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Voice for Walcha

(by email to: us@voiceforwalcha.com)
Our Reference: L451/Let1/WLH

17 January 2023

Re: Winterbourne Wind Farm Noise Assessment – Peer Review

L Huson & Associates Pty Ltd has been commissioned by the Voice for Walcha to peer review the Winterbourne Wind Farm Noise and Vibration Assessment (NVA), report reference S6207C14 dated October 2022 that was prepared by Sonus Pty Ltd. The NVA is included in the Environmental Impact Statement (EIS) dated 27 October 2022 as Appendix H that was prepared by Environmental Resources Management Australia Pty Ltd. Section 6.2 of the EIS summarises the NVA.

This peer review considers the assessment of predicted operational wind farm noise and compliance with the NSW Secretary's Environmental Assessment Requirements (SEAR) in this regard for the EIS.

In the absence of a peer review being included in the EIS then this independent peer review of the noise assessment reports within the EIS may be considered in lieu.

The SEAR lists the following that are relevant to this review that must be included in the EIS:

- an assessment of the likely impacts of the development on the environment, focusing on the specific issues identified below, including:
    - a description of the existing environment likely to be affected by the development using sufficient baseline data;
    - an assessment of the likely impacts of all stages of the development (including cumulative impacts of the development with existing and proposed developments in the region), taking into consideration any relevant State and Commonwealth legislation, environmental planning instruments, guidelines, policies, plans and industry codes of practice and including the NSW Wind Energy Guideline for State Significant Wind Energy Development (2016);
    - a description of the measures that would be implemented to avoid, mitigate and/or offset residual impacts of the development and the likely effectiveness of these measures, including details of consultation with any affected non- associated landowners in relation to the development of mitigation measures, and any negotiated agreements with these landowners; and
    - a description of the measures that would be implemented to monitor and report on the environmental performance of the development, including adaptive management strategies and contingency measures to address residual impacts

In particular, for **Noise and Vibration** – the EIS must:

- assess wind turbine noise in accordance with the NSW Wind Energy: Noise Assessment Bulletin (EPA/DPE, 2016);
- assess noise generated by ancillary infrastructure in accordance with the NSW Noise Policy for Industry (EPA, 2017);

- assess construction noise under the Interim Construction Noise Guideline (DECC, 2009);
- assess traffic noise under the NSW Road Noise Policy (DECCW, 2011); and
- assess vibration under the Assessing Vibration: A Technical Guideline (DECC, 2006); and
- assess the noise impacts on amenity / recreational use of the Oxley Wild Rivers National Park (including walking tracks, campgrounds and lookouts) considering the NSW Noise Policy for Industry (EPA, 2017).

The NSW Wind Energy Guideline for State Significant Wind Energy Development (2016) refers to the guideline Bulletin (EPA/DPE, 2016);, as follows:

> 'To ensure an adequate assessment of potential noise impacts, the Department has developed a Noise Assessment Bulletin' and notes that the EIS must include 'completed technical studies, including an accurate noise impact assessment for relevant dwellings undertaken consistent with the requirements of the Noise Assessment Bulletin'.

The Noise Bulletin (EPA/DPE, 2016), in turn, refers to a South Australia EPA Guideline, as follows:

> 'The NSW Government has adopted the 2009 South Australian document *Wind farms – environmental noise guidelines* (SA 2009). SA 2009 will form the basis of the regulatory noise standard and assessment methodology that will apply when SSD wind energy proponents are assessed and determined in NSW. Adopting SA 2009 will facilitate increased regulatory consistency between states and result in consistent standards applying to significant areas of Australia with high quality accessible wind resources.'

The SA 2009 guideline had an update in November 2021, yet the document has retained the same ISBN number, and the original guideline has been withdrawn. The most recent SA 2009 of November 2021 was issued before the NVA was prepared by Sonus, dated October 2022 and the EIS dated October 2022 that should have reflected the requirements of the updated SA 2009.

In summary, an accurate noise impact assessment in accordance with the Noise Bulletin is required for an EIS and detail is required of any negotiated agreements. SA 2009 is the regulatory noise standard and assessment methodology that will apply when SSD wind energy proponents are assessed and determined in NSW. SA 2009 has a section dealing with negotiated agreements with wind farm developers and notes that:

> 'The criteria have been developed to minimise the impact on the amenity of premises that do not have an agreement with wind farm developers. Notwithstanding this, the EPA cannot ignore noise impacts on the basis that an agreement has been made between the developer and the landowner. Developers cannot absolve themselves of their obligations under the EP Act by entering into an agreement with a landowner.
> If it can be demonstrated that a development is having an 'adverse effect on an amenity value of an area that … unreasonably interferes with the enjoyment of the area', then appropriate action can be taken under the EP Act.'

In a recent decision of the Victorian Supreme Court in *Uren v Bald Hills Wind Farm Pty Ltd* [2022] VSC 145 (**Uren**) it was found that noise nuisance (unreasonable interference) could still apply even if a wind farm development complied with noise limits imposed through the planning process.

Negotiated Agreements

I have been unable to find any example of negotiated agreements for noise in the EIS that would inform the consideration of adequate noise protection for associated/involved landowners.

The EIS does not explain how any adverse noise impacts have been addressed in the agreements or if there is adequate protection from, for example, adverse health effects that can be caused by noise.

The EIS relies upon the NVA, October 2022 referenced as report S62407C14 prepared by Sonus Pty Ltd in regard to negotiated agreements variously, as follows:

> **Definition**
>
> "Involved dwelling — Any dwelling where the landowner has reached a financial or in kind agreement in relation to the wind farm (except where the agreement excludes noise impacts)."
>
> **NVA section 3.3**
>
> "The noise criteria at involved dwellings have not been specified and therefore this report provides predicted noise levels at the involved residences, but does not consider objective criteria."
>
> **NVA section 4.1**
>
> "Preference was given to dwellings with the highest predicted noise levels in each direction of the wind farm and without agreement at the time of the monitoring, subject to permission being granted by the landowner to place equipment."

Section 3.2.2 of the EIS lists Associated/Involved dwelling owners that have entered into an agreement in relation to the proposed wind farm development.

Negotiated agreements that are in place could be supplied to the EPA for consideration. Confidentiality considerations should not prevent proper evaluation because the names of property owners can be redacted.

Completeness of the proposed development

Section 11 of the NVA advises that the turbine layout, wind turbine model, ancillary infrastructure may all be changed.

The NVA and EIS is effectively outlining a preliminary development that may meet the requirements of the SEAR. The EIS appears in reality to be a scoping study rather than an accurate noise impact assessment.

It is inconsistent for an EIS, that *must* include 'completed technical studies, including an accurate noise impact assessment for relevant dwellings undertaken consistent with the requirements of the Noise Assessment Bulletin', to state that the wind turbine layout, the turbine type, the consideration of other matters such as tonality, low frequency noise and sound power levels can all change and are issues that will be considered *after* approval of the EIS.

Candidate Wind Turbine

The planning assessment process adds a 5 dB penalty to noise model predictions if there are tonal emissions from the wind turbine type proposed. However, the Bulletin only consider particular 10-minute intervals within a compliance survey period that are weighted by the 5 dB penalty. This approach to noise compliance testing for tonal penalty is much less stringent than the approach intended at the planning stage.

Tonal audibility test results have not been provided in the EIS. The lack of tonal audibility test results effectively undermines the community protection objectives within the planning process. It is not possible to infer tonality from one-third octave manufacturer's specification.

The manufacturer must provide test results in accordance with IEC61400-11 to assess the potential for tones from the candidate wind turbine.

If such test data is not forthcoming then as a precaution it would be appropriate to add the 5 dB penalty weighting to noise model predictions that is required in SA 2009.

No detail has been provided on how the specifications were derived. If the specifications relate only to aerodynamic noise calculations, then nacelle sound sources that are primarily the cause of observed tones in practice will not have been included.

A particular wind turbine candidate has been named in the NVA. A total sound power level of 104.8 dB(A) has been assumed for a wind turbine that would comply with the dimensional constraints in the EIS. However, other wind turbines in the Vestas EnVentus platform range also meet the dimensional limit of a maximum tip height of 250m. With a hub height of 150m suggested in the NVA this would allow a rotor diameter up to 200m.

The Vestas EnVentus platform consists of a V150, V162 and V172 that have rotor diameters of 150m, 162m and 172m respectively. The V162-6.2MW wind turbine has been suggested as a candidate in the NVA. The V162-6.2MW wind turbine has a quoted sound power maximum of 104.8 dB(A) but all of the other wind turbines in the EnVentus range have higher sound power levels with the V172-7.2MW wind turbine having a quoted maximum sound power of 106.9 dB(A). This is 2.1 dB higher than the sound power used for a noise model input in the NVA.

If Winterbourne Wind wish to confirm that the V162-6.2MW wind turbine will be used then there would be no reason to assume that the sound power values used by Sonus in their noise model should be higher to reflect that from the V172.

Furthermore, the V162-6.2MW wind turbine does not have a published tower height option of 150m, as assumed in the NVA. However, the V172-7.2MW wind turbine does have a tower height option of 150m (hub height). https://nozebra.ipapercms.dk/Vestas/Communication/Productbrochure/enventus/enventus-platform-brochure/

The sound power levels used in noise predictions are based upon manufacturer's specifications rather than independent test results. Neither tonal audibility nor test uncertainty results have been offered for the candidate turbine.

SA 2009 states that "Noise propagation model and parameters as recommended in section 4.3 of the Institute of Acoustics *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise* (May 2013) may be utilised as an alternative to the above input parameters". This section 4.3 only refers to alternative parameters that could be used in an ISO9613-2 noise model and not CONCAWE that is used in the NVA. However, section 4.3 does advise on the consideration of appropriate sound power to use in any noise model where IEC61400-11 test results are unavailable. It is recommended that if only manufacturer's specifications are available that an uncertainty of 2 dB should be added to the sound power levels before use in a noise model prediction.

Without any commitment by Winterbourne Wind that the installed wind turbine will be the V162-6.2MW then the sound power levels used in the NVA should reflect the largest wind turbine option that could be installed by Vestas (106.9 dB(A)) plus an uncertainty value of +2dB. The total sound power level that should have been used in the NVA is therefore 108.9 dB(A), rather than 104.8 dB(A).

It is well understood that site effects can alter sound power levels from a wind turbine. IEC61400-11 test measurements are taken in optimal controlled conditions requiring minimal inflow turbulence to the rotor due to increased noise caused by inflow turbulence. This requirement is found in IEC61400-11.

IEC61400-11 test results invariably show an increase in sound power with increasing wind speed up to a point where rated electrical power generation is achieved. Under the test conditions of IEC61400-11 the sound power results plateau and do not increase further. However, site effects can alter this plateau and sound power levels can continue to increase above the rated electrical power of the wind turbine.

Proximity considerations of wind turbines to each other, locations near ridges and general topography are considered to be 'site effects' that can increase noise emissions above those measured using IEC61400-11. No consideration has been given to site effects so any noise model using sound power levels for a single wind turbine should be considered to be optimistic rather than conservative.

A description of site effects has been provided by an engineer from the wind turbine manufacturer Suzlon that is attached to this review as Appendix A.

CONCAWE Noise Model

SA 2009 accepts the use of the CONCAWE noise model. With the recent update to SA 2009 the required minimum range of wind farm predictions now covers the octave band frequencies from 31.5Hz to 4,000Hz rather than the previous 63Hz to 4,000Hz. Unfortunately, CONCAWE is an empirical noise model with verified propagation data covering only 63Hz to 4,000Hz octave bands. Similarly, the ISO9613-2 noise model, that is also acceptable for use in SA 2009, also has a lower octave band limit of 63 Hz.

Considering these limitations of CONCAWE and ISO9613-2 it is probably a typographic error in the updated SA 2009 that changed the lower frequency noise model requirement from 63 Hz to 31.5 Hz.

A worked example calculation from CONCAWE is shown below:

DESCRIPTION			dB(A)	Octave Band Centre Frequency, Hz						
				63	125	250	500	1k	2k	4k
Plant Sound Power Level		L_W	118	127	123	120	113	111	112	108
Directivity	(Omnidirectional source)	D		0	0	0	0	0	0	0
Geometrical Spreading	(d = 500 m)	K_1		65	65	65	65	65	65	65
Atmospheric Attenuation	(Temperature = 10 deg C, Humidity = 75%)	K_2		0	0	0	1	2	3	10
Ground Effects	(Figure 1)	K_3		0	5.5	11	8	4.5	2.5	1.5
Meteorological Correction	(Vector wind speed + 2 m/s Pasquill Stability Factor D, Category 5)	K_4		−1	−2.5	−3.5	−4	−4.5	−3	−4
Source Height Correction	(Source at 1.5m)	K_5		0	0	0	0	0	0	0
Barrier Attenuation	(3m high wall, 10m from source)	K_6	·	5	6	7	10	11	14	17
		ΣK		69	74	79.5	80	78	81.5	89.5
		L_P	40	58	49	40.5	33	33	30.5	18.5

Worked Example 1 Referred to in Section 5.3

The calculation starts with the sound power of a sound source (L_W), considers the directivity of the sound source, if any, and then applies propagation attenuation values K1, K2, K3, K4,K5 and K6 that have been determined from empirically determined formulae. The K6 barrier attenuation correction accounts for physical barriers or in-plant screening within a factory, for example. The K6 propagation correction is **not** to be applied for topographical features (CONCAWE section 5.1.6).

The CONCAWE noise model can be implemented in a spreadsheet to calculate sound pressure levels at dwelling locations surrounding a wind farm and I have done this for the Winterbourne Wind Farm at a number or sample dwellings (SR109, SR240 and SR272) as a check against the predictions in the NVA.

Two sets of calculation have been done, one where there is 100% soft ground (G=100%), as used in the NVA and with hard ground (G=0%) as required in the SA2009 guidelines for a conservative modelling approach.

The following table compares the results using CONCAWE with a spreadsheet implementing the model formulae (LHA) compared to results produced by Sonus using a SoundPlan implementation of CONCAWE. Sound power levels from the NVA at 11m/s hub height wind speed have been used together with wind turbine coordinates presented in Table 1 of the NVA.

Dwelling ID	Sonus using G=100% dB(A)	LHA using G=100% dB(A)	LHA using G=0% dB(A)
SR109	34	36.6	44
SR240	37	39.4	46.5
SR272	35	37	44.4

Predicted sound levels in the NVA are rounded to integer values and when comparing the results, it shows that the SoundPlan implementation of CONCAWE for 100% soft ground is approximately 2 dB lower than a strict implementation of CONCAWE. A clue to this discrepancy is that the NVA states that topographic barrier attenuation has been limited in the SoundPlan implementation of CONCAWE to a maximum of 2 dB.

CONCAWE *requires* that the K6 attenuation term for barrier attenuation must not be applied for topographic features and it might be that SoundPlan has incorrectly applied the K6 attenuation term.

Another interesting result arises from the use of hard ground (G=0%), as required in SA 2009, compared to 100% soft ground (G=100%) used in the NVA. The use of hard ground increases the predicted sound level by some 7dB.

A paper presented by the author of SoundPlan (Berndt, A. “Uncertainties in Environmental Noise Modeling”. Proc. ACOUSTICS 2004, Gold Coast, Australia) explains that most of the propagation noise models used today were designed decades ago when hand calculations were the norm (eg. CONCAWE, 1981). The paper explains that interpretation is often required in the computer implementation of a number of standards such as ISO9613-2 and CONCAWE. It is therefore understandable that strict calculations using a standard can produce different results to a computer-based implementation. The SoundPlan manual explains that the software has made some assumptions to extend its implementation of CONCAWE down to 31.5Hz. Strictly, CONCAWE is limited to 63Hz as there are no empirical equations for any other octave band below 63Hz so this modification should be considered inconsistent with CONCAWE.

Other ill-defined modifications to standards can be found in software implementations. For example, CONCAWE explains that sound propagation across a valley or from a hill can increase sound propagated to a dwelling (receiver) by up to 3 dB: "When propagation is to a receiver located on a hillside, or across a valley floor, the value of K5 should be reduced by up to 3 dB to account for multiple reflections from the hillside". How SoundPlan has or has not implemented this aspect of CONCAWE is unknown but there are cases where dwellings are located below sound sources (wind turbines) that are on a hillside surrounding the Winterbourne Wind Farm.

The calculations provided for the three dwellings in the table above by LHA have not accounted for this 'valley effect' that, if applied, could increase the predicted sound level at the chosen three dwellings by up to an additional 3 dB.

In summary, if a strict application of CONCAWE is implemented using hard ground, as required by SA 2009, then the sound levels predicted by Sonus in the NVA are approximately 10 dB too low. This assumes that the correct sound power was used for input to the noise models. However, as discussed above, a possible wind turbine candidate could be the V172-7.2MW wind turbine and with a correction for uncertainty of +2dB the sound power compared to that used in the NVA would be some 4 dB higher and overall predicted levels in the NVA would be a total of 14 dB too low.

For cases where the 'valley effect' applies the NVA predictions at surrounding dwellings are between 14dB and 17dB too low.

Predicting dB(C) using CONCAWE - Low frequency noise

Low frequency noise predictions of dB(C) levels should be re-calculated with the correct ground absorption factor required in SA 2009 of G=0. However, both ISO9613-2 and CONCAWE do not calculate sound levels below the 63 Hz octave band so these models should not be used to predict dB(C) sound levels in the community.

A noise model that can predict dB(C) sound levels is found in section 1.4 of the Danish Statutory Order on Noise from Windfarms no. 1284, that calculates sound propagation in one-third octave bands from 10 Hz to 160 Hz. These calculations can then complement the missing octave bands below 63 Hz when using CONCAWE or ISO9613-2.

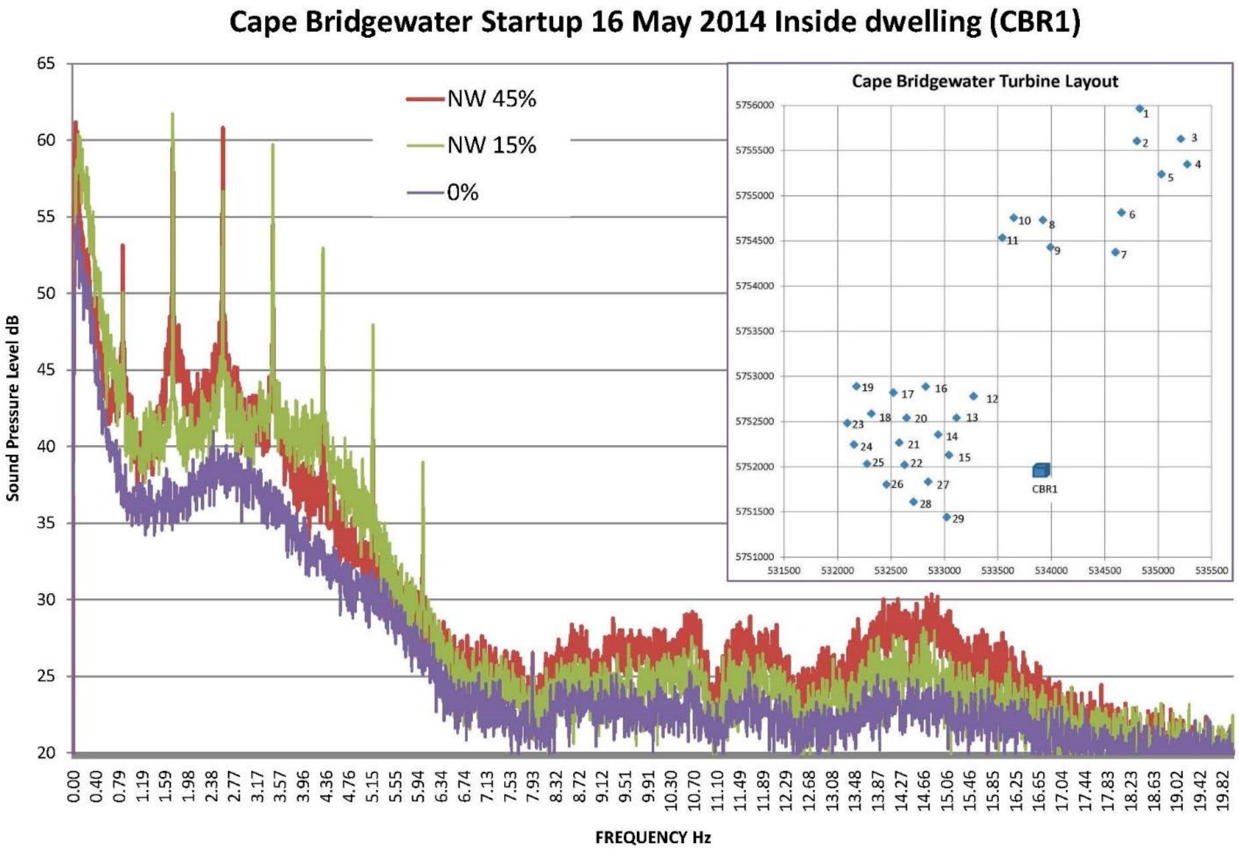
Infrasound

The SA2009 guideline mentions infrasound but considers wind farm generated infrasound to be of no concern. Unfortunately, the references used to prepare the SA2009 guideline (updated in 2021) only considered out of date information up to 2015. For example, the NHMRC reference in SA2009 is dated 2015 but after that time the NHMRC commissioned an extensive study into the health effects caused by infrasound from wind turbines to the value of $3,300,000, awarded to the University of NSW and Flinders University. This research is ongoing and one of the published papers in 2019 by researchers at Flinders University (Nguyen, D. P., Hansen, K. et al. Wind farm infrasound detectability and its effects on the perception of wind farm noise amplitude modulation, Acoustics 2019) stated in its conclusions that: "Overall these preliminary results suggest that WF noise complaints could potentially be governed to some degree by the presence of infrasound" and that " We found that self-reported noise sensitive individuals can detect the presence of low-level infrasound (48 ± 2 dB(G)) above chance."

The finding that infrasound at levels of 48 +/- 2 dB(G) can be observed by individuals is in stark contrast to the older research referenced in SA2009 which suggest that a conservative human perception threshold of 85 dB(G) might be appropriate to account for variations in sensitivity of human hearing.

The following chart from Huson(2015)[1] was obtained from a wind farm start-up to different percentage electrical generating levels of the wind farm (eg. NW 15% means 15% electrical generation in NW wind).

It is clear that infrasound below 6 Hz increases by over 20 dB after the wind farm starts to operate. The suggestions in section 2.6 of the updated SA 2009 regarding comparative studies are misplaced. The issue of adverse health effects from wind farm generated infrasound remains contentious.



Construction and Ancillary Equipment noise predictions

The NVA explains that CONCAWE was used to predict construction noise and ancillary equipment noise impacts.

The sound power data used in the NVA are plausible but the limitations on the accuracy of CONCAWE described above can also be applied to construction and ancillary equipment noise predictions.

The NVA predicts that construction noise can be problematic for some non-associated residents but fails to assess the impact upon associated residents, despite a proposed batching plant intended to be located next to an associated dwelling.

Uncertainty

Uncertainty of predicted noise impacts associated with the detailed design changes that may occur in the EIS have not been provided. For example, there has been no consideration in the EIS for different candidate WTG, layout, site effects, possible tonality and low frequency noise or noise model uncertainty.

[1] Huson, W.L. "Stationary wind turbine infrasound emissions and propagation loss measurements" 6th International Conference on Wind Turbine Noise, Glasgow 2015

A full assessment of the effect of all detailed design changes that may be considered by the proponent should be addressed in the EIS. This is a requirement from Section 5.1(9) of SA 2009.

An EIS must address all of these possible changes before any EIS is evaluated by the responsible authorities. If the changes suggested are not considered in the EIS, perhaps with a sensitivity analysis of the possible changes, then the EIS is deficient and incomplete.

Noise compliance testing after commissioning is proposed in the NVA to ensure that target noise limits will be met. If such testing shows an exceedance of target noise limits then the NVA suggests that an operating strategy will be prepared in which particular wind turbines could be operated in noise reduction mode.

The objective behind an EIS using the SA 2009 guideline is to provide a conservative impact assessment that should assure compliance with target noise limits. The SA 2009 states that: "A conservative approach should be used for predicting wind farm noise …".

Contractual obligations between a wind farm owner/operator and the wind turbine supplier are often useful in ensuring compliance with noise limits and ensuring adherence to maximum sound power outputs from installed wind turbines. Unfortunately, in the case where the supplier of the wind turbines is also the owner of the wind farm such a contingency option will not be available. Furthermore, contractual obligations such as these are outside the remit of the planning authority.

A conservative noise prediction for all aspects of the construction and operation of the Winterbourne Wind Farm should ensure that only rare unintended mechanical failures, maintenance problems or poor construction activity scheduling will be the only cases where non-compliance with target noise limits occur.

Detailed review of EIS Appendix H (Sonus NVA Report)

Background Noise Measurements

Accurate determination of background noise levels is fundamental to setting target noise limits that the developed wind farm must meet.

Wind Speed

The wind speed measurements must comply with the uncertainty requirements of SA 2009 at hub height and the uncertainty associated with the derived wind speed to hub height calculated by Winterbourne Wind from the four met masts should be included in the EIS.

Background noise measurements must be correlated to wind speed across the wind farm site. SA 2009 notes that wind speed measurement locations must be determined, as follows:

> **Measurement location**
> The same location should be used for measuring wind speed and direction for all of the following procedures:
> • background noise measurements,
> • noise predictions,
> • compliance checking.

> Therefore the wind speed measurement location at the wind farm site should not:
> • be significantly affected by the operation of the WTGs in their final location,
> • provide lower wind speed results than other locations on the wind farm site, where those locations will house WTGs that affect the noise level at a relevant receiver.
>
> For large or topographically diverse wind farm sites, the suitability of the wind speed measurement location may need to be confirmed as part of the development assessment process.

The four temporary met masts used in the Background analysis report are next to the location of proposed wind turbines. The nearest wind turbine to the four met masts are as follows: Walcha Mast, 346m; Mast 1, 267m; Mast 2, 157m and Mast 3, 64m. Wind speed data from these locations are unsuitable for background measurement purposes since the location will subsequently be affected by operation of the proposed nearby wind turbines. An alternative temporary mast location should have been chosen that will not be subject to influence from any future turbine.

As the Winterbourne wind farm is large and topographically diverse, the suitability of just four temporary met masts for use in Background data reporting should have been justified in the EIS. The EIS, pages 52 to 55, show the locations of the installed wind speed met masts and the location of future permanent met masts. The distance between the nearest proposed permanent met mast to the nearest installed met Mast 3 is approximately 2.4 km.

The EIS/NVA should explain how wind speed for compliance checking is to be collected after the temporary installed met masts are removed.

Windflow modelling across the wind farm could have been included in the EIS to support the use of the four met masts for the analysis of background survey data. For example, if the nearest met mast to a background survey location is not representative of the hub height wind speed expected across the nearest wind turbines to the background survey location, then an additional uncertainty is introduced into the analysis of background data.

SA 2009 states:

> Evidence that the wind speed and direction sensor is certified for the accurate determination of wind parameters is to be supplied as a part of the application. Accuracy of the wind speed measurements should be ±0.5 m/s, and wind direction measurements ±3º or better.

The location for the met mast supplying data used in the NVA needs to be checked and evidence supplied regarding the accuracy of the measurements, including the uncertainty in the method used to determine hub height wind speeds.

Clarification is required about the suitability of locating the four met masts given the proximity of wind turbines that shows probable adverse turbulence influence on the met mast shown in EIS figures.

Explanation is also required that the met mast locations meet the SA 2009 requirement that ‘the wind speed measurement location at the wind farm site should not .. provide lower wind speed results than other locations on the wind farm site, where those locations will house WTGs that affect the noise level at a relevant receiver.’ Windflow analysis results such as those described in Appendix A could assist in this regard.

Background analysis has been limited to 12 m/s but SA 2009 requires background data to cover all wind speeds in which the turbines can operate, which is from cut-in to cut-out (for Vestas candidate wind turbines this is 3m/s to 25 m/s at hub height).

Background measurement equipment

SA 2009 states:

> *Equipment*
> Background noise levels should be collected for continuous 10-minute intervals using sound level meters or loggers of at least Class 2 certification in accordance with Standard AS IEC−61672. The lower limit of the instrument measurement range must be chosen to provide accurate measurements which might be limited by the noise floor of the data acquisition device.

Sonus used Rion Class 2 sound level meter loggers. The type of sound level meter used and the corresponding serial numbers or calibration details are not provided in the NVA although Sonus have regularly use Rion NL-21 sound level meters fitted with UC-52 microphones for other similar projects.

The *measurement range* over which the sound level meters comply with AS IEC-61672 is not stated in the NVA but Rion specifies the measurement range of the NL-21 to be a minimum of 28 dB(A). The lower measurement level compliant with AS IEC-61672 is generally 10 dB above the noise floor of the sound level meter and microphone combination. Sonus state that the noise floor of the sound level meters is less than 20 dB(A).

Rion state that the noise floor of the sound level meter, without microphone, is "22 dB(A) or less (typically 19 dB(A))". However, the NL-21 is normally fitted with a UC-52 microphone that Rion state has an inherent noise level of 24 dB(A). This would suggest that the measurement range providing accurate results in compliance with AS IEC61672 is above 34 dB, although Sonus have not specified the actual lower measurement range of the sound level meter and microphone combination that complies with AS IEC61672.

The effect of this equipment limitation is that if the Background sound levels are shown to be below, say, 28 dBA then the reported measurements will be artificially elevated and the corresponding target noise limits will be too high[2].

Many measurements (estimate >30%) fall below 28 dBA in the results presented for Background measurements in Appendix E of the NVA.

The NVA reports Background data in scatter charts with data analysis taking the form of a least squares trend line through all of the data points. This was the method used in SA 2009 before it was updated in November 2021. The recent SA 2009 now requires integer wind speed bin analysis of all recorded data. Bin analysis is much more powerful analysis procedure than simple trend line analysis.

Only 24 -hour data is provided. Since the target noise limits are intended to protect sleep it would be appropriate to include additional night time only data charts. Night time only data should be used to set night time target noise limits.

When the base line target noise limit is 35 dBA, or Background plus 5 dB, it is important to recognise that measurement equipment must remain accurate to AS IEC-61672 Class limits below 28 dBA. If poor low level accuracy equipment is used then it would be appropriate to adjust the average integer bin sound level determination lower to compensate and provide a note in any reported sound levels below the measurement range that those measurement levels will be overestimated.

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[2] Huson, W.L.: "Constraints imposed by and limitations of IEC 61672 for the measurement of wind farm sound emissions." 6th International Conference on Wind Turbine Noise, Glasgow 2015

To meet the requirement of SA 2009 that 'The lower limit of the instrument measurement range must be chosen to provide accurate measurements which might be limited by the noise floor of the data acquisition device', then the Sonus Background noise measurements should be reviewed considering limited low sound level accuracies.

Sound level loggers capable of achieving measured results compliant with AS IEC-61672 accuracy limits are readily available down to < 23 dBA. A typical sound level meter from Larson Davis states in its manual (my emphasis in bold type):

> The measurement ranges over which the Model 831 meets the standards, which depend upon the selected frequency weighting, as shown in 'Performance Specifications" on page A-4. Measurements which include levels outside this range should not be considered accurate. An overload indication will appear when levels above the range appear.
> **However, the user should take care not to rely on measurements whose levels are below the lower limit of the specified range.**

Local wind speed at logger locations

SA 2009 states:

> As part of the development application, developers should confirm that the reported noise levels are not influenced by high wind speed across the microphone, particularly where wind speeds at the noise measurement position are expected to exceed 5 m/s (a high wind speed for the purposes of noise level measurement conditions).

The NVA notes that local wind speed at the noise measurement position was taken at only three of the seven locations surveyed. It is not reasonable to assume that measured wind speeds local to the three measurement locations are representative of the other four remote measurement locations. Thus, any data removed when wind the speed exceeds 5 m/s at the three measure locations may not be appropriate to trigger data removal from the other measurement locations.

Overall, the background survey data provided in the NVA is deficient and background surveys should be repeated using improved equipment that can measure lower sound levels that remain compliant with IEC61672 accuracy limits.

It is worth noting that any revised noise model could show other dwellings within a 35 dB(A) noise contour that would also benefit from a background noise survey. A preliminary layout was used to identify the background survey locations in the NVA.

Representative noise data

SA 2009 states:

> A community may be concerned that measurements undertaken as described in the guidelines may not be representative of noise impacts during other periods throughout the year. The compliance checking procedure may be required to be repeated where a valid concern exists to cover such shortcomings. The developer must collect representative noise data as best possible. Non-compliance may result in one or more WTGs being stopped or de-rated under certain conditions in order to meet the guidelines.

The EIS has not provided information to demonstrate that background noise data is representative of other times of the year. Only background data for Summer has been provided.

Noise model predictions

SA 2009 states:

> Noise Model
> A conservative approach should be used for predicting wind farm noise by calculating noise levels in octave bands from at least 31.5 - 4,000Hz to determine an overall predicted level and using the following inputs:
> - atmospheric conditions at 10ºC and 80% humidity,
> - weather category 6 (if CONCAWE method is utilised),
> - hard ground (zero ground factor).

The EIS has not used all of these input parameters. In a recent decision of the Victorian Supreme Court (**Uren**) relating to wind turbine noise the expert representing the wind farm (Mr Turnbull of Sonus Pty Ltd) incorrectly interpreted "the method for assessing wind farm noise prescribed" and the interpretation was accordingly not accepted by Judge Richards. It would be inappropriate for the NVA noise model to use input parameters other than those required in the SA 2009 guidelines.

Noise models produce sound pressure level output predictions based upon sound power levels (SWL) input to the noise model and various factors that address sound propagation from each sound source (WTG at hub height) to receiver dwellings. SA 2009 requires a ground factor, G, to represent hard ground.

Sound predictions can also be penalised if dB(C) predicted levels exceed 60 dB(C) or if tones are observed in measured test data from IEC61400-11 tests.

Tonality

No predictive correction penalty has been applied to the SWL of the candidate WTG for tonality. However, recent Vestas installations of their WTGs has demonstrated tonal noise emissions, as measured by Sonus at the Salt Creek Wind Farm for the Vestas V126 3.6MW turbines using the 1/3 octave band assessment method used in this NVA, that were not considered in earlier predictions for development approval of the Salt Creek Wind Farm.

The tones were identified in hub height wind speeds between 3 m/s and 7 m/s which are below the minimum wind speed of rated power. The Vestas V126 and V162 share the same proven underlying mechanical platform development. The Vestas website:
https://www.vestas.com/en/products/enventus-platform/v162-6-2-mw
describes the sound power level for the V162 6.2 MW turbine as:
"With a standard Sound Power Level of 104.8dB(A) and up to 30 percent higher energy production than the V150-4.2 MW™, the V162-6.2 MW™ establishes a new benchmark in competitiveness."

If tonality has been demonstrated to be a problem below rated power output of Vestas WTGs then it would be appropriate to insist on a proper IEC61400-11 test report to be provided with this application for any candidate wind turbine from Vestas.

If tonality is demonstrated just below the wind speed of rated electrical power then a 5 dB penalty would be applicable to predicted sound levels that would lead to potential noise limit contraventions.

If an IEC61400-11 test is unavailable for the proposed WTG then an alternative that has such a test should be offered as candidate. It is not uncommon for a WTG manufacturer to offer predicted SWL data rather than measured SWL data but in such circumstances it would be appropriate to add some additional measure of uncertainty in the predictions. The total uncertainty should include a 5 dB possible penalty to the predicted sound levels.

The Vestas V162-6.2MW WTG has yet to be installed at any wind farm. The first installation is due to commence in the second quarter of 2022 in Finland:
https://www.globalenergyworld.com/news/sustainable-energy/2021/07/02/vestas-wins-192-mw-order-finland-increases-rating-v16260-mw-enventus-turbine-62-mw

Without an IEC61400-11 test report it is not possible to evaluate tonality or provide confidence to predicted sound power levels.

From the Bulletin:

SA 2009 requires that development applications for wind energy projects report the following:

> “To help determine whether there is tonality, the method and results of testing (such as in accordance with IEC 61400−11) carried out on the proposed WTG model to determine the presence of tonality should also be specified in the development application.”

Summary

General

The NVA states on page 25 that:
“To ensure the project achieves the noise criteria, it is recommended that a pre-construction noise assessment be made based on the final turbine selection, layout and turbine specific sound power levels which are guaranteed by the manufacturer for the project. In addition, operational noise monitoring will be carried out following commissioning of the Project to verify compliance with the noise criteria.”

The EIS has not considered the effect of different layouts or details for other potential wind turbine candidates. With more credible noise modelling it is expected that a revised layout would be required to meet the SEAR.

If the development is approved then any layout change or alternative wind turbine choice must not result in an increased noise exposure to the surrounding Community.

An EIS should address all of these possible changes before any EIS is evaluated. If the changes suggested are not considered in the NVA then the EIS is deficient and should be considered incomplete.

Technical consideration of the cumulative effect of other nearby wind farm developments should be reviewed with a revised EIS using corrected CONCAWE input parameters rather than those incorrectly applied in the NVA.

Background Noise Measurements

For the reasons identified and detailed in this review there are concerns over wind speed measurements used in the Background noise scatter charts and the accuracy of sound level measurements close to the instrument noise floor (poor sound level meter low level performance and corrections required for wind speed measurements). Derived target noise limits are artificially elevated due to the inclusion of data below the lower measurement range of the instruments down to the noise floor.

Some, if not all of the Background sound level surveys need to be repeated so that there is a wind speed measurement near to each microphone location.

The wind speed measurements representing wind across the proposed wind farm should be located where there is no potential influence from subsequently constructed wind turbines that can cause errors due to wind turbine wake effects during compliance testing.

The wind speed measurements must comply with the uncertainty requirements of SA 2009 at hub height and the uncertainty should be included in the EIS.

The location of the wind met masts used to provide data in the EIS needs to be verified as to the appropriateness for each of the Background measurement locations.

The EIS has not provided information to demonstrate that background noise data is representative of other times of the year.

Noise Model

The deficiencies of the CONCAWE noise model input parameters used in the EIS have been detailed.

The deficiencies relate to unverified sound power levels, choice of a wind turbine from the range available that has the lowest sound power specification and the incorrect application of the Ground Effect term recommended in SA 2009 for the CONCAWE noise model.

The NVA significantly underestimates the noise impact in the community surrounding the proposed wind farm by at least 14 dB. This underestimation of community sound levels does not include site effects that can further increase actual sound levels, or the possibility of including a penalty for tonality if test results show that tones are present for the actual turbine used.

The noise models (including the predicted impact upon the Oxley Wild Rivers National Park) should be re-calculated with the correct ‘hard ground’ term G set to 0% and with less optimistic wind turbine sound power levels.

In addition, a sensitivity analysis is required of any alternative layout and different candidate wind turbine generator (WTG) using test results rather than manufacturer’s specifications. If no test results are provided that show lack of tonal audibility then it may be necessary to apply a 5 dB penalty to predicted sound levels as a precaution.

The predicted dB(C) levels should also be reviewed together with possible tonal qualities of the candidate WTG. Predicted dB(C) levels should be recalculated using test results and a suitable noise model that can be used below the 63 Hz octave band limit of CONCAWE.

The EIS should confirm the availability of the candidate WTGs and provide full IEC61400-11 test results.

The EIS currently shows a margin of compliance at dwelling SR240 of only 2 dB, SR109 of 3 dB, SR262 of 4 dB and 5 dB for many others. With the correct input parameters to CONCAWE it is highly likely that non-compliance will be demonstrated for many dwellings. If this situation arises then a revised layout will be required.

SA 2009 Section 5.1 (9) requires ‘an indication of accuracy of the wind farm noise prediction.’ This has not been provided.

Vestas are designing the layout, providing the wind turbines and will operate the Winterbourne Wind Farm.

It should be possible for Vestas to confirm the choice of wind turbine for this application and provide test results for the wind turbines they design and build. Currently, the EIS for this application is non-committal on a wind turbine choice or layout which does not provide confidence that the proposal will meet the requirements of the SEAR.

Negotiated Agreements

Evidence of any negotiated agreement for dwellings/residents should be provided to show how any adverse noise issues from construction activities and wind farm operations have been addressed to protect health.

For L Huson & Associates Pty Ltd,

W Les Huson BSc(Hons) MSc CPhys MInstP MIoA MAAS

Appendix A

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

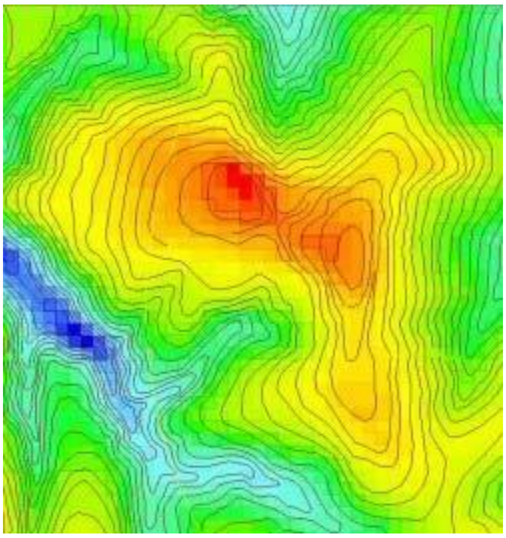
The wind resource is the most obvious factor to concentrate on when choosing a wind turbine location. We have a wide range of options to determine the wind resource of the site. The quality of the tools varies significantly and so does their price.

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.

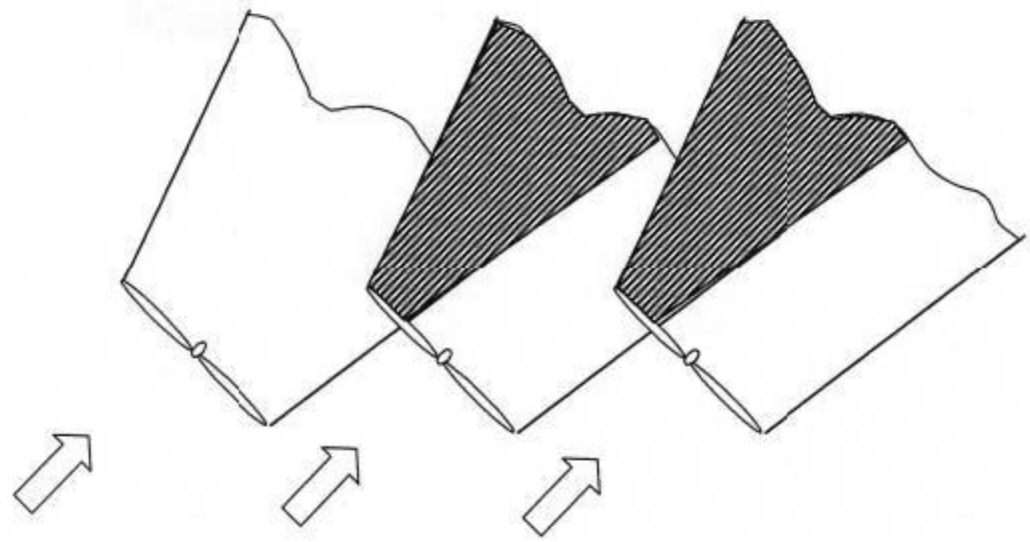


Figure 1: Shadowing in wind farm

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.

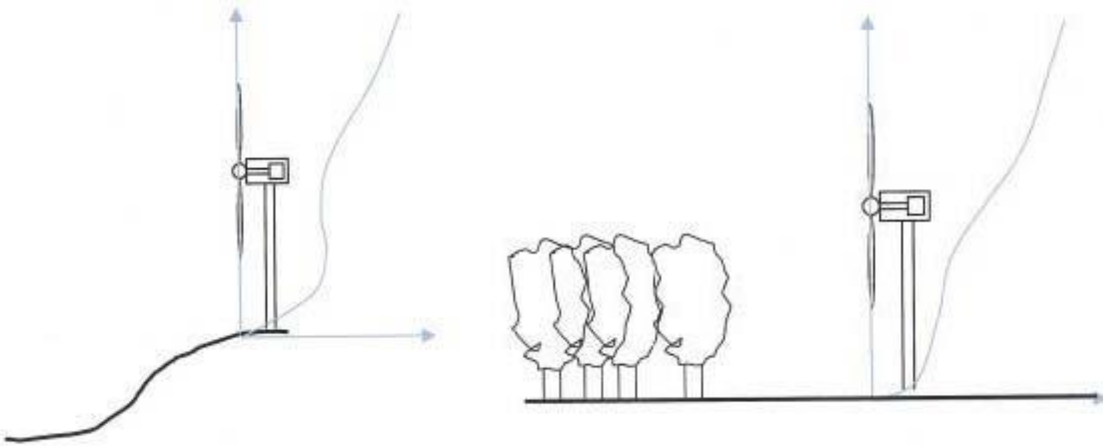


Figure 2: Distorted wind profile at steep slope (left) and behind a forest (right)

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 of 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)

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