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Critique of Amherst Island Wind Project Noise Assessment Report Prepared for Windlectric Inc.

Critique Prepared By:

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Date: March 4, 2013

1.0 Introduction

This critique was conducted on behalf of the Association to Protect Amherst Island (APAI) and SaveAI, both registered associations of citizens opposed to an industrial scale wind energy development on Amherst Island. Amherst Island is part of Loyalist Township, in turn part of the County of Lennox and Addington in Eastern Ontario. The developer, Windlectric, is a subsidiary of Algonquin Power Company.

This critique addresses errors and omissions in the Noise Assessment Report, part of the Design and Operations Report made available to Loyalist Township and the public as part of the Draft Renewable Energy Approval Documents.

The full draft documents can be found at:

http://www.amherstislandwindproject.com/public-information.html?folderid=link0.

Summary List of Reports Reviewed for this Critique

	Prepared by:	Name of Report	Report No.	Date	Abbrev. used as Reference
1	Hatch	Noise Assessment Report for Amherst Island Wind Project and related Appendices A-D	H340642-000-07-124-0002, Rev 3	Nov. 28, 2012	Noise Assessment Reports or NAR
2	Stantec	Wind Turbine Specification Report	160960595	Dec. 2012	
3	Ontario	Ontario Regulation 359/09, Renewable Energy Approvals Under Part V.0.1 Of The Act	N/A	Current to Dec. 1, 2012	REA or Ontario Regulation 259/09
4	MOE	(MOE) Ontario Noise Guidelines for Wind Farms (2008)	N/A	2008	MOE 2008 Guidelines

2.0 Qualifications

I am the Owner and Principal Consultant for E-Coustic Solutions, of Okemos, Michigan (P.O. Box 1129, Okemos MI 48805). I have been a practicing acoustical engineer for 40 years. Attached as Exhibit A is a summary of my experience demonstrating my work in addressing a broad range of problems for my clients and a narrative that provides more detail about my work on wind turbine noise. A summary of my wind related projects and testimony are also provided in Exhibit A. I have been actively involved with the Institute of Noise Control Engineers (INCE) since I started my career in the early 1970s. I have Full Member status in INCE. My clients include many large manufacturing firms, such as, General Motors, Ford, Goodyear Tire & Rubber, and others who have operations involving both community noise and worker noise exposure. In addition, I have worked for many small companies and private individuals.

My academic credentials include appointments as Adjunct Professor and Instructor to the Speech and Communication Science Departments at Michigan State University and Central Michigan University. Specific to wind turbine noise, I have worked for clients in over 60 different communities.

I have provided written and oral testimony in approximately 30 of those cases. I have authored or co-authored four papers covering topics from how to set criteria to protect public health, demonstrating that wind turbine sound emissions have both audible and inaudible characteristics and are predominantly comprised of infra and low frequency sound. A recent paper is a historical review of other types of noise sources with similar sound emission characteristics that have known adverse health effects on people exposed to their sound.

Of specific relevance to this statement in 2011, I was accepted as an expert witness on the topic of wind turbine noise and its effects by the Ontario Environmental Review Tribunal in the appeal of the Kent Breeze Wind Farms (Suncor Energy Services, Inc.) Renewable Energy Approval Cases No: 10-121/10-122. The hearings were held during February, March and May of 2011. The Tribunal's decision set a higher hurdle for Noise Assessments by concluding:

> While the Appellants were not successful in their appeals, the Tribunal notes that their involvement and that of the Respondents, has served to advance the state of the debate about wind turbines and human health. <u>This case has successfully shown that the debate should not be simplified to one about whether wind turbines can cause harm to humans. The evidence presented to the Tribunal demonstrates that they can, if facilities are placed too close to residents. The debate has now evolved to one of degree. The question that should be asked is: What protections, such as permissible noise levels or setback distances, are appropriate to protect human health</u>? ……. Just because the Appellants have not succeeded in their appeals, that is no excuse to close the book on further research. On the contrary, further research should help resolve some of the significant questions that the Appellants have raised. (Page 207 of Environmental Review Board Decision, Erickson V. Director, Ministry of the Environment, July 18, 2011) (*Emphasis added)*

This Critique will evaluate the Amherst Island Wind Project's Noise Assessment Report in light of the Tribunal's statement.

Exhibit A provides additional details on my qualifications. Attached to this report are the following documents in support of these statements:

1. Exhibit A
   a. Biographical Narrative Related to Wind Turbine Noise and Adverse Health Effects
   b. Summary Table of Significant Work and Research on Noise and Health in General
   c. List of Cases where testimony or deposition was provided in the last four (4) years.
   d. List of Publications During Last 10 Years

This Exhibit was last updated on February 8, 2013. Copies of publications are available upon request.

3.0 OVERVIEW

This review identified a number of deficiencies in the reports and information presented by Hatch (the "Noise Assessment Reports") on behalf of the Amherst Wind Project regarding the potential for excessive noise exposure on adjoining properties. Some relate to requirements of the Ontario Regulation 359/09, (Nov. 2, 2012) Renewable Energy Approvals (REA), and the 2008 Ontario Noise Guidelines for Wind Farms published by the Ontario Ministry of Environment. Others are related to the input data, assumptions and methodology used in constructing the computer model used to estimate sound propagation from wind turbines and transformers that comprise the Project to noise receptors.

They fall into the following categories:

1. Sound Power data used as input to computer sound propagation model was not corrected to include confidence levels as required by ISO 9613 <u>Acoustics-Attenuation of sound during propagation outdoors, Part 2: General method of calculation</u> and IEC 61400 <u>Wind turbine generator systems, Part 11: Acoustic noise measurement techniques</u> standards upon which the

model is based.

2. The noise prediction is not carried out in accordance with the methods outlined in ISO 9613-2.
3. The model does not represent the "predictable worst-case" noise impact as required by the MOE Ontario Noise Guidelines for Wind Farms (2008) leading to an under prediction of the sound levels at noise receptors.
4. The combined effect of the errors made in developing the model and applying its results leads to a conclusion that the project will exceed the MOE sound limit of 40 dBA and that should it be approved as it is currently designed the potential for adverse health effects will be greater than other projects where the models were correctly developed and the results correctly applied.
5. No consideration is given to potential for exposure to infra and low frequency sounds from wind turbines. There are no regulations in Ontario that establish a safe level for long term exposure to sounds in the lowest frequency ranges. Risks of adverse health effects must be considered when the safe level for exposure is not known.

The result of the first three categories of issues is that the Amherst Island Wind Project model does not address the types of audible noise from wind turbines that occurs as a result of the summer night time wind speed profile. The model does not represent the nighttime high wind shear conditions that people find most objectionable. It does not represent the "predictable worst-case" noise impact that is the goal of the MOE 2008 Guidelines.

If the model had correctly addressed ISO 9613-2 day-to-day variability and confidence limits, adjusted IEC61400-11 sound power levels to account for increased sound emissions at night, and applied the values for ground factor shown in independent studies to provide the best correlation between a model's predicted levels and those that are measured the contour map and tables would be at least eight (8) dBA higher. This increase would expand the boundary of the 40 dBA threshold to include many of the homes within or around the perimeter of the Amherst Island Wind Project. Properly modeled, this project would not comply with MOE's 40 dBA limit at receiving properties. The Findings and Opinions presented below illustrate these issues and provide an estimate of the impact of using more accurate assumptions and applying confidence levels on the noise receptors adjacent to and in the footprint of the Amherst Island Wind Project Wind Project.

This critique includes the following Exhibits:

Exhibit	Document Name or Description	Short Name (if any)
A	Experience of Richard R. James, including Biographical sketch, list of administrative agency cases, Client list, and List of Recent Publications	Summary of Experience
B	Cooperative Measurement Survey and Analysis of Low Frequency and Infrasound at the Shirley Wind Farm in Brown County, Wisconsin, conducted for the Wisconsin Public Service Commission in the High-land Wind Application Hearing. Report No: 122412-1, Dec. 24, 2012	Shirley Wind Infrasound Noise Study Team Report
C	April 29 2010, Memorandum, Cameron Hall to Supervisors regarding calculations used to establish setbacks not including confidence limits.	FOIA document
D	Propagation Modeling Parameters for Wind Turbines, Kaliski et. al. Proceedings of Noise Con 2007	
E	Improving predictions of wind turbine noise using PE modeling, Kaliski et. al. Proceedings of Noise-Con 2011	
F	Recent Developments in assessment guidelines for sound from wind power projects in Ontario, Canada, with a comparison to acoustic audit results, Howe, et. al., Proceedings of Inter-noise 2009, Ottawa, Canada	
G	June 29, 2009 Email from Tomlinson to Victor Low regarding Multiple Wind Turbine Noise Level Measurement	FOIA document

H	Effects of the wind profile at night on wind turbine sound, G.P. Van den Berg, Journal of Sound and Vibration, 2003	
I	Table of Predicted Sound Levels With Tolerances and Nightime adjustments added to Hatch Table C.1	

OVERVIEW

Wind turbine noise is distinctively annoying and is not addressed when criteria using dBA weighting and long averaging times are used.[1 2 3] The reports and documents submitted on behalf of the Project do not correctly or adequately describe the impact of the proposed project on the host community, or its residents whose homes and properties are close to the footprint of the project.

The Amherst Wind Project reports do not disclose that the 2009 World Health Organization's Night Time Noise Guidelines found the threshold for adverse health effects from common community noise sources such as road, rail and air traffic, to start when nighttime noise outside a home is 40 dBA ($L_{eq\ night\text{-}outside}$) or greater. For other types of sound, especially those with high levels of infra and low frequency sound or those that fluctuate in level the threshold would be even lower. For these other, more disturbing types of sound, the threshold for adverse health effects, especially for the more vulnerable people, may need to be as low as 30 dBA.

Although errors in the Amherst Wind Project sound propagation computer model are covered below, it is worth noting that the models predict the sound level from wind turbines operating under weather conditions defined by the IEC test methods to be associated with mild winds representing daytime conditions. The IEC standard specifies that test conditions have a low wind shear with a smooth logarithmic gradient from the ground surface to the height of the hub and blades and low levels of in-flow turbulence. These are daytime weather conditions and do not consider the higher wind shear and turbulence that occur during nighttime operation that result in increased sound power emissions from inefficiencies caused by the disturbed hub level winds. Thus, models developed using the manufacturer's sound power levels represent daytime operation, not nighttime operation. These conditions are specified in the IEC test standards for all tests of wind turbine noise. What is not considered by many acousticians constructing wind turbine project sound models is that the use of the IEC sound power data representing daytime weather and operating conditions results in the model predicting the lowest noise immissions from the wind turbines. Based on the results of this "daytime conditions" model, the Amherst Wind Project NAR erroneously concludes that the projected separation distances between wind turbines and receiving locations (e.g. homes) is acceptable.

Nothing could be further from the truth as will be shown later in this review. Had the Amherst Wind Project model considered the higher sound emissions and changes to sound propagation that occur during weather associated with nighttime operation the project would not meet the MOE criteria for predictable worst case conditions at the most impacted residence. And, for that matter, it would have shown that the Amherst Wind Project would not meet the MOE criteria at many of the other homes either. This difference between daytime and nighttime sound immissions from wind turbines is corroborated by the fact that nighttime noise is the subject of most complaints. Complaints about daytime noise are much less frequent that complaints about nighttime noise. Evidence of wide spread complaints of sleep disturbance and other adverse health effects from the many projects in

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[1] Thorne, R, "The Problems with "Noise Numbers" for Wind Farm Noise Assessment," Bulletin of Science, Technology and Society, Pg 262-290, August 2011

[2] Bray, W. James, R., " Dynamic measurements of wind turbine acoustic signals, employing sound quality engineering methods considering the time and frequency sensitivities of human perception," Noise-Con 2011, Portland Oregon. (Invited paper)

[3] It should be noted that all papers published in the Bulletin of Science, Technology and Society are peer reviewed as part of Sage Publications standard policy.

the U.S., Canada, and other countries where wind turbines were similarly located is not discussed[4]. These complaints are often associated with nighttime operation during a stable atmosphere with high wind shears above the temperature inversion boundary. This is a common weather condition in the temperate zone that has been shown to be present between 30 and 60% of all warm season nights[5,6].

The wind industry and its supporters respond to these complaints as being sporadic and motivated by reasons not associated with adverse health effects. Yet, in Norfolk County, Ontario, where turbines are sited using a 40 dBA not-to-exceed limit set by Ontario Ministry of Environment guidelines, it was reported that of 140 homes in the vicinity of the wind turbines over 40 have been abandoned[7]. CBC news reported after a review of documents obtained under the Freedom of Information Act, that in another community with 133 wind turbines there have been over 200 formal complaints lodged with the Ontario Ministry of Environment since the project started operation[8]. In the U.K., the BBC reports on a recent court case awarded damages to a family that lived 3000 feet from the nearest wind turbine[9]. The Kent-Breeze Wind project that was the subject of the Ontario Environmental Tribunal hearing in 2011 where GE 2.5 MW wind turbines were installed resulted in almost immediate adverse health effects for one family that lived 1.1 kilometers from the nearest wind turbine. The Siemens SW 2.3 113 model wind turbines have the same potential for adverse health effects as shown in Figure 1, below.

In the U.S., an eight (8) wind turbine project located in Wisconsin, Shirley Wind, has resulted in homes being vacated by three families. Distances between the homes and nearest wind turbine (a Nordex 2.5 MW N100) are from about 365 meters, 1000 meters, and 2,100 meters. A study of the three vacated homes commissioned by the Wisconsin Public Service Commission, (WPSC) conducted by a team of four separate acoustical firms found that infrasound was present in each of these homes at levels that the acoustical firms concluded were sufficient to cause the adverse health effects reported by the families who had vacated the homes. The conclusion of this study was that:

> "The four investigating firms are of the opinion that enough evidence and hypotheses have been given herein to classify LFN and infrasound as a serious issue, possibly affecting the future of the industry. It should be addressed beyond the present practice of showing that wind turbine levels are magnitudes below the threshold of hearing at low frequencies."[10] Attached as Exhibit B

The Shirley study observed that the rotational speed of the hub and blades resulted in a blade passage frequency that was below 1 Hz. This region of frequencies is associated with producing nausea and other symptoms of motion sickness in some people. Figure 1 shows a chart that plots the blade passage frequency for a number of common older and new wind turbines against the range of frequencies associated with nauseogenicity. The graph has the range of blade passage frequencies for the Siemens SW 2.3-113 wind turbine proposed for Amherst Island Wind Project shown in red. The rotational speed for the wind turbine is within the frequency range associated with nausea and motion sickness from 1 Hz and lower.

In spite of claims by some that it is not necessary to require a separation distance of over one mile, the experiences of communities with similar wind turbine projects show otherwise. People living at distances of a mile or more from wind turbines on flat, or relatively flat land, <u>are</u> experiencing

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4 Phillips, C. V. "Properly Interpreting the Epidemiologic Evidence About the Health Effects of Industrial Wind Turbines on Near-by Residents" Bulletin of Science, Technology, and Society, 2011 31:303

5 Van den Berg, G.P., "Effects of the wind profile at night on wind turbine sound" Journal of Sound and Vibration, 2003

6 Schneider, C. P. " Measuring background noise with an attended, mobile survey during nights with stable atmospheric conditions," Proceedings of the 2009 InterNoise Conference, Ottawa, Canada, August 23-26, 2009

7 Pearce, D. "Noise Complaints to be Investigated," Simcoe Reformer, July 15, 2010

8 Seglins, D., and Nicol, J. "Ontario wind farm risks downplayed: documents," CBC news, Sept. 22, 2011 at 5:23 AM

9 BBC News, "Lincolnshire wind farm noise case settled" November 30, 2011

10 A Cooperative Measurement Survey and Analysis of Low Frequency and Infrasound at the Shirley Wind Farm in Brown County, Wisconsin

adverse health effects from sleep disturbance at night from audible turbine noise and a subset of the population is experiencing adverse health effects associated with vestibular function. It must be understood that these complaints have two distinct aspects. A large number of the people who file complaints are concerned with the audible sounds from turbines they hear on their property

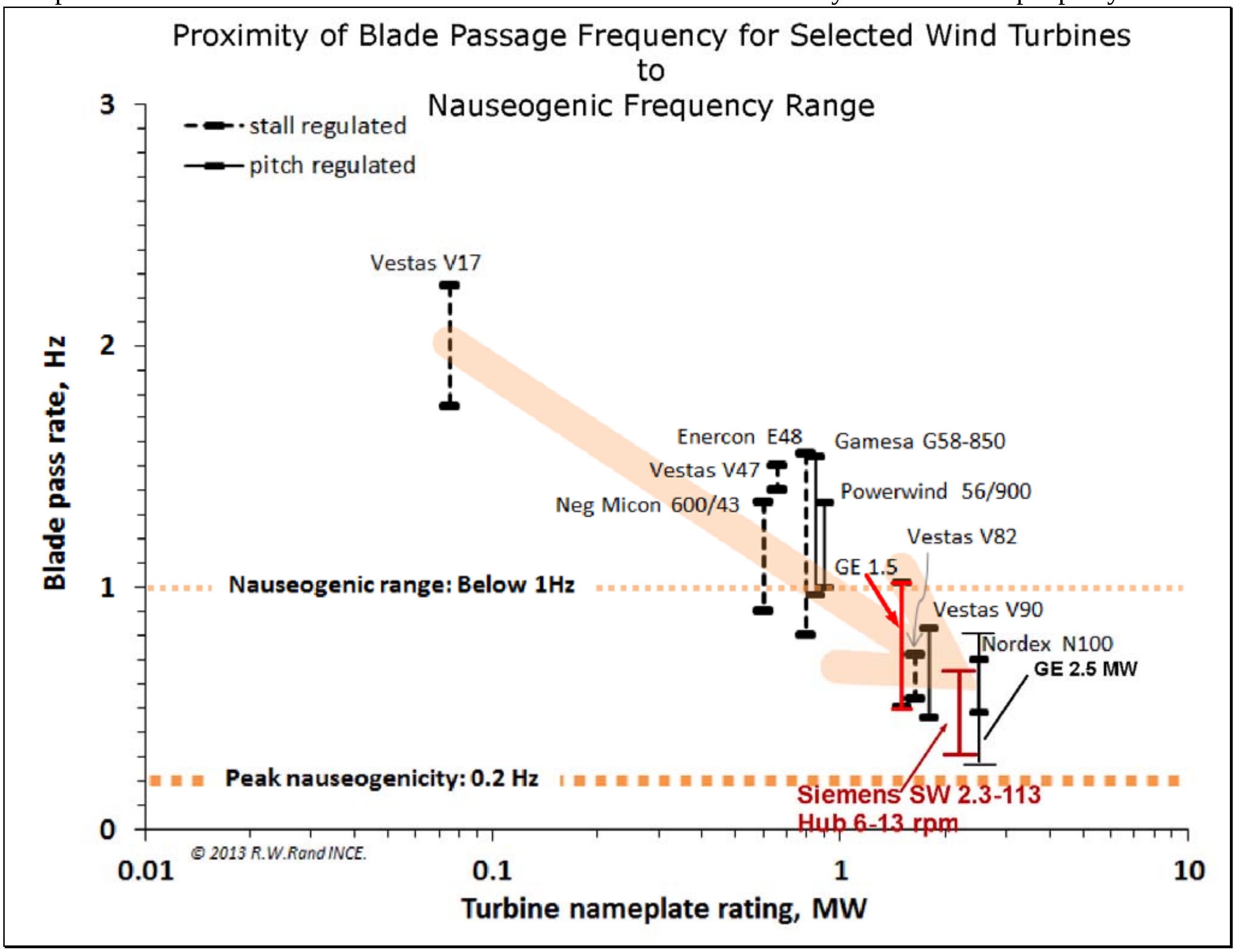

Figure 1- Nauseogenetic Region vs. Wind Turbine Blade Passage Frequency

and inside their homes, especially during evening and nighttime periods when they are trying to relax or sleep. A subset of these people have complaints about other aspects of wind turbine sound emissions that are not audible, but instead interfere with their sense of balance or cause sensations like stuffiness in the ears, headaches, and general malaise. These symptoms are not a result of the audible sounds being processed by the auditory functions of the cochlea but are instead from infra and low frequency sound currently believed to be mediated by the cochlea's vestibular organs. These organs are stimulated by infrasound at sound pressure levels far below the level required for the sounds to be heard. The characteristic noise from industrial scale wind turbines that is related to this second class of complaints is currently believed to be a result of in-flow turbulence of the air stream entering the path of the blades. The turbulence results in dynamically modulated infra and low frequency sound concentrated in the frequencies associated with the blade passage frequency and its harmonics, emitted in short duration bursts (often under 100 msec) of acoustic energy with peak sound pressure levels 30 to 40 dB higher than the sound pressure in the valleys between them. Even though these may not be reach the threshold of audibility, recent research by Dr. Alec Salt and others has demonstrated that they can cause disturbances to our organs of balance (vestibular organs in the cochlea).[11] [12]

Computer model estimates of operational sound levels from the proposed projects using input data for sound power representing daytime operation of the wind turbines understates the impact of the turbines on the community by a wide margin. Further, failure to include the upper boundary of confidence limits for the ISO and IEC procedures provides no margin for errors in the calculations. The computer model estimates do not include confidence limits, as is appropriate for any scientific or engineering study. Conservatively, use of the ISO and IEC confidence limits to establish an upper bound for the predictions would add 3.6 dB to all predicted values and contour lines. The model should reflect operation of the turbines during nighttime during periods of stable atmospheric conditions when in-flow turbulence and/or high wind shear increase the noise emissions by 6 to 10 dBA above the values reported in the Amherst Wind Project model.[13] These weather conditions are common during warm season nights.

ISO 9613-2: Acoustics-Attenuation of Sound during propagation outdoors,
Part 2: General Method of Calculation:

This standard specifies engineering methods for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of noise sources. The method is applicable, in practice, to a great variety of noise sources environments. It is applicable to most situations concerning road or rail traffic, industrial noise sources, construction activities, and many other ground based noise sources. It does not apply to sound from aircraft in flight, or to blast waves from mining, military, or similar operations. It is validated only for noise sources that are located close to the ground (approximately 30 m difference between the source and receiver height). It is also limited to noise sources that are within 1000 m of the receiving location. Meteorological conditions are limited to wind speeds of approximately 1 m/s and 5 m/s when measured at a height of 3 m to 11 m above the ground. It should also be understood that the ISO method for calculating sound propagation *"...predicts a long-term average A-weighted sound pressure level as specified in ISO 1996-1 and ISO 1996-2. The long-term average A-weighted sound pressure level encompasses levels for a wide variety of meteorological conditions*." It is not predicting a 1 Hour Leq or any other short term sound level. When all constraints are met by the situation being modeled the procedure is accurate within a +/- 3 dB range averaged over a period of weeks or months. The range of +/- 3 dB accounts for some of this variability over time and thus must be considered as integral to the sound propagation model's predicted sound levels.

IEC61400 Wind turbine generator systems standards including
Part 11 Acoustic Noise Measurement Techniques

The purpose of this standard is to provide a uniform methodology that will ensure consistency and accuracy in the measurement and analysis of acoustical emissions by wind turbine generator systems. The standard was designed to standardize the tests used by wind turbine manufacturers in rating their products. It is does not purport to represent the "worst case" sound emissions as implied in many wind energy project NAR's. It is designed to provide test results that meet well-defined acoustical emission performance requirements under a standard weather condition and operational modes for the purpose of allowing a purchaser to compare one make and model to another. This is similar in concept to the standardized tests used to rate automobile city and highway gasoline mileage. If the conditions for operation differ from the test conditions the results will also be different.

[11] Salt A, Kaltenbach J, "Infrasound from Wind Turbines Could Affect Humans," Bulletin of Science, Technology and Society, Pg 296-302, August 2011

[12] Krogh C, Gillis L, Kouwen N, Aramini J, " WindVOiCe, a Self-Reporting Survey: Adverse Health Effects, Industrial Wind Turbines, and the Need for Vigilance Monitoring," Bulletin of Science, Technology and Society, Pg 334-345, August 2011

[13] Van den Berg, G.P., "Effects of the wind profile at night on wind turbine sound" Journal of Sound and Vibration, 2003

This standard is used to determine the sound power level emitted by wind turbines under conditions defined as "normal" operation. Normal operation is specified as weather conditions that are not severe and represent operation with low and definable wind shear. Such conditions are normally defined as a "neutral" atmosphere where the windshear will generally be in the range of 0.15 to 0.20. As noted earlier, this weather condition is commonly observed during daytime of warm seasons and in particular can be described as a warm sunny afternoon in the temperate zone. Under low wind shear conditions the wind speed does not increase significantly between the height where the blade is lowest in this rotation and the top where it is at its highest peak. This allows the anemometer located on the turbine's hub to calculate the optimum angle of attack of the blades and RPM of the hub for maximum efficiency in extracting energy. Because inefficiency in extracting energy results in increased noise, heat, turbulence, and additional stresses on the blades the optimum blade angle for power extraction is often the same as for the lowest sound emissions. That is, the lowest noise immission condition for wind turbine occurs is when it is most efficiently extracting energy from the wind. The reverse is also true. When wind moving across the blades is not "well behaved" blade angles cannot be optimized and noise increases as energy production decreases.

Real World Conditions Not Considered in ISO and IEC standards

In a paper by William Palmer, P.ENG., the effect of varying wind shears on wind turbine noise is explored[14]. Figure 1 shows an example of the optimal weather conditions for a windshear of 0.14 with no stability layer (temperature inversion boundary). The IEC test uses this weather condition to measure the sound power levels emitted by the turbines. The Amherst Wind Project report used that data for its model. The problematic situation is when there is high-level windshear, such as 0.44, with a stable boundary layer. Because there will be a significant difference in the wind speed at the bottom and at the top of the blades rotation path the windshear of 0.44 will be more difficult for the turbine to find the optimum operating mode than for the 0.14 windshear. The low wind shear condition follows a logarithmic relationship described as the Power Law which permits the estimation of a wind speed at some arbitrary height such as the hub from the wind speed at a lower height such as a 10 m meteorological tower. The higher wind shear conditions are much more complex and depend on the height of the stable boundary layer. The shear rate also does not follow the simple Power Law or other simple formulas often presented by the acoustical consultants in explanations of how they account for nighttime wind shear in their models.

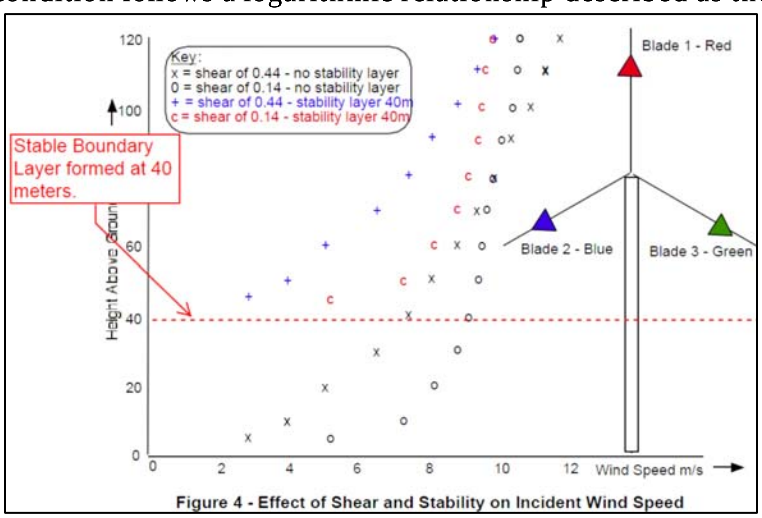

Figure 2- Example of wind shear in neutral and stable atmospheres

At night, after the sun's heating of the ground stops, the ground cools. The convection currents present in the daytime that cause the warmed air next the ground to rise upwards to mix gradually with the upper level winds in a smooth gradient also stop. A cool layer of air forms at the ground and extends upwards to the boundary layer which will form at altitudes often between 20 m to 100 m or more above the ground. This boundary layer causes a complete disconnect between the wind speeds below it and above it. Below the boundary layer winds are often calm or even still. There is insufficient wind to cause leaf rustle or other sounds associated with surface level winds. Figure 2 which is extracted from Mr. Palmer's paper shows the stable boundary at 40 m by stopping the "+" and "c"

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[14] Palmer, W. P,Eng, "A new explanation for Wind Turbine Whoosh, Wind Shear," Third International Meeting on Wind Turbine Noise, Aalborg, Denmark, June 2009.

markers for windshear at that height. These are the two curves on the left side of the figure. It is important to understand, that when a stable boundary layer forms the winds above the boundary layer are often moving at a very high rate and that rate increases rapidly with height. It is not uncommon to see wind shear coefficients of 0.7 or higher when these conditions form. It is important to also understand that the IEC 61400-11 test procedure is conducted only for conditions where wind shear is less than 0.2 even for the higher wind speed tests.

To compound the situation, the stable boundary layer can be at elevations of 100 meters or more. If the stable boundary layer forms at an elevation higher than the bottom of the blades rotation path the blade will descend into it. Under these conditions the turbine blades which are under wind load above the stable boundary layer lose that load when they enter the still air below the boundary layer. This is a situation that the turbine operating system, which depends upon one hub level anemometer, cannot detect nor can it adjust the blades to account for this change. It is this condition that Mr. Palmer believes produces the maximum sound power from the turbine blades and is responsible for the deeper more penetrating blade "thumps" that are the source of complaints during nighttime. Other researchers, like Dr. Swinbanks, think that there is also some interaction between the blades and the wind being slowed slightly in front of the tower that can produce these deep thumps. Measurements of turbines operating under this condition have shown blade whoosh (amplitude modulation) of 8 to 15 dBA above the normal sound levels. For the situation of high wind shear without the stable boundary layer blade whoosh (amplitude modulation) normally ranges from 5 to 8 dBA.

Van den Berg's early work supports these more recent reports. This phenomenon was studied for over a year by Dr. Fritz van den Berg for his graduate thesis titled: "The Sounds of High Winds." In "The Sounds of High Winds" Dr. van den Berg presents a method for determining the increased sound power emitted by wind turbines for various mismatches between the optimum angles of attack for the blades and what occurs when the blades are not at the optimum angle due to high wind shear. He shows that increases of 10 dB can be expected for angle mismatches of 9° or more. Even slight mismatches of 4 to 7° can increase sound power emitted by 3 to 8 dBA.

Suitability of Model Calculations

Although the acoustical consultants who work for the wind turbine project developers use ISO based models world-wide; the ISO algorithms have not been validated by any independent peer-reviewed process for use in siting wind turbines. General-purpose industrial, rail, and traffic noise models are developed using commercial software packages such as Cadna/A™, SoundPLAN™ 7.0, and The Predictor® which are based upon this ISO standard. The practice of using these commercial packages was promoted by the British Wind Energy Association (BWEA) and trade associations in other countries in a set of guidelines known as ETSU-R-97. The wind industry has promoted use of these guidelines in countries around the world. This practice was not followed by many of the countries in the European Union because of their concern about the limitations of the method and its use for predicting wind turbine sound propagation. For example, there are alternate models that have been developed specifically for wind turbines in the Nordic countries. These models, have been validated by peer-reviewed independent studies and used in those countries.

The proposition that appears to influence the MOE's approval and complaint process is that the model's predicted sound level at a receptor has a higher weight than the complaints and followup measurements by MOE field staff and independent acousticians. Ignoring the independent acoustical measurements, and even reports from MOE field staff that sound levels at homes are exceeding 40 dBA when winds are below 4 m/s based on claims that the models demonstrate compliance is both illogical and unscientific.

However, there is an explanation for this disconnect that points to a misapplication or misunderstanding on the part of the MOE about what the ISO model's predicted sound levels represent. Some of this has already been presented above, but please consider the following in addition to that discussion.

The Noise Assessment Report by Hatch takes the position that the ISO model predicts the sound level at a receptor as a short term Leq and that the ISO tolerances do not need to be considered when assessing compliance with the MOE noise limits. Nothing could be further from the truth. The introduction to the ISO model makes it clear that the model predicts a sound level that is a mean value representing the range of sound levels that might be expected to occur over periods of weeks or months, not hours or evenings, with weather still meeting the conditions of the model, e.g. mild downwind conditions under a mild temperature inversion. That "mean" value expressed in units of Leq, has a known variability of ± 3 dBA. This variability is part of ISO 1963-2, as it is stated in the ISO standard's section on estimated accuracy in Table 5 seen in Figure 2 below. Any model that does not include these tolerances in the final predicted sound level does not meet the ISO 9613-2 standard requirements. MOE's requirement that the noise assessments adhere to the ISO model standard means that the proper sound level to use for predicting future compliance of a project is by applying the upper boundary for estimated accuracy to the mean L_{eq} derived by applying the algorithms in the standard.

Table 5 — Estimated accuracy for broadband noise of L_{AT}(DW) calculated using equations (1) to (10)

Height, h [a]	Distance, d [a]	
	$0 < d < 100$ m	100 m $< d < 1\,000$ m
$0 < h < 5$ m	± 3 dB	± 3 dB
5 m $< h < 30$ m	± 1 dB	± 3 dB

a) h is the mean height of the source and receiver.
d is the distance between the source and receiver.

NOTE — These estimates have been made from situations where there are no effects due to reflection or attenuation due to screening.

Figure 3- ISO 9613-2 Table 5 Estimated Accuracy for calculations

Proper understanding of the ISO standard's assumptions and application of its algorithms shows that the position taken in the noise assessment, that the predicted L_{eq} values, by themselves, show compliance with the MOE's 40 dBA not to exceed sound limit, is absurd. The ISO standard, read and applied in its totality, makes it clear that the sound level that is calculated using the algorithms of the standard must include the tolerances in order to fully comply with the requirements and assumptions of the standard. This is the only way that can account for the day to day variability in sound levels that occurs for the stated weather conditions. The Leq derived from the algorithms is the mean of these variations. The sound levels for these conditions range ± 3 dB around the L_{eq} (mean).

The important point to understand is that the model predicts the ISO mean sound level over a long period of time. The mean Leq cannot be directly applied as a predicted short term L_{eq}, such as a one (1) hour or even a nighttime nine (9) hour sound level unless the tolerances are added to the mean to find the upper boundary for sound received under the ISO standard procedures. Yet, that flawed understanding is observed in the Amherst Island Wind Project model by Hatch. Use of the L_{eq}/mean sound level with +3 dB added to take into account day to day variations in sound propagation conditions is required if one is to claim that the model and its results comply with ISO 9613-2. This is just as much of a condition for using the results of the standard as are selecting the correct ground factors and input sound power levels. The +/- 3 dB range does not represent some unusual weather conditions. The +/- 3 dB range accounts for the variability in sound levels at a receptor under the mild weather conditions stated in the ISO assumptions. Thus, the MOE 2008 Guidelines describing what constitutes a "predictable worst case" nighttime condition must be evaluated by adding the upper boundary, +3 dB, to the predicted mean sound level (Leq).

The reviewer is under no delusion that use of the mean Leq without including the confidence limits for assessing compliance has been the accepted practice in Noise Assessment Reports used for permitting wind energy projects across Ontario by the MOE. But, that does not make this practice scientifically or logically acceptable. There comes a time when the MOE's acceptance of these flawed noise studies must stop. The past practice has been shown to be a misapplication of acoustical procedures and principles of the standards. Whether the MOE's practice of accepting models based only on the mean Leq is a result of not understanding the standards or is a result of some misguided intention to bias the predicted sound levels so as to produce sound level predictions that are favorable to the energy utility developer's goals, does not really matter. The practice that has been applied by the acoustical consultants who work for the utility developers and considered acceptable by the MOE, its staff, and outside experts, is gaining a reputation that has a name. As it has been practiced it must be called what it really is: "Junk Science" designed to promote a political agenda.

If the model was developed to address the concerns noted above, such that it represented commonly occurring "predictable worst case nighttime" conditions, this project would predict sound levels at the closest homes of 40 dBA or greater. The project as it is now presented will likely become a source of complaints and threats of lawsuits as have other similar projects which had similar "rosy scenario" predictions based on daytime sound power levels in the application's sound study.

Health Risks

My experience with industrial wind projects is that wind turbine utilities that appear to meet local requirements in the permitting stage often produce sound levels at the properties and homes of people adjacent or within the Project that lead to complaints once operation commences. Many of these exceed the 40 dBA $L_{(night\text{-}outside)}$ limit set by the World Health Organization (WHO 2009) for safe and healthful sleep even though the modeling indicated that the sound levels at the receiving locations would be 40 dBA or lower. Exceedances of the WHO recommended levels can result in a high level of community complaints of noise pollution, sleep disturbance, and nuisance. In addition, there is mounting evidence that for the more sensitive members of the community, especially children under six, people with pre-existing medical conditions, particularly those with diseases of the vestibular system and other organs of balance and proprioception, and seniors with existing sleep problems will be likely to experience serious health risks.

Infra and Low Frequency Sounds and their Impact on People

The Amherst Wind Project report focuses only on audible sound and relies on A-weighted sound levels for decision making. It dismisses infra-sound and low frequency sound because the MOE 2008 Guidelines do not set an exposure limit. While this may be the accepted process under MOE approval procedures it ignores a major characteristic of wind turbine noise. Figure 4 shows a table developed for the Shirley Wind Infrasound Noise Study with the 10 minute A, C, Z and G weighted sound levels for several of the samples collected in the homes. There were multiple test sites in each home that are numbered from 1-6. Note that the C-A difference in the highlighted cell is about 11.5 dB. Applying the MOE 2008 Guidelines this would indicate that there is no low frequency noise problem. However, when we compare the Z weighting to the A weighting we find a difference of 52.1 dB. This occurs because the A, C, and even G weighting excludes the infrasound energy from the wind turbines (see Figure 4-Low Freq...).

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Test Results from Shirley Wind Infrasound Noise Study
Shirley Wind Project, Glenmore Wis.
Conducted for Wisconsin Public Service Commission

Over-all Sound Levels with Various Filter settings for each 10 minute sample

R: Residence number	Weight Channel	LA 1	LA 2	LA 3	LA 4	LC 1	LC 2	LC 3	LC 4	LZ 1	LZ 2	LZ 3	LG 1	LG 2	LG 3
R1	L1	36.9	32.3	42.4	54.0	52.5	49.2	53.0	72.0	93.7	93.5	93.8	67.5	67.1	68.3
12/4/2012	L10	33.7	30.5	34.6	37.7	50.7	42.9	46.2	60.0	89.5	89.1	89.4	63.9	63.0	64.1
20:43:32	L50	33.2	30.1	30.3	32.3	48.9	39.8	42.7	48.5	80.6	80.0	80.5	58.6	55.7	58.3
2.2 mps	Leq	33.9	30.2	32.9	76.2	49.2	41.2	44.4	94.9	85.0	84.6	85.0	60.4	58.9	60.6
R1	L1	36.1	32.6	[illegible]	[illegible]	[illegible]	[illegible]	50.8	85.3	104.1	104.0	104.3	77.3	77.2	77.5
12/4/2012	L10	34.0	31.2	30.7	54.8	51.2	47.2	47[illegible]	[illegible]	[illegible]	[illegible]	98.8	71.9	71.7	72.1
21:15:33	L50	33.5	30.3	29.8	44.7	49.5	42.7	43.5	64.1	89.8	89.7	90.0	64.1	[illegible]	[illegible]
3.2 mps	Leq	35.9	33.7	34.1	54.0	50.7	46.4	47.0	73.1	94.6	94.4	94.7	68.2	[illegible]	[illegible]
R1	L1	34.9	32.4	34.4	64.2	50.4	48.0	48.2	83.5	100.6	100.4	100.7	73.7	[illegible]	[illegible]
12/4/2012	L10	32.5	30.6	30.4	52.6	48.7	44.5	44.8	75.1	95.9	95.7	96.0	69.1	69.0	69.3
21:28:08	L50	32.2	30.1	29.7	43.2	47.4	41.0	41.5	62.4	87.7	87.6	87.8	61.6	61.2	61.9
2.8 mps	Leq	32.7	30.3	30.0	51.9	47.6	42.0	42.4	71.6	91.6	91.4	91.7	65.0	64.8	65.3
R1	L1	36.5	36.8	47.5	56.9	56.9	57.5	63.4	72.7	96.6	96.2	96.4	71.3	71.4	76.8
12/5/2012	L10	31.9	31.2	39.1	38.7	48.4	45.8	50.2	60.9	90.5	90.1	90.5	65.2	64.8	67.0
12:30:22	L50	31.3	30.1	30.8	37.4	46.0	41.5	44.7	58.6	79.8	79.3	80.1	57.8	56.4	60.2
1.2 mps	Leq	32.1	31.0	37.0	53.4	47.6	45.8	51.0	70.0	86.1	85.8	86.2	61.7	61.5	65.8

dBA-dBC=44.4-32.9=11.5 dB

dBA-dBZ=85.0-32.9=52.1 dB

dBG misses most of the energy because the G-filter attenuates most energy below 2 Hz.

Figure 4-Low Frequency components of In-Home Sounds at Shirley Wind Project Homes vacated by owners re: complaints of vestibular disturbances

In spite of assertions by some in the wind energy industry that wind turbines do not produce significant infra and/or low frequency other independent acousticians and medical professionals have repeatedly reported field tests showing that wind turbine sounds are heavily weighted to the infra and low frequency end of the acoustic spectrum. The level of annoyance produced by wind turbine noise also increases substantially for low frequency sound**,** once it exceeds a person's threshold of perception. A recent paper by Dr. Henrik Moller shows that as the wind turbines get larger (e.g. longer blades and higher towers) the sound emissions shift downward in the spectrum producing a lower dBA rating while the over-all acoustic energy in the lower frequencies increases dramatically.[15] There is no reason to assume that the proposed new turbine for the Project will not have a similar characteristic.

Because infra and low frequency sounds from wind turbines also include significant dynamic modulation in the frequency range from the blade passage frequency of from 1 Hz or less, up to about 10 Hz, standard acoustical instruments such as 1/3 octave band analyzers and FFT analyzers using band filtering cannot be used to measure the short duration pulsations. This is covered in detail in the Bray/James paper referenced earlier. Instrumentation with 1/3 octave band resolution of the spectrum sound pressure levels can only be used for assessing steady state infrasound (sounds lasting many seconds or minutes), and even then, the readings may understate the total acoustic energy and the maximum sound pressure levels if care is not taken to address any amplitude pulsations or changes in frequency[16].

Infrasound is often incorrectly presumed to be in-audible until sound pressure levels reach amplitudes of 90 to 100 dB or more in the frequencies from 10 Hz and lower. However, when considering the most sensitive people, the thresholds drop approximately 6-12 dB. Further, the Thresholds of Perception referenced in technical papers (for example those by Turnbull, Leventhall, and O'Neal) that discount wind turbine infrasound emissions only consider the thresholds for a <u>single, steady, pure tone under laboratory conditions</u>. Wind turbine sounds are a complex mix of tones, all within the same critical band. For some people they will be audible at levels much lower than what is required for a single, steady, pure tone. Complex sounds are more readily audible. And, as can be seen in Figure 4, in the dBZ columns, sound pressure levels of infrasound can exceed the audibility thresholds for short periods such as 10% of the time.

The combination of people with extra sensitivity and the presence of a complex set of tones in the range from 0 to 20 Hz puts the infrasound sound pressure level peaks measured on receiving properties and inside homes within the threshold of perception for a subset of the population. Claims that wind turbine infra sound is "not significant" because it does not reach the amplitudes needed to exceed the Thresholds of Perception are mischaracterizing the situation. The truth is we only know the Thresholds of Perception for single steady pure tones. When the sounds are more complex, as for wind turbines with their multiple combinations of tones and tone fragments with varying types of amplitude and frequency modulation, we do not know the Threshold of Perception. All we know is that it will be lower than for a single steady pure tone.

Vestibular vs. Auditory Perception

There are more ways a sound can be perceived than just as audible sound. Perception mediated by the vestibular organs does not involve 'hearing' the sound. (see Salt, Pierpont and others) For audible sounds in the infra and low frequency range the annoyance and the sense of loudness increases more rapidly than the more readily audible mid-frequency sounds. Sound measured as dBA is biased toward 1,000 Hz, the center of the most audible frequency range of sound pressure. Low frequency sound is in the range below 200 Hz and is more appropriately measured as dBC for low frequency sound or in dBG for infrasound. As a result use of dBA criteria misses an important aspect of wind turbine noise and is not appropriate as a criteria for noise sources that have low frequency content.

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[15] Moller, H., Pedersen, C., "Low frequency noise from large wind turbines," Journal of the Acoustical Society of America, 129 (6), June 2011.

[16] A paper co-written by this reviewer and Wade Bray of Head Acoustics which presented the findings of an analysis of wind turbine low and infrasonic sound that shows these micro-time pulsations are present at levels that exceed the threshold of audibility for steady pure tones and also by the vestibular process identified by Salt et. al.. These papers were referenced earlier in this review.

For many years it has been presumed that only infra and low frequency sounds that reached the threshold of audibility for people posed any health risks. Many acoustical engineers were taught that if you cannot hear a sound, it cannot harm you. Recent research has shown that the human body and auditory system is more sensitive to infra and low frequency noise (ILFN) than previously believed. This perception is not one that is 'heard' but rather it is one that involves the organs of balance (vestibular systems) and is often "felt." The vestibular portion of our auditory system can respond to levels of infra and low frequency sound at pressures significantly lower (as much as 30-40 dB) than what is needed to reach the thresholds of audibility.[17]

Dr. Nina Pierpont has conducted a study of the effects of infra and low frequency sound on the organs of balance that establishes the causal link between wind turbine ILFN and medical pathologies. This research is discounted by the wind industry as not meeting standards for epidemiology and that it is not 'peer-reviewed.' Neither accusation is correct. The type of epidemiological study conducted by Dr. Pierpont is termed a case-crossover study. Dr. Carl Philips, a highly respected epidemiologist not associated with the wind industry has said: [18]

> *"In particular, my scientific analysis is based on the following points, which are expanded upon below:*
>
> *"1. Health effects from the turbine noise are biologically plausible based on what is known of the physics and from other exposures.*
>
> *"2. There is substantial evidence that suggests that some people exposed to wind turbines are suffering psychological distress and related harm from their exposure. These outcomes warrant the label "health effects" or "disease" by most accepted definitions, though arguments about this are merely a matter of semantics and cannot change the degree of harm suffered.*
>
> *"3. The various attempts to dismiss the evidence that supports point 2 appears to be based on a combination of misunderstanding of epidemiologic science and semantic games. "*
>
> *Also,*
>
> *"There is ample scientific evidence to conclude that wind turbines cause serious health problems for some people living nearby." And,*
>
> *"The reports that claim that there is no evidence of health effects are based on a very simplistic understanding of epidemiology and self-serving definitions of what does not count as evidence. Though those reports probably seem convincing prima facie, they do not represent proper scientific reasoning, and in some cases the conclusions of those reports do not even match their own analysis."*

Dr. Pierpont's study and report was peer-reviewed by some of the top experts in the U.S. and Britain who have experience with vestibular disturbances and adverse health conditions. These reviews were included in the published final report. Any criticisms leveled at Dr. Pierpont's work by supporters of wind power utilities are not supported by the facts.

There is new research to support Dr. Pierpont's study. It is not from the traditional fields that have provided guidance for acoustical engineers and others when assessing compatibility of new noise sources and existing communities. Instead it comes from the field of research into auditory and vestibular function. A recent peer reviewed paper by NIDCD/NIH researcher Dr. Alec Salt, reported that the cochlea responds to infrasound at levels 40 dB below the threshold of audibility.[19] These studies show how the body responds to extremely low levels of energy not as an auditory response, but instead as a vestibular response.

In a personal communication, this reviewer asked Dr. Salt the question: "Does infrasound from wind turbines affect the inner ear?" Dr. Salt responded:

> "There is controversy whether prolonged exposure to the sounds generated by wind turbines adversely affects human health. The un-weighted spectrum of wind turbine noise slowly rises with decreasing frequency, with

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[17] Salt et. al.

[18] Philips, Carl v., " An Analysis of the Epidemiology and Related Evidence on the Health Effects of Wind Turbines on Local Residents," for Public Service Commission of Wisconsin docket no. 1-AC-231, Wind Siting Rules, July 2010.

[19] Salt, Alec, "Responses of the ear to low frequency sounds, infrasound and wind turbines", Hearing Research, 2010. This work was supported by research grant RO1 DC01368 from NIDCD/NIH

> greatest output in the 1-2 Hz range. As human hearing is insensitive to infrasound (needing over 120 dB SPL to detect 2 Hz) it is claimed that infrasound generated by wind turbines is below threshold and therefore cannot affect people. The inner hair cells (IHC) of the cochlea, through which hearing is mediated, are velocity-sensitive and insensitive to low frequency sounds. The outer hair cells (OHC), in contrast, are displacement-sensitive and respond to infrasonic frequencies at levels up to 40 dB below those that are heard."
>
> "A review found the G-weighted noise levels generated by wind turbines with upwind rotors to be approximately 70 dBG. This is substantially below the threshold for hearing infrasound which is 95 dB G but is above the calculated level for OHC stimulation of 60 dB G. This suggests that most wind turbines will be producing an unheard stimulation of OHC. Whether this is conveyed to the brain by type II afferent fibers or influences other aspects of sound perception is not known. Listeners find the so-called amplitude modulation of higher frequency sounds (described as blade “swish” or “thump”) highly annoying. This could represent either a modulation of audible sounds (as detected by a sound level meter) or a biological modulation caused by variation of OHC gain as the operating point is biased by the infrasound. Cochlear responses to infrasound also depend on audible input, with audible tones suppressing cochlear microphonic responses to infrasound in animals. These findings demonstrate that the response of the inner ear to infrasound is complex and needs to be understood in more detail before it can be concluded that the ear cannot be affected by wind turbine noise."

During the summer of 2009, this reviewer conducted a study of homes in Ontario where people had reported adverse health effects that they associated with the operation of wind turbines in their communities[20]. The study involved collecting sound level data at the homes and properties of these people, many of who had abandoned their homes due to their problems. This study found that sound levels in the 1/3 octave bands below 20 Hz were often above 60 dB and in many cases above 70 dB. Since the shape of the spectrum for wind turbine sound emissions is greatest at the blade passage frequency which was below the threshold for the instruments used it can be assumed that the sound pressure levels in the range of 0 to 10 Hz exceeded 70 dBA. Given the statement by Dr. Salt that vestibular responses would start at levels of 60 dBG or higher this data supports the hypothesis that there reason to consider the potential for a link between the dynamically modulated infra sound produced by wind turbines and reported adverse health effects. Since the time of that study at least five (5) homes have been purchased by or for Ontario wind energy utility operators because of health effects on the owners and many others have been abandoned as stated earlier in this review because the owners did not have the economic resources to hire an attorney to fight for a buy-out.

Adverse health effects related to inaudible low frequency and infra sound have been encountered before. Acoustical engineers in the Heating, Cooling and Air Conditioning (ASHRAE) field have suspected since the 1980’s and confirmed in the late 1990’s that dynamically modulated, but inaudible, low frequency sound from poor HVAC designs or installations can cause a host of symptoms in workers in large open offices[21]. It should be noted that the C-A test used by some acousticians to test for unbalanced spectrums was developed in the late 1970's by Mr. Charles Ebbing, Manager of Carrier Corporation's Acoustical Labs as a way to identify office spaces that might cause Sick Building Syndrome. After extensive research, it was concluded that because it was not sensitive to the lowest frequencies it would be better to use Linear-A as the test.

The ASHRAE handbook devotes considerable attention to the design of systems to avoid these problems and has developed methods to rate building interiors (RC Mark II) to assess them for these low frequency problems[22]. These do not use the C-A rule. The spectrum of sound inside one of the homes at Shirley Wind is shown in the Figure below.

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[20] James, R. R., "Comments Related to EBR-010-6708 and -010-6516" Comment ID 123842, 2009

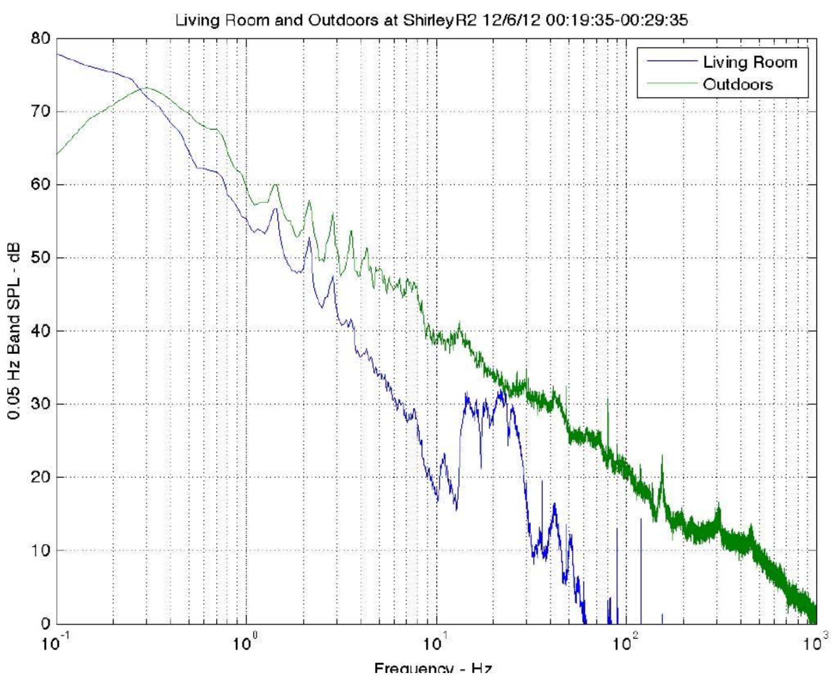
[21] Persson Waye, Kirsten, Rylander, R., Benton, S., Leventhall, H. G., Effects of Performance and Work Quality Due to Low Frequency Ventilation Noise, Journal of Sound and Vibration, (1997) 2005(4), 467-474.

[22] The study also showed that NC curves are not able to predict rumble. This use of NC curves was disproved in the 1997 Persson Waye, Leventhall study. Use of the RC Mark II procedures is more appropriate for this use.

Note that the slope of the energy is very sharp with a 50 dB difference between the energy at 0.4 Hz and 10 Hz. It also shows the building resonance responding to the infrasound from outside raising the sound pressure levels in the range of 15 to about 40 Hz over 15 dB.

Unlike the A-weighted component, the low-frequency component of wind turbine noise "*can penetrate the home's walls and roof with very little low frequency noise reduction.*[23]" Further, as discussed in the 1990 NASA study the inside of homes receiving this energy can resonate and cause an increase of the low frequency energy over and above what was outside the home. This makes the infra and low frequency sound immissions from wind turbines more likely to be an indoor problem than an outdoor problem where the audible sounds, such as blade swish and other wind turbine noises in the mid to high frequency range will dominate the soundscape.

Today, there is a renewed interest in the effects of low frequency sound from wind turbines. A paper titled: "*Infrasound, The Hidden Annoyance of Industrial Wind Turbines,*" by Prof. Claude Renard of the Naval College and Military School of the Fleet (France) concludes:



"The information given above is enough to understand that it is better not to be exposed to infrasound which propagates far from its point of origin and against which it is impossible to protect oneself due to the long wavelengths.

"Those most affected by exposure to infrasound are rural inhabitants living in proximity to wind turbines, and those working in air-conditioned offices.

"The people in the former category are exposed to the infrasound 24 hours a day, whereas people in the latter category are only exposed to infrasound 6 hours a day.

"The most important issue is therefore to know what intensity of infrasound can be tolerated without inconvenience over these periods of time.

"We do not have the answer to this question."

For some unknown portion of the community, there will be a risk of the adverse health effects currently described as Wind Turbine Syndrome mediated through the body's organs of balance (vestibular) and proprioception. This is a different set of symptoms and causes than what would be expected from exposure to higher levels of infra and low frequency sound (above the threshold of audibility) and are not related to the audibility of the ILFN. Papers on infra and low frequency sound from wind turbines generally only consider adverse health effects to occur when the sound pressure level of the noise source exceeds the Threshold of Perception of audibility of steady pure tones. Given the discussion above it should be clear that the human auditory system is more likely to perceive a sound that has multiple tones that vary in frequency and amplitude over short periods of time, as does wind turbine noise, than a steady pure tone and that symptoms can occur at sound pressure levels below the threshold of audibility.

[23] Kamperman and James (2008), p. 3.

The combination of the above negative factors in the reports prepared as submittals regarding the Project's wind turbine noise emissions/pollution will result in sleep disturbance for a significant fraction of those who live up to a mile or more away. Chronic sleep disturbance results in serious health effects. Further, some people will be at risk of the adverse health effects collectively described as Wind Turbine Syndrome as a result of the infra and low frequency sounds emitted by multi-megawatt wind turbines.

4.0 Statement of Findings and Opinions Regarding Amherst Island Wind Project Noise Assessment

Findings and Opinions based on review of information required by the MOE's 2008 Ontario Noise Guidelines for Wind Farms or the Renewable Energy Act (REA) that is missing or incomplete in the Noise Assessment Reports are addressed first. Findings and Opinions based on methodology or other deviations from generally recognized acoustical engineering principles are also addressed.

4.1 Statement of Findings

In this section I cite the section of the applicable regulation or guidance document which my review finds that the Noise Assessment Reports has not met or adhered to, and then, under the sub-heading "Finding", I discuss the specific deficiency in the Noise Assessment Reports.

DEFICIENCY 1:

Re: Does not meet requirements for information disclosure and reporting of Ontario Regulation 359/09 (Nov. w, 2012) Renewable Energy Approvals (REA) and/or **MOE Ontario Noise Guidelines for Wind Farms (2008)**

Re: Ontario Regulation 359/09 (Nov. 2, 2012) Renewable Energy Approvals (REA), Definitions

“sound power level” means the rating that,

> (a) is given to a wind turbine by the manufacturer of the wind turbine, calculated in accordance with standard CAN/CSA-C61400-11-07, “Wind Turbine Generator Systems – Part 11: Acoustic Noise Measurement Techniques”, dated October 2007, rounded to the nearest whole number, and
>
> (b) applies in respect of the wind turbine when the wind turbine is operating at 95 per cent of its name plate capacity;

Also Re: MOE 2008

6.2.3 Adjustment to Wind Turbine Generator Acoustic Emissions for Wind Speed Profile

> The wind speed profile on site of the Wind Farm may have an effect on the manufacturer’s wind turbine acoustic emission data and, consequently, on the sound levels predicted at a Point of Reception. Therefore, the wind turbine generator acoustic emission levels must be consistent with the wind speed profile of the project area.
>
> To address this issue, the assessment must use manufacturer’s acoustic emission data adjusted for the average summer night time wind speed profile, representative of the site.
>
> The adjusted acoustic emissions data must be used in the Noise Assessment Report at each receptor. The manufacturer’s acoustic emissions data and the adjusted acoustic emission data used in the Noise Assessment must be tabulated in Table 3.

Finding 1:

The Hatch model uses the Sound Power Level as reported by Siemens without the necessary adjustments required in the IEC 61400-11 and IEC 61400-14 test standards. The model was developed using the mean apparent sound power level from a group of measurements. IEC 61400-11 and 14 require that this mean apparent sound level be adjusted by adding the confidence adjustments for the test measurements to produce the Declared Apparent Sound Power Level. The declared sound power level is the appropriate input value for the model output to represent the mean predicted sound level with a 95% confidence level. Table 1 of O. 359/09 Row 14 states the measurement confidence limits must be reported. The Amherst Island Wind Project models do not report or include the measurement confidence levels.

IEC 61400 -14 Declaration of apparent sound power level and tonality values which is referenced in IEC 61400-11, differentiates the apparent sound power level from the declared sound power level. The difference being that the declared sound power level has the measurement confidence tolerance added to the apparent sound power level.

Section 5.1 of IEC 61400-14 states:

> "The apparent sound power level shall be declared by dual-number noise emission values reporting both L_W and *K*. *K* represents a certain confidence level and *K* =1.645 reflects probability of 5% that an apparent sound power level measurement result made according to IEC 61400-11 performed at a turbine of the batch exceeds the declared value."

The sound power data used as input for the model reported in Tables C.1 and C.2 of the NAR are the test series mean levels without adjustment for confidence limits as required by IEC 61400-14 to obtain the declared apparent sound power level. For the Siemens' SWT 2.3 113 the apparent sound power level is given as 105 dBA at 8 m/s. Given a generic measurement confidence of +/- 2 dB the declared sound power level used as model input would be 107 dBA. The basis for making this adjustment is in both the REA and MOE 2008 Guidelines because they require adherence to IEC 61400-11 which incorporates the requirements of IEC 61400-14 by reference. Thus, the proper input value for the Hatch models should all be increased by 2 dB.

Note: If Siemens' had provided the measurement uncertainty values for these turbines then it would be the sum of the actual confidence level for the test measurements plus the confidence level for turbine-to-turbine test variability. However, 2 dB is a commonly used value when the specific information is not available.

The result is that all of the predicted sound levels at receptors increase by 2 dB. This change to the model input would result in all noise receptors listed in NAR Table C.1 Noise Level Summary Tables currently having a calculated sound level of 38.1 dBA or more will, after adjustment, be over the 40 dBA criteria. There are 149 noise receptors identified in Table C.1 that will not meet the 40 dBA limit if IEC measurement variability is considered in the predicted sound level.

The need to include the confidence levels in the model for the Project is known to the staff of the MOE, as are the consequences of not doing so. A memorandum dated April 9, 2010 from Cameron Hall, Senior Environmental Officer, Guelph District Office to his District Manager and Supervisor is illustrative of this understanding:

> "...these setbacks were reportedly determined In Accordance with the Ministry of Environment's 2009 Publication "Development of Noise Setbacks for Wind Farms" ("2009 Ministry Setback Development Publication"). The setbacks were determined using a computer model which reportedly has an error of +/-3 dB. The computer model uses sound level mission statement provided by the manufacturer of the wind turbines (WTGs). In the case of the Melanchthon Eco-Power centre General Electric WTGs the sound level emissions are reported to have an error +/- 2 dB. So in fact, the ministry is using a computer program with output error of plus/-3 dB, where the data input into the computer program may have a +/- 2 dB error. It is not clear if these errors are added, subtracting, multiplying or divided by each other. If the errors are simply added, then the potential error in the predicted sound level limits receptor is +/- 5 dB. In the Melanchthon Eco-Power Centre case, and approval was issued where the predicted sound levels and most of the receptors was 40 dBA (rounded-off). If a 5 dBA error is applied, then the predicted sound level at the receptor could actually be as low as 35 dBA or as high as 45 dBA. Given the years involved in the computer model it appears reasonable to suggest that the conservative approach might be to only establish setbacks and approve locating WTGs where the predicted sound levels at receptors are 35 to 37 dBA." (See Exhibit C, part of the "FOIA documents" referenced in this critique).

The models developed for Amherst Island Wind Project are deficient because they fail to include the confidence level adjustments required in IEC61400-11 and 14 and failure to include these adjustments is a recognized reason for complaints as indicated in the FOIA documents as seen in Exhibits C and G.

DEFICIENCY 2:

Re: O. Reg. 359/09: Table 1 (Reports)

The Renewable Energy Approvals Table 1 Reports, O. Reg. 359/09, at row 14 provides requirements for the Noise Assessment Report that are not met by the Amherst Island Wind Project Noise Assessment Report. Row 14. Specifications report, wind facility (not class 2) requires:

> Provide specifications of each wind turbine, including:
> i) The make, model, name plate capacity, hub height above grade and rotational speeds.
> ii) The acoustic emissions data, determined and reported in accordance with standard CAN/CSA-C61400-11-07, "Wind Turbine Generator Systems — Part 11: Acoustic Noise Measurement Techniques", dated October 2007, including the overall sound power level, **measurement uncertainty value**, **octave-band sound power levels (linear weighted)** and **tonality and tonal audibility**. (Emphasis added)

Finding 2: The information provided in the Noise Assessment Report or its Appendix materials does not provide the measurement uncertainty value, the octave band sound power level (linear-weighted) or the tonality and tonal audibility information for the make and models of wind turbines proposed for the project. There is no information indicating the tonal and tonal -audibility potentially produced by the longer blades on the proposed models. Measurement uncertainty is not provided for the proposed models. Octave band sound power levels are provided only for the wind speeds of 6 m/s (SWT-2.221-113) and 8 m/s (SWT 2.3-113) as A-weighted sound levels not linear weighted values. Values used for sound power levels at 7, 9 and 10 m/s wind speeds are missing.

DEFICIENCY 3:

Re: MOE Ontario Noise Guidelines for Wind Farms (2008) Section 6.2.2 "Wind Turbines"

This section states that:

> "The acoustic emissions of the wind turbine must be specified by the manufacturer for the full range of rate operation in wind speeds. As a minimum, the information must include the sound power levels, frequency spectrum an octave bands (63 to 8000 Hz), and tonality and integer wind speeds from 6 to 10 m/s. The acoustic emission information must be determined and reported in accordance with the international standard CAN/CSA - C61400 - 11 - 07, reference [5]."

Finding 3: The Hatch noise impact statement only included manufacturers data for 6 and 8 m/s wind speeds and failed to include the 7, 9, and 10 m/s data as required by the MOE. See Finding 2 for the response to the similar requirement of the REA.

DEFICIENCY 4:

Re: MOE Ontario Noise Guidelines for Wind Farms (2008), Section 6.4.7 Prediction Method,

> "Predictions of the total sound level at a Point of Reception or a Participating Receptor must be carried out according to the method described in standard ISO 9613 - 2, reference [6]. The calculations are subject to the specific parameters indicated in section 6.4.10."

Finding 4:

ISO-9613, part 2, Section 9, Accuracy and Limitations of the method includes Table 5, *Estimated accuracy for broadband noise of L_{AT} (DW) calculated using equations (1) to (10)* states the confidence limits are +/- 3 dB. But this is true only if the model adheres to all assumptions and limitations specified in the standard. The Amherst Island Wind Project model does not include any adjustments to apparent sound power levels for the ISO confidence limits. The requirement to follow ISO 9613-2 carries with it a requirement to properly apply the confidence levels associated with the standard's algorithms. The stated confidence limits are +/- 3 dB for predictions between 100 and 1000 m. from each noise source. The argument for applying the confidence level to predicted sound levels is the same as for the similar requirements to follow IEC 61400-11 requirements to adjust measurement test values for the confidence level to provide results a stated degree of confidence.

The FOIA document referenced in Finding 1 demonstrates that the need to account for confidence limits in both the mathematical calculations (ISO 9613-2) and the measurement procedure for sound power levels (IEC 61400-11) are understood by the MOE staff. The FOIA document quotation in Finding 1, and the document in general, shows that the consequences of not including them (as done in the Amherst Island Wind Project models) will lead to approval of projects that result in complaints and other adverse effects.

If the NAR model had included a combined 2 and 3 dB adjustment to account for the confidence levels as described in the FOIA quotation of Finding 1 then all noise receptors in Table C.1 Receptor noise level summary table with a predicted sound level of 35.1 dBA or higher would exceed the 40 dBA limits of the MOE Guidelines. This would put 364 noise receptors inside the study zone over the limit for the SWT 113 series wind turbine project described in the NAR. With the adjustments for day to day variability and nighttime operations it is possible to state that **436 noise receptors or vacant lot surrogates may exceed the 40 dBA threshold within the 95% confidence limits of both the modeling and measurement protocols**. Without that adjustment, as the data is presented in Tables C.1 and C.2 there is no confidence that noise receptors or vacant lot surrogates will be under the 40 dBA threshold.

DEFICIENCY 5:

Re: MOE Ontario Noise Guidelines for Wind Farms (2008), Section 6.4 .10 Specific Parameters, section C) states:

> "The term for ground attenuation must be calculated using the "General" method in the standard ISO 9613 – 2, Reference [6]. For Class 2 and 3 Areas, the assessment must use ground factor values not exceeding the following:
>
> **G_s** = 1.0,
> **G_m** = 0.8, and
> **G_r** = 0.5. "

Finding 5:

For the model to represent a predictable worst-case scenario the presence of reflective ground such as hard packed farm fields must be considered. Ground attenuation for that situation would be equal to 0.0. The Hatch model did not make this conservative assumption by instead used ground attenuation equal to 0.7, almost the upper limit of the range permitted by MOE. Several studies have been conducted by Mr. Ken Kaliski, Brd. Cert. INCE, Resource Systems Group (RSG) to compare the various methods available in the ISO 9613-2 standard for constructing a model of wind turbines on flat farmland. These studies have been reported in two major conferences and published in several variations in several journals. The study found that when using the General Method of ISO 9613-2 with octave band level of detail (referred to as ISO-Spectral in the studies) that the most accurate predictions required setting the ground factor for all three variables (G_s, G_m, and G_r) equal to 0.

Predictions made with higher ground factors such as those used in the Amherst Island Wind Project model resulted in a 5 dBA under-estimate of the true measured sound level. See **Exhibit D** "*Propagation Modeling Parameters for Wind Turbines", Proceedings of Noise-Con 2007*, for one of the earlier presentations made on this study. Also, see **Exhibit E** "*Improving predictions of wind turbine noise using PE modeling," Proceedings of Noise-Con 2011* for a more recent paper on the issues raised here about ground effects and other issues related to use of ISO 9613-2 for models of wind turbine projects.

The MOE Guidelines do not require that the ground factors be applied. The requirements of MOE 2008 Guidelines Section 6.4 stress that the model must reflect the principle of "predictable worst-case noise impact." It must be assumed that the person(s) responsible for constructing models of proposed projects are qualified acoustical experts and that they are current with the literature on the specific topics of their work. Thus, to provide accurate model predictions for Amherst Island Wind Project Wind using the ISO methods required by the MOE the ground factors should have been set to 0 to provide the more accurate predictions as discussed in the Kaliski reports. The effect on the predicted sound levels at the noise receptors and vacant lot surrogates would be to increase the sound levels reported in NAR Tables C.1 and C.2 by 5 dBA. As shown in Finding 4, a 5 dBA increase would result in 364 receptors and surrogates exceeding the 40 dBA threshold.

DEFICIENCY 6:

Re: MOE Ontario Noise Guidelines for Wind Farms (2008), Section 6.2.3 Adjustment to Wind Turbine Generator Acoustic Emissions for Wind Speed Profile requires that the assessment must use the manufacturers acoustic emission data adjusted for the average summer nighttime wind speed profile, representative of the site. The manufacturers acoustic emissions data and the adjusted acoustic emission data used in the Noise Assessment must be tabulated in Table 3. And,

Re: MOE Ontario Noise Guidelines for Wind Farms (2008), Section 6.4 Detailed Noise Impact Assessment, "The noise assessment must represent the maximum rated output of the wind farm, and reflect the principle of "predictable worst-case" noise impact, publications NPC-205 and NPC-232, references [2] and [4].

Finding 7:

Models developed as part of the approval process for wind turbine utilities in Ontario have found to under predict the sound levels measured during complaint follow up both in the USA and in Ontario by 3 to 5 dBA. This is reported in the Proceedings of InterNoise 2009 in a paper by *Mr. Brian Howe and Nick McCabe of Howe Gastmeier Chapnik Limited (HGC Engineering) titled: "Recent developments in assessment guidelines for sound from wind power projects in Ontario, Canada, with a comparison to acoustic audit results*," (**Exhibit F**). The paper discusses the various improvements that have been incorporated into the 2008 Guidelines to address earlier variability in model results. Yet, even with these improvements there remains a significant difference between what the model used for project approval predicted and what is found during follow-up measurements in the field. In the conclusion section of the paper it is stated:

> "These improvements have increased the consistency between assessments, although there remains in practice variations of at least +/- 5 dB between the predicted impacts and sound levels measured in the field. Despite the relatively robust approval process that is currently in place, complaints related to noise and health effects still occur and there is pressure from a segment of the public to increase the setback distance between wind turbine generators and residential dwellings." Exhibit F, page 8, (Emphasis added)

Similar findings have been reported by others who have compared model predictions to operational levels during complaint follow-up. The general conclusion is that models do not reflect many of the real world operating conditions leading to understatement of at least 5 dBA of the noise impact on adjacent properties.

In a report funded by the US DOE for the Minnesota Public Utility Commission, titled: "Assessing Sound Emissions from Proposed Wind Farms & Measuring the Performance of Completed Projects," October 11, 2011, pages 12-13, the author, Mr. David Hessler of Hessler Associates, Inc. stated:

> "Extensive field experience measuring operational projects indicates that sound levels **commonly fluctuate by roughly +/- 5 dBA about the mean trend line** and that short-lived (10 to 20 minute) spikes on the order of 15 to 20 dBA above the mean are occasionally observed when atmospheric conditions strongly favor the generation and propagation of noise." (Emphasis added)

The point that Mr. Hessler makes in the Minnesota document is well known to acousticians working on wind turbine noise issues. Weather conditions and operating modes of wind turbines not accounted for in the model presented in the NAR can increase the mean/average/Leq sound levels by 5 dBA or more. This should be expected given that +/- 5 dB is the confidence level for the combined measurement data and modeling protocols. This has been verified by myself as well as other acoustical consultants in the U.S., Ontario, New Zealand, Australia, and the U.K..

In the submittal by Mr. William Palmer titled: *"Review of the St. Columban Wind Project Wind Project-Design and Operations Report, dated May 12, 2012* lists other studies that support the variability. Mr. Palmer points out that the model presented in the NAR represents the noise emissions from a new wind turbine. As a turbine's blades and other components age the noise levels will increase. Stefan Oelerman, an acoustician with the National Aerospace Laboratory (NLR), the Netherlands, reported in a 2005 and 2007 paper that as blades become dusty and bug splattered the noise level of the wind turbine increases by 3 to 5 dB. Studies conducted in Ontario by multiple acoustical consultants, Aercoustics Engineering Limited's study of the Kruger Wind Farm, a study of Melancthon Wind Farm by HGC, and another by Valcoustics Canada Limited conclude that the models under predict the real world sound levels as much as 3 to 5 dBA 18 to 50% of the time.

Similar observations are found in MOE staff communications released under FOIA. For example an exchange between Mr. Gary Tomlinson, Senior Environmental Officer, Guelph District office, Victor Low, (ENE), Jane Glassco (ENE), Bill Bardwick, (ENE) between June 26 and 29th, 2009 includes the following observation:

> "The complainants state, and observations made by GDO Staff confirm that, at some locations that the cumulative noise emissions from the operation of a number of wind turbines, (blade swish) are exceeding the requirements set out in the CofA(Air). …… In cases where GDO staff have identified exceedances of the CofA, (noise levels measured between 44 dBA and 45 dBA utilizing NPC-103 methodology with wind speeds of less than 6 m/s)…" (**Exhibit G**, page 2 of 5) (Emphasis added).

The main point of this Finding is that once the MOE is aware of situations where the models used for the approval process are under-predicting the real world measurements of "predictable worst-case" noise impacts it must be concluded that the models do not comply with the requirements of Section 6.4 Detailed Noise Assessment . This means that models programmed with the uncorrected test sample mean sound power levels without adjustments for confidence limits, using an ISO modeling method that has an additional 3 dB confidence level (which is also not applied), and using ground factors that have been shown to result in under prediction in ISO model in well reported studies specific to wind turbine models on flat farmland must be considered deficient for demonstrating compliance with the 40 dBA threshold of the 2008 MOE Guidelines.

The situation described in the FOI excerpt is one likely reason why there is a common finding that the sound levels predicted by models designed to MOE 2008 are 3 to 5 dBA lower than what is measured during compliance visits noted above. That is the MOE Guidelines prohibits use of a 5 dB penalty for blade swish. Thus, models are routinely developed that exclude this aspect of wind turbine noise emissions. But, the requirement that the models represent the "predictable worst-case" noise impact and the field reports that show blade swish increases sound levels above the predicted values requires the acoustic energy from blade swish to considered if the model is to accurately represent a worst-case noise impact.

This reviewer suggests that the blade swish can be accounted for as an increase in the sound power levels emitted by the wind turbines instead of the prohibited 5 dB penalty for impulsive noise. The adjustment would be in the range of +5 dBA based on field reports noted above. Increasing the manufacturer's acoustic emissions data for the higher sound emissions during periods of blade swish (as permitted in Section 6.2.3) would result in more accurate model predictions. Using this approach to adjusting the model's for the "predictable worst-case" noise impact would account for the routine under prediction noted by MOE staff and independent consultants. . The MOE documents provided under FOIA and included as **Exhibits C** and **G** demonstrate that this line of reasoning is similar to the concerns raised by the MOE field staff.

MOE's 2008 Ontario Noise Guidelines for Wind Farms provide for such an adjustment in section 6.2.3 Adjustment to Wind Turbine Generator Acoustic Emissions for Wind Speed Profile that:

> "The wind speed profile on site of the Wind Farm may have an effect on the manufacturer's wind turbine acoustic emission data and, consequently, on the sound levels predicted at a Point of Reception. Therefore, the wind turbine generator acoustic emission levels must be consistent with the wind speed profile of the project area." (emphasis added)
>
> "To address this issue, the assessment must use manufacturer's acoustic emission data adjusted for the average summer night time wind speed profile, representative of the site." (emphasis added)

In "Effects of the wind profile at night on wind turbine sound" (**Exhibit H**) G.P. van den Berg states:

> "....measurements show that the wind speed at hub height at night is up to 2.6 times higher than expected, causing a higher rotational speed of the wind turbines and consequentially up to 15 dB higher sound levels, relative to the same reference wind speed in daytime. Moreover, especially at high rotational speeds the turbines produce a 'thumping', impulsive sound, increasing annoyance further. It is concluded that prediction of noise immission at night from (tall) wind turbines is underestimated when measurement data are used (implicitly) assuming a wind profile valid in daytime."

The "thumping" referred to in the Van den Berg paper occurs in synchronization with blade rotation (about one "thump" or "whoosh" per 0.8 second assuming the SWT 2.3-113 wind turbine hub is rotating at 16 rpm). "Thumping" as used here, is not the moderate blade "swish" of 1-3 dBA present when the turbine is operating in weather and wind conditions specified for the IEC tests. This moderate daytime "swish" is included as part of the wind turbine sound power ratings provided by the manufacturer. The "thumping" of concern is the much louder noise that is not accounted for in the manufacturer's test data. This occurs typically at night under a stable atmosphere where there is high wind shear. This "thumping" can modulate by 5 to 10 dBA or more and is a result of increased sound power emissions from the wind turbine's blades.

Based on this the field observations of this reviewer, and that of the independent acousticians and MOE staff's experience the nighttime noise is increased by at least 5 dBA over what is observed for similar hub level wind speeds during the day under low wind shear conditions required for the IEC 61400-11 tests. If the increased sound power caused by the nighttime atmospheric conditions had been added to the manufacturer's sound power for mild atmospheric conditions the predicted values would be 5 dBA or more higher than what is shown in the Amherst Island Wind Project report tables and contour map.

DEFICIENCY 8:

Re: *Noise Guidelines for Wind Farms, Interpretation for Applying MOE NPC Publications to, Wind Power Generation Facilities*

Section 6 of the MOE's "*Noise Guidelines for Wind Farms*" describes the requirements for a detailed Noise Assessment . These guidelines stipulate that the report:

> "must demonstrate compliance with the applicable sound level limits and the supporting information must be organized in a clear and concise manner. The report must be prepared by qualified acoustical consultant and the cover document must be signed by the proponent for the project."

Finding 8:

A review of the NAR materials found no indication that the staff of Hatch are qualified acoustical consultants. The identified personnel do not appear on the membership list of the Institute of Noise Control Engineers (INCE) nor do they present other qualifying credentials.

Further, the preparer's of the NAR for Amherst Island Wind Project have not incorporated findings from other acoustical consultants and experts into their work for the project, as would be expected of qualified, professional acoustical consultants. The preparers of the NAR did not consider the information about successes and failures of other projects or the research into how to develop accurate models of wind turbines. These are strong indications that the staff members involved with modeling may not have independent qualifications in acoustics.

4.2 Opinions

Opinion 1

Using the NAR project description there will be a maximum of thirty three (33) Siemens SWT 2.3 - 113 series wind turbines and two (2) SWT-2.221-113 models included in the proposed mix of wind turbines. The NAR Table C.1 shows that 149 receptors will be within 2 dBA of the allowed 40 dBA under even the rosy scenario present in the Hatch NAR. If only the ISO tolerance of ±3 dBA for day to day variability is considered 178 receptors exceed the MOE criteria. Not only does this demonstrate the marginal nature of the proposed project, from compliance perspective, it also means there are few noise reduction options should the project be found to be out of compliance in the future. Use of noise reduced modes can only reduce sound levels by about 3 dBA and this results in a significant impact on energy production. It means there are fewer mitigation measures available should noise complaints be filed once is operational. For complaints that related to one or more of the turbines operating during what is described here-in as 'nighttime' conditions (e.g. +5 dB over Table C.1) there may be no mitigation method available other than turning the wind turbine off during nights or other conditions when wind turbines produce higher than expected noise. Further there is nothing that will guarantee that the noise reduced modes will always be used.

The approval process is the only time when adverse effects of locating wind turbines too close to occupied structures can be prevented. The findings presented above show that even with this tight design the model is under predicting the sound levels that would be measured during a complaint follow-up.

This is why it is critical to address the flaws identified in this critique by either rejecting the project in total or requiring that an alternative design be developed that addresses the issues raised herein, and that can show model results that provide a margin of safety to accommodate them. The Project as designed does not provide a adequate margin of safety. The FOIA documents (Exhibits C and G) demonstrate the challenges with ensuring noise compliance with regulations once a project is operational. This means that the approval process is the only time to avoid granting permits to projects that do not fit into a community. Since this project is already a tight fit there are sufficient grounds to believe that this project is likely to exceed the MOE allowable noise standard, result in complaints, and create adverse effects as a result of the noise emitted from the project. FOIA documents and experience with complaints that have gone unresolved demonstrate that the MOE compliance protocols have not been effective in establishing whether a wind project complies or does not comply with MOE regulations. As a result, if Amherst Island Wind Project is approved in spite of the flaws identified in this report there is no recourse available to enforce mitigation or otherwise address complaints.

Opinion 2

The approval process is the only safety mechanism to prevent the consequences of a project that proposes to locate wind turbines so close to occupied structures (noise receptors) that the margin between the predicted sound levels reported in Table C.1 of the Noise Assessment Reports and the MOE criteria of 40 dBA is zero for three (3) receptors and only a tenth of a decibel (e.g. 39.9 dB) below the 40 dBA threshold for six (6) more receptors. As demonstrated in the Findings section, below, it is likely that 436 noise receptors or vacant lot surrogates would exceed the 40 dBA threshold once the project is operational during commonly occurring nighttime conditions. Accordingly, MOE would be negligent if it approves this project as it is currently designed since the outcome is going to be the same.

Further, as evidenced by the FOIA documents, the Noise Assessment Reports submitted for other projects have under estimated the affect of the projects on noise receptors and that once these project were operational complaints have been filed because the operational sound levels were higher than predicted. It is submitted that this outcome will likely occur again at the Amherst Island Wind Project, particularly in light of the tightness of the project's design. As a result, it is my professional opinion that the project, as designed, should not be approved.

Opinion 3

High Probability of Exceeding 40 DBA Outside homes

In considering the impact of the way the model was constructed and how its results were described regarding compliance and potential for adverse health effects there is a great difference between the risk to public health as reported by Hatch and my own interpretation. As discussed above the model is programmed to represent a day time condition that is close to "predictable best case" scenario.

To demonstrate that the Amherst Wind Project is not compatible with the host community Exhibit I has been prepared to show the impact of considering the higher sound emissions and immissions that occur on typical nights. The table is based on the information from the Amherst Wind Project Noise Assessment Report, Table C.1 Noise Impact Summary. To that information two additional columns have been added to the right by this reviewer to represent the operation of the Amherst Wind Project during the day with the ISO 3 dB upper bound for day to day variability in sound and 5 dB for operation at night. As explained earlier, nighttime operation can cause increase of 5 to about 15 dBA over daytime operation. For this example, a 5 dBA increase in the Leq (mean sound level) has been assumed. The last column represents that "nighttime" condition with 3 dB added to the mean L_{eq} to identify the upper bound for sound levels at night. The table has been color coded to show which properties and home will exceed the MOE LIMIT of 40 dBA during nighttime operation. Yellow highlights show receptors that will exceed the 40 dBA limit when the Hatch model representing daytime operation plus 3 dB for variability in weather conditions occurring over multiple days, weeks, or months is considered. Pink highlights show the additional receptors that may exceed 40 dBA during operation at night when higher wind shear and turbulence is present than was present for the IEC 61400-11 measurements of sound power levels. This includes the 3 dB adjustment for variability in weather and sound propagation required for ISO 9613-2.

The results shown in the table for Exhibit I can be used to estimate the annoyance potential for this project. The table below shows the values extracted from Exhibit I that will be used in that evaluation.

Table of Day, Evening and Night Sound Levels for Amherst Island Model (dBA)				
	Lowest Lower Bound	Lowest Mean Leq	Highest Mean Leq	Highest Upper Bound
Daytime model (Hatch)	28.1	31.1	40.0	43
Night model (E-CS using +5 dB for higher nighttime emissions)	33.1	36.1	45.0	48.0

Using the information provide in this table it is possible to project the range of community responses to the proposed project. Figure 5 shows a chart from a pending paper by Steve Ambrose and Rob Rand, two acousticians from Maine who have done considerable work on wind turbines in the U.S.. This chart blends the Pedersen annoyance information with other community annoyance predictors. It is based on the L_{eq} and not the L_{dn} or L_{den}. This chart is also marked with red arrows showing the benchmark sound levels and has a red ellipse to show the range of responses to sound for the range of sounds shown in the Exhibit I: Table of Non-Participating Project Noise Receptors (436 receptors)" which is based on Hatch NAR, Appendix C, Table C.1

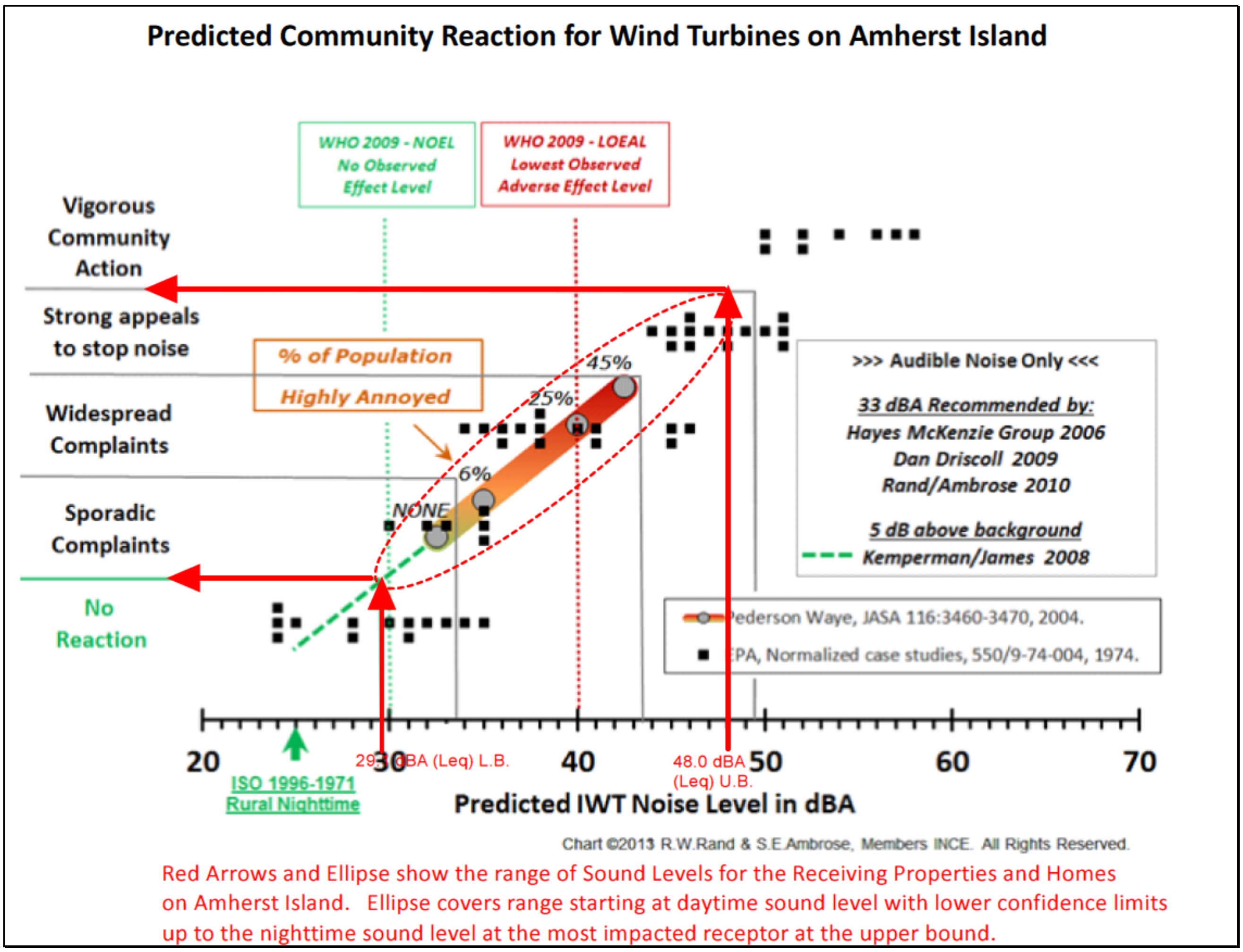


Figure 4-Predicted community response to Amherst Wind Project

The ellipse shows that the range of sound levels for the day and night conditions at the most impacted receptor range from "sporadic complaints" at the quietest conditions (daytime Leq under 30 dBA) to "Strong Appeals to Stop the Noise" for the typical nighttime L_{eq} of 48 dBA, just under "Vigorous Community Action" for the upper bound conditions at night.

CONCLUSION

In my professional opinion, the Amherst Wind Project Noise Assessment Report does not meet the requirements set forth in the REA or the MOE 2008 Guidelines. Further, the project itself poses a very strong probability, almost amounting to a mathematical certainty, that the project will:

1. Only four of the 436 Receptors within the study area on the island are within the MOE compliance limits of 40 dBA when normal variation in nighttime sound emissions (+5) and sound propagation prediction (+3) is taken into consideration.
2. Exceed the MOE limit of 40 Leq for wind turbine noise at the most impacted residence and at other non-participating residences (homes) under commonly occurring nighttime conditions. This includes people living in homes between 500m. and 1 kilometer and likely out to at least 2 km.
3. Result in higher levels of infra and low frequency sound than are considered safe for people in residential, educational, and other inhabited structures on a 24/7/365 exposure basis. The MOE 2008 Guidelines test provide no limits for infra and low frequency sound and, therefore, are not useful for protecting residents from this type of problem. The project poses significant risks to the health of people who may respond to vestibular disturbances independent of audible sounds that might cause awakenings and other direct effects on health.
4. Result in adverse health effects related to sleep disturbance and other direct consequences to health and well-being of people living within Noise Impact Study Area from the range of audible sounds produced by the wind turbines especially during periods when sound levels outside their homes exceed 40 dBA at night. This is supported by the WHO 2009 Nighttime Noise Guideline's threshold for observed adverse health effects which is 40 dBA at night at the facade of a home.
5. No reasonable mitigation methods are available to accommodate post construction findings that the project is causing adverse impacts on people living in the Project foot print.

In my opinion the Amherst Wind Project is not compatible with the host community and current land use.

====End of Report======

Sincerely,
E-Coustic Solutions

Richard R. James, INCE

Attachments: Exhibits A-I