STATE OF NEW HAMPSHIRE

BEFORE THE SITE EVALUATION COMMITTEE

Docket No. SEC 2015-02

APPLICATION OF ANTRIM WIND ENERGY, LLC
FOR A CERTIFICATE OF SITE AND FACILITY

PREFILED DIRECT TESTIMONY OF ROBERT D. O'NEAL ON BEHALF OF ANTRIM WIND ENERGY, LLC

February 19, 2016

Q. Please state your name, title and business address.

A: My name is Robert O'Neal. I am a Principal at Epsilon Associates, Inc. ("Epsilon"). My business address is 3 Clock Tower Place, Suite 250, Maynard, MA 01754.

Q. Briefly summarize your educational background and work experience.

A: I received a Bachelor of Arts degree in Engineering Science from Dartmouth College in 1983. I earned a Masters in Atmospheric Science from Colorado State University in 1987. I have over twenty-five years of experience in the areas of community noise impacts, meteorological data collection and analyses, and air quality modeling. My noise impact evaluation experience includes the design and implementation of sound level measurement programs, modeling of future impacts, conceptual mitigation analyses, and compliance testing. I am a member of the Institute of Noise Control Engineers ("INCE"), the Acoustical Society of America, the American Meteorological Society, and the Air &Waste Management Association.

I am Board Certified by INCE in Noise Control Engineering and I am a Certified Consulting Meteorologist (CCM) by the American Meteorological Society. Both of these certifications are national programs.

From 1987 until 1997, I was employed by Tech Environmental, Inc. where I was a Project Manager responsible for noise impact assessments and air quality modeling studies. In 1997, I joined Earth Tech, Inc. as a Program Director. In that capacity, I was responsible for community noise studies for electric generating stations, as well as meteorological analyses, and air quality modeling. In 2000, I joined Epsilon Associates, Inc. as a Senior Consultant. In 2004, I was made a Principal of the firm. My practice at Epsilon continues to focus on community noise impact assessments and meteorological analyses for power generation facilities in the Northeast, Mid-Atlantic region, the Midwest, and the Southwestern United States. Since 2004, my noise impact assessment work has focused on wind energy generation facilities.

Additional detail regarding my education, background and experience is contained in my curriculum vitae which is attached hereto as Attachment RDO-1.

Q. Have you ever testified before the New Hampshire Site Evaluation Committee ("SEC")?

A. Yes. I gave testimony on the issue of sound levels before the SEC in Docket 2010-01, which pertained to Groton Wind, LLC's application for a certificate of site and facility. I also provided testimony to the SEC regarding the same subject matter in connection with Antrim Wind Energy, LLC's ("AWE") application for a certificate of site and facility in Docket 2012-01.

Q. What is your role in relation to the Antrim Wind Project and AWE's application for a certificate of site and facility (the "Application")?

A. I have been retained by AWE to evaluate and assess sound levels and "shadow flicker" effects associated with the operation of wind turbines and a collector substation associated with the Antrim Wind Project (the "Project").

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to present and discuss the results of the comprehensive sound level assessment conducted by Epsilon in connection with the Antrim Wind Project. Epsilon's Sound Level Assessment Report is attached as Appendix 13A to AWE's Application. I will also address the Shadow Flicker Analysis performed by Epsilon relative to the Project.

Q. Are you familiar with the site of the wind energy facility proposed in AWE's Application?

A. Yes. I have reviewed the site plans and discussed the project with representatives of AWE. I have also personally visited the Project site and the area surrounding it to assess potentially sensitive receptors to sound emissions from the Project.

I. Sound Level Assessment Report

Q. What assessments did Epsilon conduct in connection with sound levels associated with the proposed Project?

A. Epsilon conducted a comprehensive sound level assessment to evaluate the potential effect of sound associated with the operation of the proposed wind energy facility at the Project site. First, existing sound levels were measured at five locations intended to be representative of nearby residences in various directions from the proposed wind farm. The five measurement locations are described in detail in the Sound Level Assessment Report attached as Appendix 13A to the Application. These measurements were taken to establish background sound levels as a function of wind speed prior to operation of the proposed wind farm. By documenting existing sound levels in the community, we can place the predicted sound levels from the Project into context. Figure 5-1 of the Sound Level Impact Assessment report shows the proposed wind turbine locations overlaid upon an aerial photograph of the surrounding area, as well as the actual measurement locations, and all structures within a two mile radius in any direction of each wind turbine.

Epsilon also measured existing wind speeds during the same time that it measured ambient sound levels as described above, as wind speed can have a strong influence on ambient sound levels. As the wind speed near the ground increases, the sound levels increase due to either the wind itself, and/or rustling of vegetation or other objects. Epsilon deployed a modular weather station with tripod and data logger to continuously measure the wind speed and wind direction. The wind sensors were mounted at a height of 2 meters above ground level and data were logged every 10 minutes.

Q. Was the sound measurement program conducted in 2011 modified or updated in connection with the adoption of the new NH SEC rules?

A. Yes. In accordance with the requirements of the newly adopted NH SEC rule Site 301.18, an ambient sound level survey was conducted in January 2016 to characterize the current acoustical environment under varying wind conditions in the community. The details of the measurement program and the results are found in Section 5 of the Sound Level Assessment Report, dated February 17, 2016.

Q. Did Epsilon model sound levels for the wind turbines that AWE proposes to construct?

A. Yes. Epsilon modeled the predicted sound levels associated with the operation of nine (9) Siemens SWT-3.2-113 wind turbines at the Project site. Epsilon modeled sound levels for 344 potentially sound-sensitive structures within a 2-mile radius of each wind turbine using a height of 1.5 meters AGL to mimic the ears of a typical standing observer. Epsilon also modeled sound levels throughout a large grid of over 200,000 receptor points covering an area approximately 8 km by 10 km.

Q. Did Epsilon also perform an assessment of the predicted sound levels associated with the substation?

A. Yes. In addition to the wind turbines, the project will include a collector substation, and Epsilon has evaluated the predicted sound levels associated with the transformer required to interconnect the 34.5 kV line bringing power from the Project with the regional power grid. The proposed transformer, which is rated at 24/32/40 megavolt-ampere (MVA), has various cooling mechanisms that modestly effect its sound levels. Epsilon modeled the predicted sound levels for the transformer using sound level data for typical transformers of comparable size and assumed the maximum MVA rating, loudest cooling sound, and no barrier walls around the transformer for a conservative result.

Q. Please briefly describe the modeling scenarios used to conduct Epsilon's analysis.

A. The anticipated noise impacts associated with the Project were predicted using the Cadna/A noise calculation software. This software uses the ISO 9613-2 international standard for sound propagation. The benefit of this software is that it provides for a refined set of computations that account for topography, ground attenuation, multiple building reflections, drop-off with distance, and atmospheric absorption. The inputs and parameters employed in the model are described in detail in the Sound Level Assessment Report attached as Appendix 13A to the Application.

As indicated above, sound levels anticipated from the operation of all nine wind turbines were modeled at 344 of the closest community receptors and throughout a large grid of over 200,000 receptor points within an area of approximately 8 km by 10 km. The five monitoring locations were also covered by the modeling points. Sound levels were computed assuming that the receptors are always located directly downwind from all turbines simultaneously, an approach that provides conservative results and is required by the ISO 9613-2 calculation methodology. This conservative set of modeling assumptions has been verified multiple times through post-construction sound level measurement programs at operating wind farms. For example, post-construction sound level measurements for Groton Wind, a NH ridgeline site, found that the predicted sound levels were conservative (higher) than measured sound levels under worst-case operating conditions for sound. The modeled locations and results of the sound level modeling are depicted on a sound level contour map depicted in Figure 7-1 of the Sound Level Impact Assessment Report. For ease of reference, Figure 7-1 is submitted with this prefiled testimony and is labeled Attachment RDO – 2. The colored contour lines in Figure 7-1 show the sound levels for worst-case wind turbine operational sound levels. These are "Project-only" sound levels, and do not include contribution from existing sounds in the community ("background").

Q. Are there regulations or standards that would apply to the Project?

A. The Project will be subject to the requirements contained in the recently adopted NH SEC sound standards for wind energy facilities of 45 dBA (daytime) or 40 dBA (nighttime) contained in Site 301.14(f)(2)(a). The Project is also subject to the sound levels specified in the Agreement between the Town of Antrim and Antrim Wind Energy LLC.

In addition, AWE entered into an agreement with the Town of Antrim dated March 8, 2012 that imposes certain Residential Noise Restrictions upon the Project. Section 11.1 of the Agreement states that "sound from the Wind Farm during Operations at the exterior facades of homes shall not exceed 50dBA or 5 dBA above ambient, whichever is greater, during daytime and 45 dBA or 5dBA above ambient, whichever is greater, at night."

Q. What other criteria are typically considered when evaluating sound levels?

A. The science of sound analysis around wind farms has developed significantly since the early wind projects of the 1990s, and there is no one sound standard to follow. It is helpful to look at guidelines put forth by a number of organizations that have proposed sound limits based on rigorous study and science. Comparing these guidelines to the limits set in past SEC dockets and the limits currently under consideration by the SEC will help establish the scientific framework for imposing proper sound limits.

A useful guideline for putting sound levels in perspective is the "Guideline for Community Noise" (World Health Organization, Geneva, 1999). This document states that daytime and evening outdoor living area sound levels at a residence should not exceed an L_{eq} of 55 dBA to prevent serious annoyance and an L_{eq} of 50 dBA to prevent moderate annoyance from a steady, continuous noise. 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 16 hours for daytime and 8 hours for nighttime. In other words, they are not 10-minute averages but over a longer period of time.

Since the 1999 World Health Organization (WHO) "Guideline for Community Noise" report was issued, WHO released another report in 2009 entitled "Night Noise Guidelines for Europe." The 2009 WHO 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

(Executive Summary pp. XVII-XVIII). However, the 40 dBA guideline is an "$L_{night, outside}$" descriptor, which is NOT the same as a short-term measurement. $L_{night, outside}$ is defined as the A-weighted long-term average sound level determined over all the night periods of a year; in which the night is eight hours (23:00 to 07:00 local time). Thus, the $L_{night, outside}$ is an annual average, and is not an appropriate descriptor to use for evaluating a permit's compliance criteria.

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 the worst-case (highest) short-term sound level measured on a given night. In other words, the $L_{night, outside}$ guideline of 40 dBA, is not a 10-minute or 1-hour sound level, but is an annual level. Therefore the most recent guideline from the WHO in 2009 is less stringent than the level proposed in the draft SEC rules (short-term nighttime level of 40 dBA), and is still highly protective of public health. The Project will easily meet both guidelines.

Another useful guideline for comparing sound levels is the "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety" (U.S. Environmental Protection Agency, Office of Noise Abatement and Control, Washington, DC, 550/9-74-004, March 1974). This document, often referred to as the "Levels" document, identifies an L_{dn} of 55 dBA outdoors in residential areas as the maximum level below which no effects on public health and welfare occur due to interference with speech or other activities. This level includes a 10 dBA "penalty" for sound levels at night (10 p.m. to 7 a.m.). This level will permit normal speech communication, and would also protect against sleep interference inside a home with the windows open. A constant sound level of 48.6 dBA 24 hours per day would be equal to an L_{dn} of 55 dBA.

Q. Please summarize the results of Epsilon's sound level studies relative to the criteria described above.

A. The predicted worst-case sound levels from the Antrim Wind Energy Project will be below 40 dBA at all occupied buildings. A review of Table 7-5 shows that the highest sound level will be at receptor #20 (38.1 dBA). All other residences will be below 38 dBA under worst-case operating conditions. Therefore, the Antrim Wind Energy Project will easily meet the SEC standard in 301.14(f)(2)(a), and the criteria applied to the Lempster and Groton wind projects. It will also comply with the parameters set forth by the SEC in Docket 2012-01, though the 40 dBA night time criterion imposed by the SEC in that docket was based on an annual average metric that is not applicable to the day-to-day operation of a wind project.

Q. Based upon your assessment, will sound levels associated with the Antrim Wind Project have any unreasonable adverse effects?

A. No. Sound levels due to wind turbine operation are expected to be 40 dBA or less at all participating and non-participating residences. These sound levels will meet the SEC standard in Site 301.14. In addition, the Project will meet previously approved noise conditions from the SEC, as well as the World Health Organization's 1999 and 2009 guidelines (though the 2009 guidelines should not be applied on a daily basis), and the US EPA guideline of 48.6 dBA (24-hour) which is equal to an L_{dn} of 55 dBA.

II. Shadow Flicker Analysis

Q. What analysis did Epsilon perform regarding shadow flicker associated with the Project?

A. Epsilon conducted a shadow flicker analysis to predict the expected annual duration of shadow flicker caused by the operation of the nine (9) proposed wind turbines at modeled locations in the area of the Project. A copy of Epsilon's Shadow Flicker Analysis is attached to AWE's Application at Appendix 13B.

Q. Did anyone assist you in performing the analysis and developing the conclusions drawn in the shadow flicker analysis report?

A. Yes. Richard M. Lampeter, a Senior Consultant at Epsilon who has significant experience in shadow flicker modeling, assisted in conducting and preparing the Shadow Flicker Analysis and developing the results and conclusion set forth below.

Q. What is "shadow flicker"?

A. Shadow flicker is defined in SEC site 102.48 as "the alternating changes in light intensity that can occur when the rotating blades of a wind turbine are back lit by the sun and cast shadows on the ground or on structures." In order for shadow flicker to occur and have any impact, a wind turbine must be operating, the sun must be shining, and an observer must be present to observe the effect.

Q. Are there any regulations limiting or otherwise controlling shadow flicker resulting from the operation of wind turbines that would apply to the Project?

A. The New Hampshire Site Evaluation Committee through rulemaking docket 2014-04 adopted rules on December 15, 2015 outlining application requirements and criteria for energy facilities, including wind energy facilities. As part of these revised regulations, Site 301.14(f)(2)b. contains wind energy facility shadow flicker standards which state the following:

> *With respect to shadow flicker, the shadow flicker created by the applicant's energy facility during operations shall not occur more than 8 hours per year at or within any residence, learning space, workplace, health care setting, outdoor or indoor public gathering area, or other occupied building;*

Furthermore, the NH SEC has established specific details on shadow flicker analysis per the following as set forth in Site 301.08(a)(2):

> *An assessment that identifies the astronomical maximum as well as the anticipated hours per year of shadow flicker expected to be perceived at each residence, learning space, workplace, health care setting, outdoor or indoor public gathering area, other occupied building, and roadway, within a minimum of 1 mile of any turbine, based on shadow flicker modeling that assumes an impact distance of at least 1 mile from each of the turbines;*

Q. Please briefly describe Epsilon's methodology for evaluating shadow flicker associated with the Project.

A. Shadow flicker was modeled using a software package, WindPRO version 3.0.639. WindPRO is a software suite developed by EMD International A/S and is used for assessing potential environmental impacts from wind turbines. Worst-case shadow flicker in the area surrounding the wind turbines was calculated based on data inputs including: location of the wind turbines, location of sensitive receptors, wind turbine dimensions, calculation limits, and terrain data. Worst-case is defined as the sun is always shining during daylight hours (i.e., never a cloud all year) and the winds are always strong enough during daylight hours that the wind turbine is always operating. Both of these assumptions are overly conservative. Based on user input geographic information, the model was able to incorporate the appropriate sun angle and maximum daily sunlight for this latitude into the calculations.

The Site 301.08(a)(2) regulations require analysis of shadow flicker at sensitive receptors one (1) mile from any wind turbine. There are 150 sensitive receptors within one mile of any wind turbine.

The WindPRO shadow flicker module can be further refined by incorporating sunshine probabilities and wind turbine operational estimates by wind direction over the course of a year. The values for this further refinement, also known as the "expected" shadow flicker, were included in this analysis. The Siemens SWT-3.2-113 wind turbine has a cut-in wind speed of 3 m/s, and a cut-out wind speed of 25 m/s. Based on the extrapolated data from the AWE on-site meteorological tower the wind turbines would operate for 8,240 hours out of 8,760 hours per year (94%). This corresponds to the period when hub height winds would be between 3 m/s and 25 m/s.

Q. What were the results of the modeling performed by Epsilon?

A. The predicted shadow flicker duration ranged from 0 hours, 0 minutes per year to 13 hours, 48 minutes per year. Of the 150 identified sensitive receptors, the majority of the modeling locations, 77 receptors, are predicted to experience no shadow flicker. A total of 49 locations are predicted to experience some shadow flicker but less than 8 hours per year. The modeling results showed that 24 locations are expected to experience between 8 hours and 13 hours 48 minutes of shadow flicker per year. The modeled locations and results of the shadow flicker modeling are depicted on a contour map as Figure 4-2 of the Shadow Flicker Analysis Report. For ease of reference, Figure 4-2 is submitted with this prefiled testimony and is labeled Attachment RDO – 3.

Q. Having conducted the Shadow Flicker Analysis, what are Epsilon's conclusions with respect to the Project?

A. A shadow flicker analysis was conducted to calculate the duration and location of shadow flicker in the vicinity of the Antrim Wind Energy Project. Shadow flicker resulting from the operation of the nine (9) wind turbines was calculated at 150 sensitive receptors and isolines were generated from a grid encompassing the area surrounding the wind turbines. The expected annual duration of shadow flicker at sensitive receptors ranges from 0 hours, 0 minutes per year to 13 hours, 48 minutes per year.. This analysis is conservative in that modeling locations were treated as "greenhouses" and obstacles such as structures and vegetation were not included.

AWE will utilize a shadow control method provided by Siemens to ensure that the 24 locations that are conservatively expected to experience between 8 hours and 13 hours and 48 minutes of shadow flicker per year, will not exceed a total of 8 hours per year. The remaining 49 locations that will experience some shadow flicker will not require AWE to implement any operational control measures to comply with the SEC rule. The Siemens shadow control method will allow AWE to utilize operational controls to curtail specific turbines that are identified as potentially causing shadow flicker in excess of the 8 hour maximum at any of the 24 locations to reduce the actual shadow flicker to no more than 8 hours per year.

Q. Based upon your analysis, will "shadow flicker" caused by the operation of the Antrim Wind Project have any unreasonable adverse effects?

A. No. All of the residential locations surrounding the Antrim Wind Energy project are predicted to experience no more than 8 hours per year of shadow flicker utilizing the shadow control methodology to be implemented by Siemens. This level will meet the SEC standard of 8 hours per year.

Q. Does this conclude your pre-filed testimony?

A. Yes.