

Eco Awareness Society

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May 13, 2010

Eastern District Planning Commission
32 Paint St., Unit 4
Port Hawkesbury, Nova Scotia B9A 3J8

Attn: Wanda Ryan, Development Officer

Re: Shear Wind Inc's application for development permits to construct 14 wind turbines in Antigonish County

Dear Ms. Ryan,

Shear Wind Inc. has submitted its provincial environmental registration documents and addendum as evidence that its project will comply with the Antigonish County land use bylaw regarding wind development. A staff report prepared by the Eastern District Planning Commission (EDPC) was narrowly based on these documents and recommended rezoning. However, given the numerous deficiencies in Shear Wind's background noise study and noise estimate modeling as provided in these documents, it cannot be reasonably concluded that Shear Wind Inc has met the burden of proof in demonstrating that it is likely their project will comply with the Antigonish Wind Resource Bylaw section 5.4(h) which states:

“The mean value of sound pressure level from a wind turbine shall not exceed 40dBA or above the existing background noise, whichever is greater, at the nearest residence”

In support of the foregoing statements, the critique that follows provides supporting evidence and rationale. I am writing this critique from the vantage point of one that has a Masters of Science in Mechanical Engineering from Purdue University, West Lafayette, Indiana, has taken additional seminar work in acoustics and was the lead acoustics engineer for Bendix Research Labs on their supercharger program during the mid 80's. I also have extensive experience with mathematical models and developing software simulations based on those models [Overmyer 2010]. As such, this critique should be considered a peer review.

Background noise level summary

The EDPC staff report quoted Shear Wind's environmental assessment documents stating that the rural background noise levels are an average of 45.2 dB(A) which is greater than the default noise limit of 40 dB(A) as stated in the bylaw. However, public input to Shear Wind's environmental assessment detailed

- The background noise study placed microphones in trees more than 1/2 km from any residence
- Addendum abandoned noise study and without rationale cited the higher value off a 20-40 dB(A) range from a literature source.
- Typical, measured, rural background noise levels in the technical literature and from studies in Nova Scotia report levels 18 to 25 dB(A) lower than what Shear Wind reports

Consequently, Shear Wind's background noise study bears no relevance to actual background noise levels around residences in close proximity to Shear Wind's proposed wind power plant and their project must meet the lower limit of 40 dB(A) as set forth in the bylaw..

Operational, noise level estimates summary

The EDPC staff report, cites the Shear Wind noise study maps in estimating the maximum, mean noise level at the nearest residence to be "on the low end of a range from 35 to 39 dB(A)." I shall use 36 dB(A) as a fixed value that meets the report' description. However, Shear Wind misused their noise modeling software and misinterpreted the results. Specific deficiencies include:

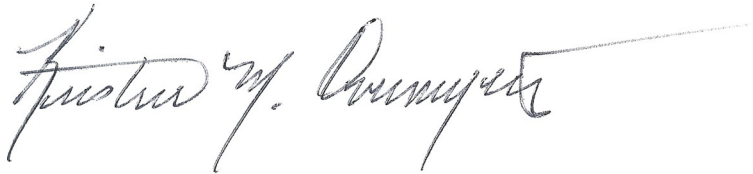
- Their noise model has no documented accuracy beyond 1 km although Shear Wind reports values beyond this limit.
- Their noise model has no documented accuracy above 5 m/sec wind velocity although Shear Wind reports values above this condition.
- Their noise report misinterprets the noise model output as maximum mean values when in fact the model outputs meteorological averages.
- The total sound power input data for their specified wind turbine is based on IEC 64100-11, which does not guaranteed the value so calculated to be the maximum; this value is estimated at a wind speed that is less than half the full, operational, wind velocity for the specified wind turbine.
- The sound modeling software Shear Wind used makes no warranty as to its fitness for use in estimating noise levels around wind power plants
- Shear Wind provides no evidence that the noise modeling software correlates well to actual post construction, operational, noise levels at wind power plants. In fact, the technical literature documents evidence that their model underestimates actual operational noise levels by at least 5 to 8 dB(A).

Given the number and seriousness of the problems in Shear Wind's noise modeling and the fact that their stated value of 36 dB(A) is already close to the 40 dB(A) limit, that their project actually complies with the wind bylaw is at best indeterminate. Considering that the deficiencies error on the side of underestimating and that actual measurements demonstrate this to be the case for the type of model that Shear Wind uses, it is more likely the case that their project will fail to comply with the bylaw.

While many of the above problems were pointed out to Nova Scotia Environment (NSE) through public input during their review of Shear Wind's environmental assessment, according to Helen MacPhail, the NSE manager for this assessment, government reviewers were not provided the public input. In fact, the final approval provides no response to the problems raised. Therefore, NSE's approval of the overall assessment cannot be reasonably construed to be either an adequate peer review or an endorsement of the reliability of the specific information regarding background noise and wind project noise estimates.

To grant Shear Wind a development permit without first investigating and responding to the deficiencies detailed in this document, would demonstrate a lack of due diligence in carrying out both the intent and letter of the Antigonish County Municipal Planning Strategy and Land Use Bylaw.

Most Sincerely,

A handwritten signature in cursive script, reading "Kristen M. Overmyer". The signature is written in black ink and includes a long horizontal flourish extending to the right.

Kristen M. Overmyer, M.S.M.E.
President, Eco Awareness Society

Evidence and Rationale

Background noise study not credible

Regarding Appendix F, “Background Sound Levels”, of Shear Wind’s original registration documents, while not completely clear, it appears that this section is attempting to make the point that background noise will mask wind turbine noise at residences in the vicinity. The test method does not support this claim. I offer the following as argument to that effect.

The statement on page 3 which states, “Typically, the instruments were set at between 1 and 2 meters above ground level to emulate the level of a human receptor” implies that some attempt was being made to associate the sound levels measured with a human receptor. However, Table 1, “Summary of Monitory Locations” places 3 of the 4 monitoring devices *in trees*; 1: “In fork of tree behind cabin and woodshed”, 2: “in tree in woods 40m from road”, 4: “In tree in woods 30m from road.” Such placement completely negates any relevance to a human receptor; simply put, humans rarely experience wind turbine noise while sitting in a tree.

Page 6, section 5.0 concludes, “The sound level measurements collected in the 48 hour period October 2007 at four locations within the Glen Dhu wind farm site are considered representative of typical background sound levels for the area in autumn conditions. The locations selected are near the boundaries of the proposed wind farm and are considered to reflect the conditions to which on-site or neighboring human and ecological receptors would be exposed.” No discussion or rationale is given to support the phrase “considered representative.” Given that:

- these receptor sites were placed in trees where the noise levels would be much greater than standing outside the tree
- these receptor sites were on top of a mountain and more than ½ kilometer from any residence
- no measurements were taken at actual resident receptor sites
- the report makes no attempt to correlate wind conditions on the mountain top to those at resident receptor sites
- ambient noise sources, such as trees, near any resident receptor site are not documented to exist
- measurements were taken over just 2 days and therefore have no statistical significance

The conclusions simply do not follow from the data and its method of acquisition. I conclude that this report fails to provide any evidence or rationale that in any way connects the acquired data to ambient noise levels near a residence that will be impacted by this wind power plant. That “Under some conditions with fall foliage present, background sound levels [in trees] may exceed provincial guidelines for night time sound levels” in no way implies that wind turbine noise will be masked by ambient noise at residences.

Background noise study abandoned

As discussed above, Shear Wind’s original environmental assessment registration documents did contain a background noise study as Appendix F. However, as detailed above, this study was flawed to the point of being irrelevant. In Shear Wind’s addendum to their original registration documents, they did not rebut any of the points raised concerning the inadequacy of their original

study nor did they conduct a new study using acceptable protocols. Now, in their addendum, in reference to background noise levels, they make only a vague reference in the last line on page 7 of their addendum stating, “The noise model indicates that sound levels at these distances are at typical background levels for rural locations”. This is actually a step backwards from their original registration wherein they at least attempted to establish these levels through (an albeit flawed) test procedure.

There are other references to background noise levels in their addendum. In subsection 3.1.1 Audio Effects, they state,

“This represents sound levels less than the noise in a busy office (roughly 60 db(A) but slightly higher than night-time ambient background noise levels in the countryside (20-40 db(A)).”

The data they cite is from “Summary Report Literature Search on the Potential Health Impacts Associated with Wind-to-Energy Turbine Operations” by the Health Assessment Section, Bureau of Environmental Health, Ohio Department of Health, March 2008 [Health 2008]. Also, in section 3.2 “Exposure Assessment”, subsection 3.2.1 “Audio Effects” they state,

“At these distances, audible sound levels attributed to the wind turbines are below those levels which are considered to be normal background sound levels (40db(A)) (see Figure 2.3).”

Shear Wind has chosen the higher of the background levels but provides no data, reports, measurements or other rationale for doing so. The difference between 20 and 40 dB(A) is very large. A 10 dB(A) increase in noise level represents a subjective doubling of perceived loudness. Therefore, 30 dB(A) is twice as loud as 20 dB(A), and 40 dB(A) is twice as loud as 30 dB(A) or *four times* as loud as 20 dB(A).

Typical rural background noise levels

On page 7, in Figure 1 of Kamperman 2008, Kamperman et al., show background sound spectra data measured in rural Michigan (near Ubly) on a June evening. From their figure, the 3 hour 20 minute cumulative equivalent, A-weighted background value is approximately 17 db(A). This is more than 25 dB(A) lower than the 45.2 dB(A) value computed by Shear Wind in their original background noise study and cited as evidence by the Eastern District Planning Commission’s staff report that Shear Wind’s project will comply with the Antigonish bylaw.

In environmental assessment documents prepared for the Digby Wind Power project in Nova Scotia, page 6 of Appendix F, a background noise study that actually placed microphones closed to residences reports levels in the 26 to 27 dB(A) range [Stantec 2009]. This is 18 dB(A) lower than the values reported by Shear Wind and used by the (EDPC) staff report.

Given that:

- Shear Wind’s original background noise study was not credible
- Shear Wind provides no evidence or rationale for the background level stated in their addendum
- Actual rural levels measure in Nova Scotia and elsewhere are significantly lower than 40 dB(A)

until such time that Shear Wind provides convincing evidence to the contrary, the default background noise level of 40 dB(A) as set forth in the bylaw should be used for determining compliance of Shear Wind’s project.

Noise model used beyond prescribed distance limits

Page 7 of the Shear Wind addendum states that they used the WindPRO software program for calculating the noise levels shown in their sound iso-contour map Figure 2.3 “Estimated Turbine Sound Levels”. This software program purports to use the ISO 9613-2 (German variant) sound propagation model. Table 5 on page 32 of the ISO 9613-2 standard [ISO 1996] gives the model accuracy for the distance range of 100 to 1000 meters to be +/- 3 dB. The outer limit of model applicability is therefore 1000 meters or 1 km. Since no accuracy is specified for distances greater than 1 km, the results are indeterminate beyond 1 km; there is simply no basis upon which to quantify an accuracy for greater distances. Shear Wind’s noise estimate maps provide noise values at distances greater than 1 km. These values cannot be relied upon.

Noise model used beyond prescribed wind velocity limits

In describing the meteorological conditions under which the calculations of ISO 9613-2 apply, page 11 of the standard states,

“Downwind propagation conditions for the method specified in this part of ISO 9613 are as specified in 5.4.3.3 of ISO 1996-2:1987, namely

- wind direction within an angle of $\pm 45^\circ$ of the direction connecting the centre of the dominant sound source and the centre of the specified receiver region, with the wind blowing from source to receiver, and
- wind speed between approximately 1 m/s and 5 m/s, measured at a height of 3 m to 11 m above the ground. ”

In their addendum, Shear Wind’s noise estimate map reports values at a wind velocity of 10 m/s or double the wind velocity at which the calculations apply. Given ISO 9613-2 does not specify an accuracy under these conditions, the values so presented are of unknown reliability.

Noise model output misinterpreted

The bylaw states that “The mean value of sound pressure level from a wind turbine shall not exceed 40dBA or above the existing background noise, whichever is greater, at the nearest residence.” The term “mean value” addresses the amplitude modulated or pulsating character typical of wind turbine noise and corresponds to the “slow” response setting for a sound pressure level meter. This setting essentially smooths the roughly 1 second periodic fluctuation and provides a “mean” reading. This mean reading *should not exceed* 40 dB(A) (in the absence of credible alternative background noise data). Therefore, any noise modeling must predict a *maximum* for this value. The following paragraphs are from the ISO 9613-2 standard:

Page 31: “The estimates of accuracy in table 5 are for downwind conditions averaged over independent situations (as specified in clause 5). They should not necessarily be expected to agree with the variation in measurements made at a given site on a given day. The latter can be expected to be considerably larger than the values in table 5.”

Clause 5 on page 11: “The equations for calculating the average downwind sound pressure level LAT(DW) in this part of ISO 9613, including the equations for attenuation given in clause 7, are the average for meteorological conditions within these limits. The term average here means the average over a short time interval, as de-fined in 3.1.”

Section 3.1 page 8: “The time interval T should be long enough to average the effects of varying meteorological parameters. Two different situations are considered in this part of ISO 9613, namely short-term downwind and long-term overall averages.”

From these paragraphs, it can be seen that the values calculated by ISO 9613-2 are not simple mean values, but averages over meteorological conditions; the actual measured (mean) variations at a given site on a given day can be expected to be significantly greater than those shown in table 5 (+/- 3 dB at 1 km). Given that Shear Wind estimates 36 dB (the low end of 35-39 dB), an additional variation of just 2 dB, or 5 dB total, would make their project non-compliant with the Antigonish wind bylaw. While the model may serve as a tool for comparing wind power plant layouts in a relative sense, the fact that the actual variation is not quantified, renders this modeling approach inappropriate for predicting absolute maximums.

Total sound power not the guaranteed maximum

The primary piece of input data, the wind turbine's total sound power level, is stated in Shear Wind's addendum Appendix E to be 104 dB(A). This number was obtained using IEC 61400-11 [IEC 2002], which is the test specification for obtaining the raw sound data that is used to compute this value. The use of this value is not appropriate as the IEC 61400-11 test specification does not warrant that the value so obtained represents the maximum possible for the turbine being tested. The tests are designed for repeatability and therefore specify tightly controlled conditions some of which follow:

- The maximum test wind speed is 10m/sec at ten meters elevation
- Measurements are A-weighted
- Measurements are taken on a nearly flat plane at moderate wind speeds with low turbulence

There are many differences between these very controlled conditions in the test and the real world use of wind turbines that can contribute to the real world values being significantly higher. Regarding the maximum test wind speed, the Enercon E82 can operate in winds as high as 28 – 34 m/sec (the cut-out wind speed range) at the nacelle. Given that the rated speed (max power reached) is 12 m/sec at the nacelle and the E82 sound data reports 95% power at just under 10 m/sec at 10 m elevation, the max wind operational wind velocity at the nacelle is 2.8 times greater than the nacelle wind speed at the maximum test condition ($=34/12$). Both from the standpoint of increased available kinetic energy (8 times greater) and increased pressure differentials across the airfoils, the opportunity for producing substantially greater noise is significant.

Regarding the measurements being taken on a nearly flat plane with low turbulence, many wind power plants are arrayed along mountain ridgelines, which induce turbulence and lead to greater noise generation. Under smooth flow conditions, the wind attack angle to the airfoil is nearly constant and the airflow remains attached to the airfoil until it nearly reaches the tip where it separates and breaks into turbulence. It is this turbulence that produces the broadband noise. With increased angles of attack, the airflow will separate from the airfoil at increasingly greater distances from the tip, producing more turbulence and noise. At around 14 degrees of attack angle, the airflow separates near the leading edge and the airfoil stalls (loses lift) producing even more turbulence and noise. Gusty, turbulent wind conditions created by ridgelines cause sudden changes in the wind attack angle on the airfoil creating premature boundary layer separations and even intermittent stalls both of which produce increased noise.

The iso-contour maps generated using data from IEC 61400-11 and the sound propagation model ISO 9613-2 are useful for making comparisons between turbine layouts, but they should not be used as a rationale for asserting *maximum noise levels* to be experienced by human receptors in the vicinity of a wind turbine power plant. Doing so results in artificially low predicted values.

Noise modeling software makes no warranty

The WindPro software license makes no guarantee of suitability for any purpose. From the WindPro license taken from their website:

“Limitation of Liability:

The software is provided on an "as is" basis without warranty of any kind. EMD International A/S does not warrant, guarantee or make any representations regarding the functionality of the software, any results obtained by the use of the software and any software support provided by EMD International A/S and their Agencies/Partners in terms of correctness, accuracy, reliability, usefulness, or otherwise.”

This would include making no warrantee for reliably predicting noise levels for wind power plants. Given the uncertainties in the underlying ISO 9613-2 sound propagation model, this is not unexpected.

Noise model correlates poorly to real-world noise levels

In response to noise problems reported by Daniel d’Entremont, at the Pubnico Point wind power plant in Pubnico, Nova Scotia, Natural Resources Canada commissioned measurements and a study, which were performed by Howe Gastmeier Chapnik Limited (HGC) of Ontario [HGC 2006]. HGC performed the noise analysis using the ISO 9613-2 sound propagation model (the same as Shear Wind’s) and an estimated total sound power for each wind turbine of 105 dB(A). This latter value is typical of total sound powers predicted by IEC 61400-11 for turbines in the 2 mw range. They computed an estimated noise level at the d’Entremont residence of 49 dB(A) at a wind speed of 9 m/sec. This value underestimates the noise level they actually measured at a lower wind velocity of 5-6 m/s (Figure 3.a) by 5 dB(A). The original analysis performed by the wind proponent using the Danish sound model estimated a value of 43 dB or 9 dB lower than measured.

It is usual for the wind turbine noise to increase over the 5-6 m/s to 9 m/s causing the discrepancy between predicted and actual levels to be even greater. For example, the Enercon 70 61400-11 results show a 4+ dB increase from 6 to 10 m/s, which would place the HGC 9613-2 estimates at 9 dB below actual. Unfortunately, although HGC measured noise levels at these higher wind speeds, they described the data as being contaminated by wind, rain, and other artifact noise so that the data could not be used.

It is also significant that HGC was measuring 10 minute averages; the opportunity for fluctuations in mean value of +/- 3 dB is very real and would place their predictions at 8 dB below actual. Given that Shear Wind estimated 36 dB(A) (low end of 35 to 39 dB) at the nearest residence for the Antigonish wind turbines, the discrepancies between estimated and actual sound levels demonstrated by the Pubnico study of 5 and more decibels would put their project in violation of the Antigonish county bylaw limit of 40 dB(A).

Works Cited

- [Health 2008] Health Assessment Section Bureau of Environmental Health Ohio Department of Health. "Summary Report Literature Search on the Potential Health Impacts Associated with Wind-to-Energy Turbine Operations". March, 2008.
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- [IEC 2002] Wind turbine generator systems - Part 11: Acoustic noise measurement techniques. IEC 61400-11, 2nd addition. 2002-12.
- [ISO 1996] Acoustics -Attenuation of sound during propagation outdoors - Part 2: General method of calculation. International Standards Organization. Reference number ISO 9613-2:1996(E). First edition 1996-12-15.
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