Exhibit A5

BEFORE THE
PUBLIC UTILITIES COMMISSION
STATE OF SOUTH DAKOTA

IN THE MATTER OF THE APPLICATION OF DAKOTA RANGE I, LLC AND DAKOTA RANGE II, LLC FOR AN ENERGY FACILITY PERMIT TO CONSTRUCT A WIND ENERGY FACILITY

SD PUC DOCKET EL18-____

PREFILED TESTIMONY OF ROBERT O'NEAL ON BEHALF OF DAKOTA RANGE I, LLC AND DAKOTA RANGE II, LLC

January 24, 2018

EXHIBIT
A5

I. INTRODUCTION AND QUALIFICATIONS

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

A. My name is Robert O'Neal and I work for Epsilon Associates, Inc. ("Epsilon"), located at 3 Mill & Main Place, Suite 250, Maynard, Massachusetts 01754.

Q. Briefly describe your educational and professional background and your current work for Epsilon.

A. I have more than 30 years of experience in the areas of community noise impact assessments, meteorological data collection and analyses, and air quality modeling. My noise impact evaluation experience includes design and implementation of sound level measurement programs nationwide, modeling of future impacts, conceptual mitigation analyses, and compliance testing. I am a nationally recognized acoustics expert in the wind energy field, having performed noise impact assessments in over 25 states across the U.S. and Canada, and have also directed and reviewed shadow flicker studies for wind energy projects. I have provided expert witness testimony on noise impact studies, shadow flicker issues, and air pollution modeling in front of local boards, courts of law, and adjudicatory hearings.

I have a B.A. in Engineering Science from Dartmouth College, and an M.S. in Atmospheric Science from Colorado State University. I am a Certified Consulting Meteorologist, a member of the American Meteorological Society, a member of the Acoustical Society of America, and Board Certified by the Institute of Noise Control Engineering ("INCE"). A copy of my curriculum vitae is provided as Exhibit 1.

Q. What is your company's role with respect to the Dakota Range Wind Project ("Project")?

A. Epsilon conducted sound level and shadow flicker modeling analyses of the Project's proposed layout, and prepared a Sound Level Modeling Report ("Sound Report") and a Shadow Flicker Modeling Report ("Shadow Flicker Report"), which are provided in Appendices I and J, respectively, of the Project's Energy Facility Permit Application ("Application").

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to discuss the methodology and results of the sound level modeling analysis and shadow flicker modeling analysis Epsilon conducted for the Project. In addition, I will discuss how the modeling demonstrates that the Project will comply with applicable acoustic and shadow flicker regulations and/or commitments made by Dakota Range I, LLC and Dakota Range II, LLC ("Dakota Range").

Q. Please identify the sections of the Application that you are sponsoring for the record.

A. I am sponsoring the following portions of the Application:

- Section 16.3: Sound
- Section 16.4: Shadow Flicker
- Appendix I: Sound Level Modeling Report
- Appendix J: Shadow Flicker Modeling Report

II. WIND TURBINE SOUND AND APPLICABLE STANDARDS

Q. Please provide an overview of the sound that may be generated by modern utility-scale wind turbines, such as those that will be used for the Project.

A. Wind turbine noise can originate from two different sources: mechanical sound from the interaction of turbine components, and aerodynamic sound produced by the flow of air over the rotor blades. In addition to the turbines, the transformer located at a wind project's substation will also emit sound.

Due to advances in wind turbine design, mechanical noise has been greatly reduced in modern turbines and does not contribute significantly to sound levels outside of the nacelle. Aerodynamic noise has also been reduced due to slower rotational speeds and changes in materials of construction.

Q. How are wind turbine sound levels measured?

A. While sound (noise) levels are measured and quantified in several ways, all of them use the logarithmic decibel ("dB") scale to accommodate the wide range of sound intensities found in the environment. A property of the decibel scale is that the sound pressure levels of two or more separate sounds are not directly additive. For example, if a sound of 50 dB is added to another sound of 50 dB, the total is only a 3-decibel increase (53 dB), which is equal to doubling in sound energy but not equal to a doubling in decibel quantity. Thus, every 3-dB change in sound level represents a doubling or halving of sound energy, and a change in sound levels of less than 3 dB is generally imperceptible to the human ear. Also, if one source of noise is at least 10 dB louder than another source, then the total sound level is simply the sound level of the higher-level source. For example, a sound source at 60 dB plus another sound source at 47 dB is equal to 60 dB.

A sound level meter is a standardized instrument used to measure sound. It contains "weighting networks" (e.g., A-, C-, Z-weightings) to adjust the frequency response of the instrument. Frequencies, reported in Hertz ("Hz"), are detailed characterizations of sounds, often addressed in musical terms as "pitch" or "tone." The most commonly used weighting network is the A-weighting because it most closely approximates how the human ear responds to sound at various frequencies (in the 20 to 20,000 Hz range). The A-weighting network, which reports in decibels designated as "dBA," is the accepted scale used for community sound level measurements.

Sounds in the environment vary with time, and the two sound level metrics that are commonly reported in community noise monitoring are:

- L_{90}, which is the sound level in dBA exceeded 90 percent of the time during a measurement period. The L_{90} is close to the lowest sound level observed. It is essentially the same as the "residual" sound level, which is the sound level observed when there are no obvious nearby intermittent noise sources.
- L_{eq}, the equivalent level, is the level of a hypothetical steady sound that would have the same energy (i.e., the same time-averaged mean square sound pressure) as the actual fluctuating sound observed. The equivalent level is designated L_{eq} and is commonly A-weighted. The equivalent level represents the time average of the fluctuating sound

pressure, but because sound is represented on a logarithmic scale and the averaging is done with time-averaged mean square sound pressure values, the L_{eq} is mostly determined by occasional loud noises.

Q. How does the sound from wind turbines fit within the range of sound audible to humans?

A. The sound levels at the base of a modern utility-scale wind turbine are typically between 55-60 dBA when the wind turbine is operating at full power. By comparison, normal conversation between two people is 55-65 dBA when they are about three feet apart. Therefore, one can hold a conversation at the base of an operating wind turbine. Sound levels decrease with distance away from a wind turbine. At 50 dBA it would sound approximately half as loud as conversational speech, and between 30 and 40 dBA it is comparable to sound levels in a quiet rural area.

Q. Are you aware of any federal or state sound level regulations for wind energy conversion facilities located in South Dakota?

A. There are no federal sound level regulations specific to wind energy conversion facilities. Also, it is my understanding that the State of South Dakota does not have statutes or rules governing sound level requirements for wind energy conversion facilities.

Q. Has Grant County established a sound level requirement for wind energy facilities to be located in that county?

A. Yes. Per Section 1211.04(13) of the *Zoning Ordinance for Grant County*, Grant County imposes the following requirement for wind energy facilities: "Noise level shall not exceed 50 dBA, average A-weighted Sound pressure including constructive interference effects at the perimeter of the principal and accessory structures of existing off-site residences, businesses, and buildings owned and/or maintained by a governmental entity."

Q. Has Codington County established a sound level requirement for wind energy facilities to be located in that county?

A. Yes. Per Section 5.22.03(12) of the *Comprehensive Zoning Regulations for Codington County*, Codington County requires the following: "Noise level shall not exceed 50 dBA, average A-weighted Sound pressure including constructive interference effects at the property line of existing off-site residences, businesses, and buildings owned and/or maintained by a governmental entity." The Codington County requirement mirrors the Grant County requirement, except that Codington County sets its noise level limit at the property line, rather than at the perimeter of off-site structures.

Q. Based on your expertise, could you explain what the phrase "noise level shall not exceed 50 dBA, average A-weighted Sound pressure including constructive interference effects" means?

A. The language from that part of the sound ordinance appears to have been written by a lay person, but the intent is that it means a sound level limit of 50 dBA using an equivalent sound level metric ("L_{eq}"). The L_{eq} metric is used by the wind turbine manufacturers for their sound level data since it is required by standard. The L_{eq} is also a commonly used metric for community noise ordinances and standards, and thus is an appropriate metric in the context of the County ordinances. Additional information on the L_{eq} metric is found in Section 3.0 of the Sound Report, attached as Appendix I to the Application.

III. ACOUSTIC ANALYSIS

Q. Was the Sound Report provided as Appendix I to the Application prepared by you or under your supervision and control?

A. Yes.

Q. What was the purpose of the acoustic modeling and analysis discussed in the Report?

A. The purpose was to conservatively model the sound level to be produced by the Project in order to confirm the Project will comply with applicable noise limits established by Grant and Codington Counties.

Q. Who provided the turbine model, turbine layout, and receptors to be used when conducting the acoustic modeling for the Project?

A. The turbine model (Vestas V136-4.2), the proposed layout (including 72 primary and 25 alternate turbine locations), and the receptor dataset (86 sensitive receptors and 267 accessory receptors in Codington County, and 103 sensitive receptors and 288 accessory receptors in Grant County) were provided by Dakota Range. With respect to receptors, there were no businesses or buildings owned and/or maintained by a governmental entity within the area modeled, so the dataset consisted only of existing residences (sensitive receptors) and accessory structures (accessory receptors).

Q. Are the turbine model and turbine layout the same as depicted in Figure 2 of the Application?

A. Yes.

Q. Could you provide an overview of the methodology used in conducting the acoustic modeling analysis for the Project?

A. A conservative prediction of sound levels associated with the Project was made using Cadna/A noise calculation software, which is commonly used in the industry for sound modeling. This software incorporates the ISO 9613-2 international standard for sound propagation (Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation).

In addition to the turbine model specifications, proposed Project layout, and the receptor locations discussed above, inputs and significant parameters employed in the model included:

- Project Layout: All 97 primary and alternate locations were modeled, although only 72 locations will be constructed.
- Modeling Location: Sound levels at receptors were modeled as discrete points at a height of 1.5 meters above ground level to correlate with the typical ear height of a standing person. Sound levels were also modeled throughout a large grid of receptor points, each spaced 25 meters apart, to allow for the generation of sound level isolines, which are lines on a map depicting sound levels.

- Terrain Elevation: The terrain height contour elevations for the area modeled were generated from elevation information derived from the National Elevation Dataset ("NED") developed by the U.S. Geological Survey.
- Source Sound Levels: The expected sound power levels associated with the Vestas V136-4.2 wind turbine were obtained from a Vestas technical report, and the expected sound levels from the Project substation were estimated based on information provided by Dakota Range and techniques in the Electric Power Plant Environmental Noise Guide produced by the Edison Electric Institute. The octave-band sound power levels calculated for the Vestas V136-4.2 wind turbines represent "worst-case" operational sound level emissions. Further, all turbines were assumed to be operating simultaneously and at the design wind speed corresponding to the greatest sound level impacts, and an uncertainty factor of 2.0 dBA was added to the sound power level for each modeled wind turbine.
- Ground Attenuation: Spectral ground absorption was calculated using a G-factor of 0.5, which corresponds to "mixed ground" consisting of both hard and porous ground cover. No additional attenuation due to tree shielding, air turbulence, or wind shadow effects was considered in the model.
- Meteorological Assumptions: Meteorological conditions were selected to minimize atmospheric attenuation in the 500 Hz and 1 kHz octave bands where the human ear is most sensitive. The model also assumed favorable conditions for sound propagation, corresponding to a moderate, well-developed ground-based temperature inversion, as might occur on a calm, clear night or equivalently downwind propagation.

Q. Could you summarize the results of the analysis for the residences in Codington County?

A. In Codington County, the sound levels range from 17 to 43 dBA at the 86 modeled sensitive receptors (which includes both participating and nonparticipating residences), and from 14 to 43 dBA at the 267 modeled accessory receptors. At the property line of the off-site residences, the sound levels are less than 48 dBA. Thus, the Project is below Codington County's noise requirement of 50 dBA or less at the property line of off-site residences.

Q. Could you summarize the results of the analysis for the residences in Grant County?

A. In Grant County, the sound levels range from 22 to 45 dBA at the 103 modeled sensitive receptors (which includes both participating and nonparticipating residences), and from 23 to 47 dBA at the 288 modeled accessory receptors. Thus, the Project is well below Grant County's noise requirement of 50 dBA or less at off-site residences and accessory structures.

Q. How accurate is your analysis of the anticipated sound levels that will be generated by the Project?

A. The Massachusetts Clean Energy Center's Research Study on Wind Turbine Acoustics ("RSOWTA"),[1] showed that the same parameters used in the Sound Report resulted in model results (L_{eq1hr}) that were nearly identical (within one dBA) to the monitoring results, with the exception of one outlier. Another study showed that for sites with similar topography to the Project, the same modeling parameters used in the Sound Report resulted in measured sound levels within one dBA of the modeled sound levels.[2]

Q. Are you aware of any post-construction noise studies for other wind farms that support the accuracy and conservativeness of the pre-construction noise modeling you conducted for the Project?

A. The conservative set of modeling assumptions for this analysis has been verified through post-construction sound level measurement programs at five different operating wind energy facilities in the RSOWTA. According to the RSOWTA, ISO 9613-2 model with mixed ground (G=0.5) with +2 dB added to the results was most precise and accurate at modeling the hourly L_{eq}. In addition, a post-construction measurement program conduction by Epsilon in the Rocky Mountain region found measured sound levels met the regulatory sound level limit under worst-case operating conditions at locations modeled to be at the regulatory limit.

IV. SHADOW FLICKER AND APPLICABLE STANDARDS

[1] RSG et al, "Massachusetts Study on Wind Turbine Acoustics," Massachusetts Clean Energy Center and Massachusetts Department of Environmental Protection, 2016.

[2] Cooper, J. and T. Evans, "Accuracy of noise predictions for wind farms," Proceedings of the 5th International Conference on Wind Turbine Noise, Denver, CO, 2013.

Q. Could you please explain what shadow flicker is?

A. With respect to wind turbines, shadow flicker is an intermittent change in the intensity of light in a given area resulting from the operation of a wind turbine due to its interaction with the sun. While indoors, an observer experiences repeated changes in the brightness of the room as shadows cast from the wind turbine blades briefly pass by windows as the blades rotate. In order for this to occur, the wind turbine must be operating, the sun must be shining, and the window must be within the shadow region of the wind turbine, otherwise there is no shadow flicker.

Q. Are you aware of any federal, state, or local shadow flicker regulations for wind energy facilities located in South Dakota?

A. There are no federal shadow flicker regulations, and it is also my understanding that there are no shadow flicker requirements at the state or county levels.

Q. Has the Project made a commitment regarding Project shadow flicker levels at non-participating residences, businesses, and buildings owned and/or maintained by a governmental entity?

A. Yes, Dakota Range has committed to a maximum of 30 hours per year of shadow flicker at any existing non-participating residence, business, or building owned and/or maintained by a governmental entity, unless otherwise agreed to by the landowner.

V. SHADOW FLICKER ANALYSIS

Q. Was the Shadow Flicker Report provided as Appendix J to the Application prepared by you or under your supervision and control?

A. Yes.

Q. What was the purpose of the shadow flicker modeling and analysis discussed in the Shadow Flicker Report?

A. The purpose was to conservatively model the shadow flicker levels to be produced by the Project at specified receptors in order to confirm the Project will meet the shadow flicker commitment made by Dakota Range.

Q. Were the same turbine model, turbine layout, and sensitive receptor data used for the shadow flicker analysis as were used for the acoustic analysis?

A. Yes.

Q. Could you provide an overview of the methodology used in conducting the shadow flicker modeling?

A. Shadow flicker was modeled using WindPRO, which is software commonly used to assess potential wind turbine shadow flicker levels. Two different modeling scenarios were used: a "worst-case" scenario and an "expected" scenario.

In addition to the proposed Project layout, turbine dimensions, and receptor data provided by Dakota Range, the following inputs were used for the "worst-case" scenario:

- <u>Greenhouse Mode</u>: Each receptor was assumed to have windows in all directions ("greenhouse" mode), which yields conservative results.
- <u>Terrain</u>: The terrain height contour elevations for the area modeled were generated from elevation information derived from the U.S. Geological Survey's NED. A conservative "bare earth" modeling approach was used, which excludes obstacles (i.e., buildings and vegetation) from the analysis. When accounted for in the shadow flicker calculations, such obstacles may significantly mitigate or eliminate the flicker effect depending on their size, type, and location.
- <u>Constant Sunshine and Operation</u>: The sun was assumed to always be shining during daylight hours and the wind turbine was assumed to always be operating.

For the "expected" scenario, the worst-case model was further refined by incorporating site-specific sunshine probabilities and yearly wind turbine operational estimates:

- Sunshine Probabilities: Monthly sunshine probability values were obtained from the National Oceanic and Atmospheric Administration's National Centers for Environmental Information publicly available historical dataset for Huron, South Dakota.
- Operational Estimates: Using the percentage of site-specific wind data annually below cut-in wind speed (i.e., the wind speed at which a turbine will begin to rotate), Epsilon calculated the number of operational hours for each of the 16 wind direction sectors. These hours per wind direction sector were used by WindPRO to estimate the "wind direction" and "operation time" reduction factors. Based on this dataset, the wind turbines would operate 96 percent of the year due to cut-in and cut-out specifications of the proposed unit.

The values produced by the "expected" shadow flicker refinement are presented in the Shadow Flicker Report.

Q. Could you summarize the results of the shadow flicker modeling?

A. Utilizing the conservative modeling parameters, the shadow flicker modeling results indicate that 20 of the 189 sensitive receptors may experience shadow flicker levels between 10 and 30 hours per year, with the annual maximum expected level of shadow flicker at a nonparticipating residence at 29 hours. While the modeling indicates that 11 participating residences could experience annual shadow flicker levels above 30 hours per year, since the modeling treated homes as "greenhouses" and assumed no vegetation or other existing structures, the "expected" levels are likely higher than actual levels will be. Dakota Range plans to discuss the results with participating landowners and, if concerns are raised, will conduct modeling using site-specific data to further refine results. Additionally, mitigation measures, such as vegetative screening or darkening shades, can be implemented to address shadow flicker concerns should they arise after the Project is operational.

Q. Based on the results of the shadow flicker analysis set forth in the Report, will the Project comply with Dakota Range's shadow flicker commitment?

A. Yes, even using the conservative modeling methodology described above, the Project is not projected to result in shadow flicker levels above 30 hours per year at any non-participating residence, business, or building owned and/or maintained by a governmental entity.

VI. CONCLUSION

Q. Does this conclude your direct testimony?

A. Yes.

Dated this 24th day of January, 2018.

Robert O'Neal