EXHIBIT A3

BEFORE THE
PUBLIC UTILITIES COMMISSION
STATE OF SOUTH DAKOTA

IN THE MATTER OF THE APPLICATION OF DAKOTA RANGE III, LLC FOR AN ENERGY FACILITY PERMIT OF A WIND ENERGY CONVERSION FACILITY AND A 345-KV TRANSMISSION LINE FOR THE DAKOTA RANGE III PROJECT

SD PUC DOCKET EL18-____

PREFILED TESTIMONY OF ROBERT O'NEAL
ON BEHALF OF DAKOTA RANGE III, LLC

October 26, 2018

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 and courts of law, and in 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 III 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 Analysis ("Sound Analysis") and a Shadow Flicker Modeling Analysis ("Shadow Flicker Analysis"), which are provided in Appendices G and H, respectively, of the Project's Energy Facility Permit Application

("Application"). I am preparing reports on both analyses, which will be provided in the docket.

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 III, LLC ("Dakota Range III").

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 H: Sound Level Modeling Analysis
- Appendix I: Shadow Flicker Modeling Analysis

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. Section 1211.03(13) of Grant County's current Zoning Ordinance imposes the following requirement for wind energy facilities: "Noise level shall not exceed 50 dBA, 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 property line of existing off-site residences, businesses, and public buildings." Constructive interference effects are accounted for by assuming all wind turbines are running at the same time. Each wind turbine's individual contribution to the total sound level at an off-site residence is added together in accordance with the international standard of sound propagation (ISO 9613-2).

However, as of the date of this testimony, we understand that Grant County is considering a proposed amendment to this section of the Ordinance as follows:

- Noise level shall not exceed 45 dBA, average A-weighted Sound pressure including constructive interference effects measured twenty-five (25) feet from the perimeter of the existing non-participating residences, businesses, and buildings owned and/or maintained by a governmental entity.
- Noise level shall not exceed 50 dBA, average A-weighted Sound pressure including constructive interference effects measured twenty-five (25) feet from the perimeter of participating residences, businesses, and buildings owned and/or maintained by a governmental entity.

Grant County is also proposing to amend this section of the Ordinance to include the following additional language: "Noise level measurements shall be made with a sound level meter using the A-weighting scale, in accordance with standards promulgated by the American National Standards Institute. A L90 measurement shall be used and have a measurement period no less than ten (10) minutes unless otherwise specified by the Board of Adjustment."

We took these proposed revisions into consideration when conducting our modeling.

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

A. Yes. Per Section 1613.03(5) of the *Roberts County Ordinance*, Roberts County requires the following: "Noise level shall not exceed 50 dB (A), average A-weighted Sound pressure including constructive interference effects as measured at the exterior wall of the closest principal and accessory structures." A waiver may be granted.

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. A sound level modeled to be less than 45 dBA on a L_{eq} basis will also be lower than 45 dBA on an L_{90} basis since the L_{90} will always be equal to or lower than the L_{eq} for a sound source.

III. ACOUSTIC ANALYSIS

Q. Was the Sound Analysis provided as Appendix H 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?

A. The purpose was to conservatively model the sound level to be produced by the Project and to confirm the Project will comply with applicable noise limits established by Grant and Roberts 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 with 45 turbine locations and the receptor dataset (135 sensitive receptors consisting of residences and 74 accessory receptors in Roberts County, and 68 sensitive receptors and 295 accessory receptors in Grant County) were provided by Dakota Range. There were 4 businesses that were included in the modeling. No buildings owned and/or maintained by a governmental entity were within the area modeled, so the dataset consisted of existing residences (sensitive receptors) and businesses 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 45 turbine locations were modeled.
- 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 MW 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 MW 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. In addition, an uncertainty factor of 2.0 dBA was added to the sound power level for the proposed turbine to account for uncertainty in the manufacturer's sound data.

- 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 Roberts County?

A. In Roberts County, the sound levels range from 28 to 43 dBA at the 135 modeled sensitive receptors (which includes both participating and nonparticipating residences), and from 27 to 43 dBA at the 74 modeled accessory receptors. The highest sound level at a sensitive receptor in Roberts County was modeled to be 43 dBA at two non-participating occupied residences. Sound levels at the modeled accessory structures do not exceed 43 dBA. Thus, the Project is below Roberts County's noise requirement of 50 dBA or less at off-site residences and accessory structures.

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

A. In Grant County, the sound levels range from 26 to 43 dBA at the 68 modeled sensitive receptors (which includes both participating and nonparticipating residences), and from 25 to 44 dBA at the 295 modeled accessory receptors. The highest sound level at a participating receptor in Grant County is modeled to be 43 dBA, and 41 dBA at a non-participating receptor. This is at an off-site occupied structure. Sound levels at the modeled accessory structures do not exceed 44 dBA. Thus, the Project is well below Grant County's noise level requirement.

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 one dBA less than 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 conducted by Epsilon in the Rocky Mountain region found measured sound levels met the predicted sound level under worst-case operating conditions.

IV. SHADOW FLICKER AND APPLICABLE STANDARDS

Q. Could you please explain what shadow flicker is?

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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.

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 level. However, Roberts County's Zoning Ordinance does contain shadow flicker requirements. Grant County currently does not have regulations for shadow flicker, but we understand that Grant County is proposing amendments to its ordinance that would include requirements for shadow flicker.

Q. Please describe Roberts County's shadow flicker requirement for wind energy facilities to be located in that county.

A. Per Section 1613.03(10) of Roberts County's Zoning Ordinance, Roberts County imposes the following requirement for shadow flicker: "A Flicker Analysis shall include the duration and location of flicker potential for all schools, churches, businesses and occupied dwellings within a one (1) mile radius of each turbine within a project. The applicant shall provide a site map identifying the locations of shadow flicker that may be caused by the project and the expected durations of the flicker at these locations from sun-rise to sun-set over the course of a year. The analysis shall account for topography but not for obstacles such as accessory structures and trees. Flicker at any receptor shall not exceed thirty (30) hours per year within the analysis area." A waiver may be granted.

Q. Please describe Grant County's shadow flicker requirement for wind energy facilities to be located in that county.

A. As I stated above, Grant County currently does not have regulations for shadow flicker, but we understand that Grant County is proposing amendments to its ordinance that would include requirements for shadow flicker. Grant County's proposed shadow flicker requirement is as follows: "A Flicker Analysis shall include the duration and location of flicker potential for all schools, churches, businesses and occupied dwellings within a one (1) mile radius of each turbine within a project. The applicant shall provide a site map identifying the locations of shadow flicker that may be caused by the project and the expected durations of the flicker at these locations from sun-rise to sun-set over the course of a year. The analysis shall account for topography but not for obstacles such as accessory structures and trees. Flicker at any receptor shall not exceed thirty (30) hours per year within the analysis area." A waiver may be granted.

Q. Has the Project committed to meet these requirements?

A. Yes, Dakota Range III will meet the shadow flicker requirement set forth in Roberts County, and the currently proposed shadow flicker requirement in Grant County.

V. SHADOW FLICKER ANALYSIS

Q. Was the Shadow Flicker Analysis 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 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 to assess shadow flicker result and confirm the Project will meet the shadow flicker requirements in Robert's County and Dakota Range III's shadow flicker commitment for the Project.

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:

- Greenhouse Mode: Each receptor was assumed to have glass on all sides of the building in all directions ("greenhouse" mode), which yields conservative results.
- Terrain: 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.
- Constant Sunshine and Operation: 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: The number of operational hours for each of the 16 wind direction sectors was provided by Dakota Range. 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 Analysis.

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

A. Utilizing the conservative modeling parameters and expected shadow flicker values, the shadow flicker modeling results indicate that 14 of the 203 sensitive receptors may experience shadow flicker levels between 10 and 30 hours per year, with an annual maximum expected level of shadow flicker at nonparticipating residences below 30 hours per year. While the modeling indicates that one participating residence 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. Additionally, Dakota Range III will seek a waiver from this landowner and, if a waiver is not granted, Dakota Range III will take steps to ensure shadow flicker levels do not exceed 30 hours per year.

VI. CONCLUSION

Q. Does this conclude your direct testimony?

A. Yes.

Dated this 26th day of October, 2018.

Robert O'Neal