 is unjustified.

Condition 31 (Active Noise Management System)

136 No valid justification has been provided for the removal of this condition.

137 A number of reputable acoustics companies have systems available to implement such a system. One such system has been operating continuously at the Cotton Farm wind farm in the UK for the past four years.

138 The data is provided to authorised individuals via internet link in a browser to download noise data from Class 1/Type 1 approved measurement equipment in one third octave bands, being sampled at a rate of 10 samples per second.

139 Audio WAV files are also recorded and the system can assess special audible characteristics and overall A-weighted sound levels in statistics required from a permit (LA90 or LA95 in 10-minute samples, for example).

140 I see no need to delete this condition because it is a supplemental compliance assessment tool eminently suited to benefit any responsible authority charged with assessing compliance with noise limits. The system can also provide operational information from the wind farm SCADA system to provide the transparency that is so often lacking at wind farms currently operating in Victoria.

Condition changes due to contemporary guidance and legislation

141 All of the suggested condition improvements can simply be accommodated in the preparation of a noise modelling plan, noise compliance testing plan (including provision for an on/off testing plan) and an active noise management plan (Plans) that are all required to be prepared under the extant permit. They also all subject to approval by the Minister for Planning that can refer to specific guidance provided in current legislation and the PPGWEF.

142 The perceived deficiencies expressed by JACOBS and SONUS regarding the NZS6808:1998 standard compared to the latest 2010 version can simply be addressed by inclusion in these plans. For example, the Background Noise Measurement Plan prepared by SONUS successfully corrected the incorrect assumption that an acoustics consultant charged

with background noise measurement tasks had to be NATA approved. In another example, the background noise monitoring plan states: "The noise logging will collect both L95 and L90 data to enable comparison against the 1998 and 2010 versions of the New Zealand Standard, respectively".

143 Whilst the different Plans can add objectivity from current legislation and guidelines they must not diminish the intent of the extant conditions.

144 Only the issue of changing noise targets in the event that a high acoustic amenity is demonstrated would there be a requirement to change a condition of the extant permit.

145 However, if no high acoustic amenity can be demonstrated for this area then there is no need to change the noise target level conditions, or any other condition.

SUMMARY OF OPINIONS

146 It is not surprising that for a similar number of alternative wind turbines located in similar positions to those in the extant permit, each of which having similar, if not lower sound power levels to those already approved, that predicted noise levels by SONUS in the community will show similar results.

147 I am sceptical about the claimed sound power emissions from wind turbines generating power above 3.2MW having the slightly lower acoustic sound power output as a 2 MW wind turbine from the same manufacturer.

148 The estimated sound power outputs need test verification before they can be used to justify the requested Amendment outlined by JACOBS.

149 NZS6808:2010 imposes additional requirements and has objective assessments for SAC that were not in the 1998 version of this standard that was used for the current planning permit. However, those additional requirements can be included in Plans required to be prepared under the extant permit. This has already been done in the case of the approved background noise measurement plan.

150 The candidate wind turbine used for the Project may not be the final one chosen for the SHWF. Given that the SHWF development should be well advanced after seven years, it would have been appropriate to have completed a preliminary tender process to better define the candidate wind turbine(s).

151 It is my opinion that the Amendment should not be approved upon the estimated sound power outputs from wind turbine models, yet to go into production, that do not have test certificates.

152 It is appropriate to enquire of the developer if the IEC Class of the candidate wind turbines in the Application are suitable for the SHWF. If not, then it is my opinion that the Application is flawed and should be refused.

153 The Applicant is effectively requiring the Panel to decide upon an Application for an unspecified 'final choice' wind turbine that must have no tonal emission qualities with separation distances between the turbines that may not be appropriate or accepted by the manufacturer of the particular wind turbine design described in the Application. In my opinion the Application is premature and should be refused.

154 I have not had the opportunity to review any Noise Compliance Assessment Plan. Such a plan may not have been prepared. However, I have reviewed the approved background noise measurement plan and note that it fails to address the requirements to estimate uncertainty in the measurements, data analysis in wind quadrants and Day and Night periods.

155 It is my view that the background noise measurement plan must be reissued for approval after addressing all of the requirements in the extant permit.

156 In the event that there has been a Noise Compliance Assessment Plan prepared that relates to the current planning permit then it must be updated in a way to reflect the requirements of NZS6808:2010 and the latest PPGWEF before seeking approval. Any such plan must not diminish the force of any extant permit conditions. This requirement should be fundamental in the assessment of the Application that seeks to change so many extant permit conditions.

157 The Noise Compliance Assessment Plan must in my opinion reflect the penalty for SAC that should apply to target noise limits as described in the PPGWEF, January 2016.

158 In my opinion it appears that the extensive changes to the extant permit for the SHWF is an opportunistic attempt to undermine the efforts of the Panel that decided the comprehensive extant permit for this wind farm.

159 It is my opinion that the changes suggested in the Application will impose greater uncertainty, rather than less in the assessment of performance targets for noise from this wind farm.

160 The Panel may consider a Decision of the Hearing Commissioners in New Zealand regarding the application of NZS6808:2010 in relation to the Resource Management Act 1991 and the issue of high amenity areas made on 22 August 2016 that I believe is relevant to this Application.

161 Assessment of high acoustic amenity should be made using the objective method described in NZS6808:2010 section C5.3.1. If the Panel decides that the area surrounding the SHWF does not merit the category of high acoustic amenity then in my opinion there is no need to refer to this issue in a permit and the extant permit does not warrant the extensive permit condition changes sought in the Application.

162 The Informative Appendix C of NZS6808:2010 states that: "Where compliance or non-compliance is marginal and contested, steps should be taken to reduce the uncertainty, where practical"

163 It is my opinion that practical steps can be taken to reduce the uncertainty in noise modelling by applying factors and corrections described in the following.

164 The addition of a correction of +2 dB(A) to sound power levels used as input to a specific noise model to account for TI and wake effects can improve the accuracy of the model for the scale of turbines allowed in the extant permit.

165 For consistency, it is my opinion after checking model results with the CONCAWE model used in the Application that the specific noise model to use for ongoing assessments is that used by MDA in the initial permit application in 2010 (this is my preferred noise model).

166 I agree with SONUS that the ISO9613-2 noise model has limitations and that the predictions provided by MDA show how this noise model can be adjusted to show an apparent 3 dB(A) improvement in predicted noise levels in the community, when no such benefits exist.

167 If optimistic sound power levels are used for the wind turbines in the noise model then optimistic predicted noise levels will result. Correction factors can be applied to my preferred noise model to allow for increased wind shear and turbulence intensity that will be caused by the increase in rotor area and hub height and the reduced effective separation distance of the new layout that is described in the Application.

168 Correction to account for an increase in wind turbine sound power levels due to increased wind shear and turbulence intensity is consistent with NZS6808:2010 and I suggest that a correction factor to address this issue is an increase in the sound power input to my preferred noise model of 2 dB(A) overall or 5 dB(A) in each one third or octave band sound power level, derived from IEC61400-11 measurement test results, applying from 315 Hz and lower frequencies. These corrections for TI and wind shear are applicable to the size of wind turbine in the extant permit.

169 Because of increased wind shear and TI for the larger wind turbines, being the subject of the Application, it is my opinion that the correction to the sound power levels should be 4 dB(A) overall or 7 dB(A) in each one third or octave band at 315 Hz and lower frequencies.

170 In my opinion an added correction shall be applied to IEC61400-11sound power test results of 2 dB(A) in each octave or one third octave test results to account for measurement uncertainty in IEC61400-11 (as supported by MDA in their peer review) and the fact that a single production sample result may not be truly representative of a batch of over 150 wind turbines for the SHWF.

171 I recommend that my preferred noise model with corrections must be rerun to determine any additional dwelling that may require background noise monitoring inside the 35 dB(A) noise contour for the chosen wind turbine model that will be constructed.

172 It is my opinion, in the interest of openness and fairness for the Community, that there should be a requirement allowing for any public independent review of noise compliance reports, and the free supply of any data used to prepare those reports.

173 A similar public independent review of any proposed noise compliance testing plan should also be available. This requirement can be included in the approved Plans under the extant permit and does not require a separate permit condition.

174 It is my opinion that any noise compliance testing plan or changes to a permit condition must not undermine or diminish any extant permit conditions.

175 Compliance assessment of the SHWF should in my opinion be specified to be use on / off testing. A method described in a recent compliance assessment from the UK (Green Cat Renewables) would be appropriate and this will further reduce uncertainty in compliance testing and can also be used to determine background levels. If this approach is used for background testing then a suitable modification to the background noise monitoring plan will be required.

176 Wind farm tonal and amplitude modulation (SAC) objective assessment methodologies from NZS6808:2010 require reference in the noise compliance testing plan. A subjective assessment of SAC should not be allowed. No change to the extant permit is required to achieve this outcome.

177 In my opinion the application of penalties of up to 6 dB(A) total must be applied to the target compliance sound levels in accordance with the PPGWEF, not to the individual measurement data as described in NZS6808:2010.

178 If wind speed data from one or more site anemometers providuce turbulence corrupted data after the SHWF becomes operational. I advise that any wind speed

measurements used for noise compliance purposes are calculated from the wind turbines nearest to the noise compliance monitoring point. This may require the averaging of wind speed related data from a number of the nearest wind turbines. However, this problem may not arise if condition 20(c) of the extant permit is complied with.

179 It is my opinion that after account is properly made of the changes requested in wind turbine size and changed layout, described in the Application, that noise emissions will increase compared to the permitted example Senvion MM92 wind turbine.

180 I cannot support the predictions made by SONUS in the Application since the sound power levels of the candidate wind turbines used in the predictions are not derived from test results of the actual turbine models. Even if the sound power levels turn out to be representative of the final wind turbine choice for the SHWF they are underestimated by at least 6 dB(A) and in my opinion will give rise to non-compliance at some dwellings.

181 I recommend that a revised noise model is run (rather than CONCAWE) using the corrections suggested for the preferred noise model to assess the extent of possible non-compliances.

DOCUMENTS REFERENCED

182 In addition to the references fully described in this Statement, the following documents have been referenced and used to assist in preparing the opinions described in this Statement.

183 Bass, J. H., Bullmore, A. J., Sloth, E. (1998) “Development of a wind farm noise propagation prediction model – Final Report” Joule III Contract JOR3-CT95-0051Jan 1996 to May 1998.

184 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

185 Green Cat Renewables (2015) “Ark Hill Wind Farm – Noise Assessment – compliance report

186 Huson, W Les, “Review of the application of NZS6808 to wind farms in Australia”., L Huson & Associates Pty Ltd, Victoria, Australia, published in proceedings of Acoustics 2006, Joint Conference of the NZ and Australia Acoustical Societies, Christchurch, November 2006.

187 International Electrotechnical Committee, “IEC 61400-11:2002, WIND TURBINE GENERATOR SYSTEMS – Part 11: Acoustic noise measurement techniques”

188 ISO 9613 Acoustics – Attenuation of sound during propagation outdoors
Part 1:1993 Calculation of the absorption of sound by the atmosphere
Part 2:1996 General method of calculation

189 New Zealand Standards, "NZS6808 : 1998, Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators"

190 New Zealand Standards, "NZS6808 : 2010, Acoustics – Wind farm noise"

191 Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria, 2016

DECLARATION

192 I have made all the enquiries that I believe are desirable and appropriate and no matters of significance which I regard as relevant have to my knowledge been withheld from the Panel.

William Leslie Huson 29 January 2017

APPENDIX

Source: (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

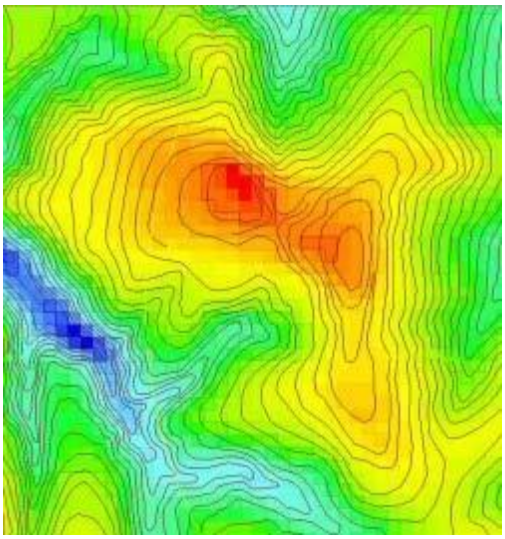
The wind resource is the most obvious factor to concentrate on when choosing a wind turbine location. We have a wide range of options to determine the wind resource of the site. The quality of the tools varies significantly and so does their price.

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.

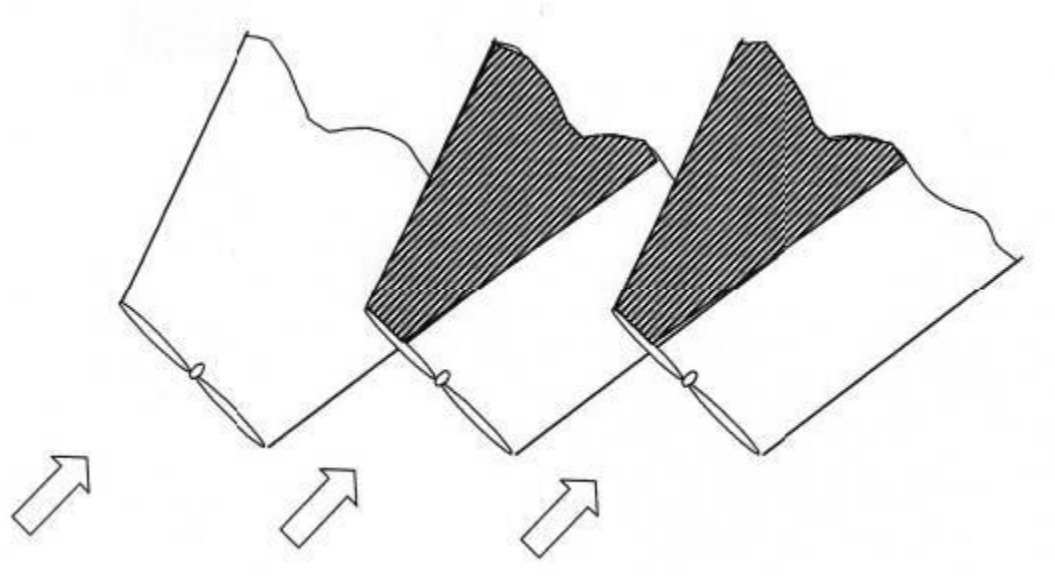


Figure 1: Shadowing in wind farm

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.

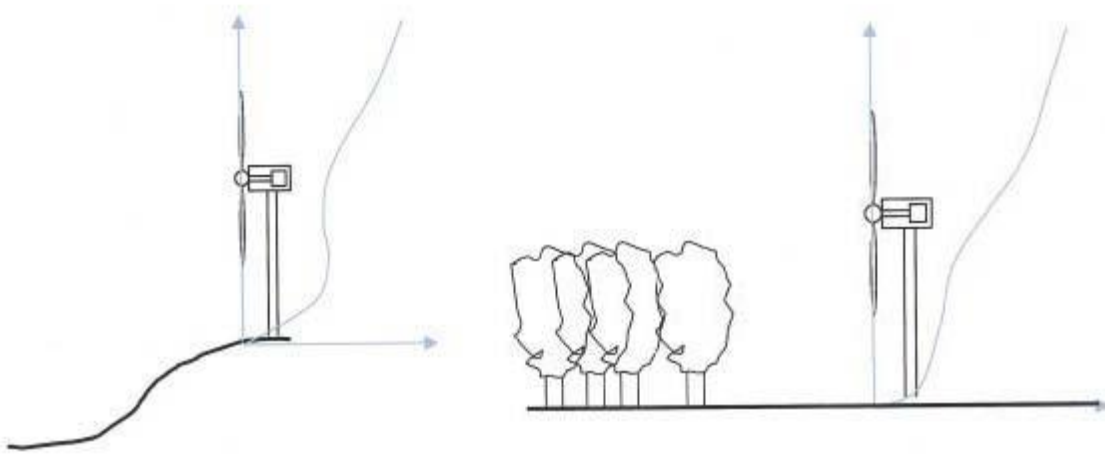


Figure 2: Distorted wind profile at steep slope (left) and behind a forest (right)

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.

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