Epsilon
ASSOCIATES INC.

Niagara County BOH Noise letter 120215

December 2, 2015 Epsilon Ref. 4337

3 Clock Tower Place, Suite 250
Maynard, MA 01754
www.epsilonassociates.com

978 897 7100
FAX 978 897 0099

Niagara County Board of Health
5467 Upper Mountain Road, Suite 100
Lockport, NY 14094

Subject: Lighthouse Wind – Sound from Wind Turbines

Dear Board of Health:

On behalf of Apex Clean Energy, Epsilon Associates, Inc. (Epsilon) is pleased to submit this letter discussing some of the issues and questions raised about sound levels from wind turbines associated with Lighthouse Wind. In particular, I will touch on low frequency and infrasound.

Qualifications

I am Board Certified in Noise Control Engineering, and a Certified Consulting Meteorologist with over 28 years of experience in the areas of community noise impacts, and meteorological data analyses. I serve on the Board of Directors for the Institute of Noise Control Engineering (INCE).

I have written journal articles and presented technical papers on wind turbine and noise issues at wind energy and acoustic-focused conferences. I have also testified as an expert witness in many court cases involving wind turbines and noise issues. Much of this work has been on behalf of developers, but I have also worked for the Connecticut Siting Council for Renewables, the New Hampshire Site Evaluation Committee, and the Mason County (Michigan) Planning Commission on wind projects.

Since 2004, my noise impact assessment work has focused on wind energy generation facilities. I have managed or actively participated in sound level studies for over 75 wind energy projects in 25 states. I have conducted pre-construction sound level measurement programs, predictive sound level modeling, and post-construction sound level compliance monitoring at many of these sites. In addition, I was the lead investigator for a low frequency and infrasound research study on wind turbines, and am wrapping up a research study on wind turbine acoustics sponsored by the Massachusetts Clean Energy Center and the Massachusetts Department of Environmental Protection.

Basic Concepts

Human beings are capable of hearing a wide range of sounds, from the high-pitched sounds of a bird song to the low-pitched sound of a bass guitar. Sounds are based on their loudness (*i.e.*, volume or sound pressure level) or pitch (*i.e.*, tonal or frequency content). The standard unit used to describe the tonal or frequency content is the Hertz (Hz). People can typically perceive sounds ranging from 20 Hz to 20,000 Hz.

The frequency range of ***low frequency sound*** is generally from 20 Hz to 200 Hz, and the range below 20 Hz is often described as ***infrasound***. At low frequencies, a much higher sound level is necessary for a sound to be heard as compared to higher frequencies. For example, at 10 Hz (infrasound range), the sound level must be approximately 97 decibels (dB) or greater to be audible for a typical person. However, at 100 Hz (low frequency range), a sound level around 27 dB or greater may be audible. These sound level thresholds may vary somewhat for the general population but they provide an idea of low frequency and/or infrasound audibility.

Figure 1 provides a graphical representation of frequencies measured in one-third octave bands from 4 Hz to 16,000 Hz. It also labels the portions of the spectrum generally referred to as Infrasound, Low Frequency, and Middle to High Frequencies. In addition, the approximate levels of audibility at each frequency are plotted on the graph. For example, at 1000 Hz sound is audible at approximately 2-3 dB, while at 20 Hz sound is audible at approximately 79 dB.

There is nothing mysterious about low frequency sound or infrasound. Although you cannot hear it, it is all around us in our communities today from both natural (thunder; waves; wind) and man-made (air conditioners; cars; refrigerators) sources. Scientific studies have shown that low frequency and infrasound energy from wind turbines are below levels that cause vibration, rattle, annoyance, or sleep disturbance at typical residential setbacks. Figure 2 presents the results of low frequency sound and infrasound measured at two locations within the Project area, and for perspective, compares them to sound levels from wind turbines at another wind farm approximately 1,600 feet away. As the figure demonstrates, under similar wind conditions, levels of infrasound and low frequency noise are similar. When winds are calm and wind turbines are not operating, there is still low frequency and infrasound energy in the community.

Sound Level Prediction Discussion

Sound energy will travel from a point source and be at a different sound level when it arrives some distance away. The sound pressure level at a known distance is calculated according to a set of physical principles. In New York State, and many other parts of the world, these calculations are done using International Standard ISO 9613-2 "Acoustics – Attenuation of sound during propagation outdoors. Part 2: General method of calculation".

In basic terms, the sound pressure level at a known distance starts with the sound power level of the source and is corrected to account for the following:

- Directivity (takes directionality into consideration);
- Distance (sound decreases as distance increases);
- Atmospheric absorption (varies by octave band and is a function of temperature and relative humidity);
- Ground effects (how do sound waves reflect off the ground);
- Screening (obstacles between the source and receiver will affect sound); and
- Miscellaneous attenuation (sound traveling through foliage for example).

All these computations are governed by the ISO 9613-2 standard and have been incorporated in software packages used by acoustical consultants to calculate sound levels from many sources at various distances. The Cadna/A software is one such package, and will be used for this Project.

The sound level predictions are conservative (err on the high side) for the following reasons:

- Maximum sound level from each wind turbine is assumed,
- Additional safety factor accounting for uncertainty included,
- Wind turbine height included in model,
- Meteorological conditions—temperature inversion; T; RH,
- Wind always blowing from turbine to house, and
- All wind turbines operating at maximum power simultaneously.

Post-construction sound level measurement programs around wind farms have found that actual sound levels are typically several decibels lower than the predicted worst-case sound levels. While the sound from a wind turbine may be audible at times at some locations, audibility is not a regulatory noise limit.[1] [2]

Representative Papers on Noise Impacts

Low frequency sound and infrasound from wind turbines. Noise Control Engineering Journal. I was the lead investigator for Epsilon Associates, Inc. as we conducted a research study on this issue for one of our clients. Our research effort was threefold: (1) a literature search on guidelines and standards used to evaluate low frequency sound and infrasound, (2) a field study to measure wind turbine noise inside and outside nearby residences, and (3) a comparison of that field data to the guidelines and standards researched above. The results of this research were published in a peer-reviewed journal [O'Neal, R.D., Hellweg, Jr., R.D. and R. M. Lampeter, 2011. *Low frequency sound and infrasound from wind turbines*. Noise Control Engineering Journal, 59 (2), 135-157]. As set out in our paper, our results showed that infrasound and low frequency sound will meet these criteria and standards at distances of 1,000 feet (305 meters) and 1,500 feet (457 meters) from the nearest wind turbines.

Wind Turbine Health Impact Study, Report of Independent Expert Panel. In January 2012, a report prepared for the Massachusetts Department of Environmental Protection and the Massachusetts Department of Public Health was prepared by a panel of independent experts. The expert panel evaluated information from peer-reviewed scientific studies, other reports, popular media, and public comments on the nature and type of health complaints commonly reported by individuals who reside near existing wind turbines. The panel's findings were consistent with other independent reviews of wind turbine impacts: While wind turbines may be a source of annoyance to some people, they do not cause health effects.

---

[1] "Wind Energy Sound Monitoring Under High Shear Conditions," Robert D. O'Neal, Epsilon Associates, Inc., presented at NOISE-CON 2014, Fort Lauderdale, FL, September 2014.

[2] "Wind turbine noise modeling and verification: two case studies – Mars Hill and Stetson Mountain I, Maine," Charles F. Wallace, Jr. et al, Resource Systems Engineering, presented at NOISE-CON 2011, Portland, OR, July 2011.

Pedersen et al paper. No matter what the sound levels are from a wind turbine, some people may find it annoying for non-acoustical reasons. This is shown through a field study in the Netherlands published in the Journal of the Acoustical Society of America.[3] This paper provides a dose-response relationship between A-weighted sound levels and reported perception and annoyance from wind turbines. The study found that annoyance increased with increasing sound levels. However, one percent of respondents were "very annoyed" even at sound levels less than 30 dBA. Only six percent were "very annoyed" at levels above 45 dBA. The vast majority of people living near wind farms either "did not notice" or "noticed, but not annoyed" at sound levels below 45 dBA. The study found that annoyance is strongly correlated with a negative attitude toward the visual impact of wind turbines.

Health Canada study. Health Canada is the Federal department responsible for helping Canadians maintain and improve their health. They rely on high-quality scientific research as the basis for their work. In July 2012, Health Canada announced its intention to undertake a large scale epidemiology study in collaboration with Statistics Canada. The study was launched to support a broader evidence base on which to provide federal advice and in acknowledgement of the community health concerns expressed in relation to wind turbines. Health Canada completed its preliminary analysis of the data obtained, and released the results in November 2014. The study did not find any evidence of a link between exposure to wind turbine noise and any of the self-reported or measured health effects examined.

McCunney et al paper. A recent literature review on wind turbines and health found that "Infrasound and low frequency sound do not present unique health risks", and "Annoyance seems more strongly related to individual characteristics than noise from turbines."[4]

---

[3] Pedersen, Eja, F. van den Berg, R. Bakker, J. Bouma. "Response to noise from modern wind farms in the The Netherlands", J. Acoust. Soc. Am. **126** (2), August 2009.

[4] McCunney, Robert J., K. Mundt, W. D. Colby, R. Dobie, K. Kaliski, and M. Blais. "Wind Turbines and Health: A Critical Review of the Scientific Literature." Journal of Occupational and Environmental Medicine **56** (11), November 2014.

World Health Organization Night Noise Guidelines for Europe. The World Health Organization (WHO) 2009 "Night Noise Guidelines for Europe" report recommends a night noise guideline (NNG) of 40 dBA. This is a health-based limit to protect the public from the adverse health effects of night noise. However, the 40 dBA guideline is defined as the A-weighted long-term average sound level determined over all the night periods of a year.

Since $L_{night, outside}$ considers 365 nights of operation, there will be some nights the wind turbines do not operate at all and many others where they will operate at a level below maximum sound level. Therefore, the $L_{night, outside}$ sound level will ALWAYS be lower than a short-term measurement. A short-term nighttime sound limit of 45 dBA is consistent with the WHO annual $L_{night, outside}$ level of 40 dBA.

WHO Guideline for Community Noise. The "Guideline for Community Noise" (WHO, Geneva, 1999) states that at night, sound levels at the outside facades of the living spaces should not exceed an L_{eq} of 45 dBA, so that people may sleep with bedroom windows open. The time base for these WHO sound levels is 8 hours for nighttime. In other words, they are not 10-minute averages but over a longer period of time.

Conclusion

The science and research on this topic are clear – a standard sound level limit of 45 dBA and a 1,500 foot setback from non-participating residents which will be used by Apex, will protect residents in the vicinity of a wind farm from adverse health effects and annoyance. The objective of a noise limit should not be to make every wind turbine inaudible to every person, or to annoy zero percent of the population. That is unreasonable, and impossible for any source of sound. Meeting a standard such as this strikes a reasonable balance of minimizing community noise, and allowing for responsible siting of wind turbines.

I will be in attendance at the December 3, 2015 Niagara County BOH meeting if you have any further questions. In addition, please feel free to call me at (978) 461-6236, or e-mail me at roneal@epsilonassociates.com.

Sincerely,

EPSILON ASSOCIATES, INC.

Robert D. O'Neal

Robert D. O'Neal, CCM, INCE Bd. Cert.
Principal

Figure 1. Threshold of Audibility vs. Frequency (4 Hz--16,000 Hz)

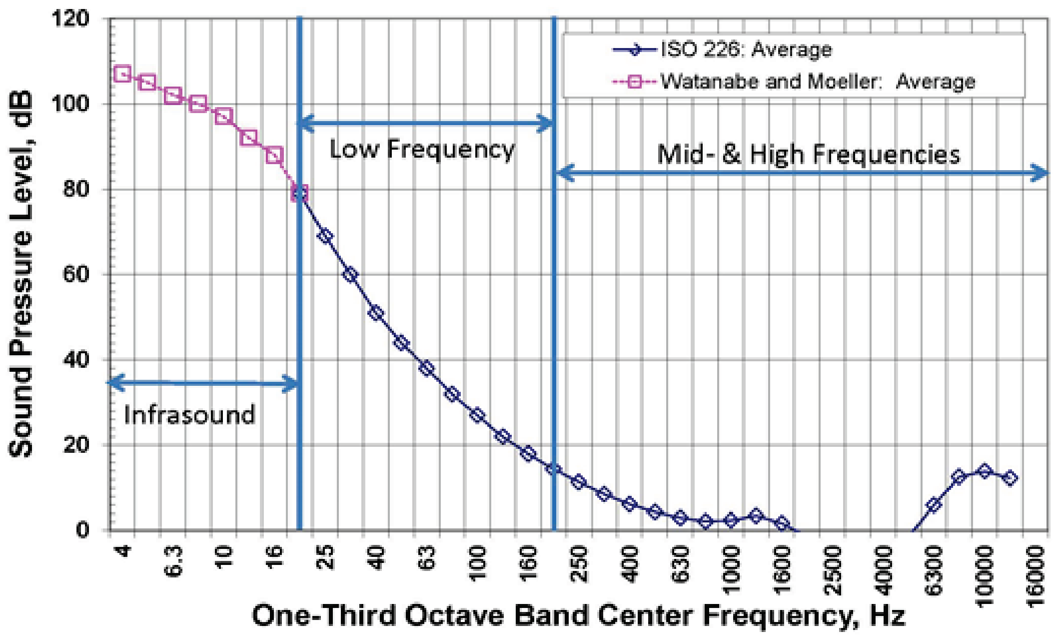

Figure 2. Existing Infrasound & Low Frequency Noise—Niagara County