BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE APPLICATION BY CROCKER WIND FARM, LLC FOR A PERMIT FOR A WIND ENERGY FACILITY AND A 345 KV TRANSMISSION LINE IN CLARK COUNTY, SOUTH DAKOTA, FOR CROCKER WIND FARM

SD PUC DOCKET EL-17-028

PREFILED TESTIMONY OF EDDIE DUNCAN ON BEHALF OF CROCKER WIND FARM, LLC

December 15, 2017

I. INTRODUCTION AND QUALIFICATIONS

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

A. My name is Eddie Duncan and I work for RSG, Inc. ("RSG"), as the Director of the Acoustics Practice. My business address is RSG, Inc., 55 Railroad Row, White River Junction, Vermont 05001.

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

A. I hold a bachelor's degree in Engineering Science from Rensselaer Polytechnic Institute, where I focused on acoustics. I also have a master's degree in Environmental Studies from Green Mountain College, where I focused on environmental law and policy, specifically noise pollution policy.

I am the Director of the acoustics practice at RSG. I am Board Certified in Noise Control Engineering by the Institute of Noise Control Engineering. I am a member of the Acoustical Society of America, where I have served as a member of the Technical Committee on Architectural Acoustics for 10 years. I have 15 years of experience in the field of acoustics with much of that experience measuring, modeling, and analyzing noise from renewable energy sources and power transmission projects. I regularly present papers at professional societies on the topics of noise from renewable energy projects, power transmission projects, and modeling and monitoring methodologies. A copy of my curriculum vitae is provided as **Exhibit 1**.

II. PURPOSE OF TESTIMONY

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

A. RSG conducted acoustic modeling of the Project's proposed layout, and prepared an associated Sound Level Assessment ("Report"), which is provided in Appendix E 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 acoustic modeling RSG conducted for the Project. In addition, I will discuss how the modeling demonstrates that the Project will comply with applicable acoustic regulations and commitments made by Crocker Wind Farm, LLC ("Crocker").

Q. Please identify the portions of the Energy Facility Permit Application ("Application") that you are sponsoring for the record.

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

- Section 9.5.4: Noise
- Appendix E: Crocker Wind Farm Sound Level Assessment

III. 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 by the Project.

A. When in motion, wind turbines emit audible sound by way of two primary mechanisms. First, mechanical sound is produced by mechanical and electrical equipment within the nacelle. In modern wind turbines, the design of the nacelle reduces the amount of sound heard outside of the nacelle. Second, "aerodynamic noise" is produced by the blades passing through the air. In addition to the turbines, the transformer located at the Project's collector substation will also emit sound.

Q. Please provide an overview of how humans perceive sound, and how perceived levels are measured.

A. The human ear perceives the magnitude (level) of a sound, but also its pitch (frequency), and the time-varying nature of level and frequency. Normal human hearing is sensitive to sound fluctuations over an enormous range of pressures, from about 20 micropascals (the "threshold of audibility") to about 20 pascals (the "threshold of pain"). The frequency of a sound is the rate at which it fluctuates in time, expressed in Hertz ("Hz"), or cycles per second.

The decibel scale compresses the range of magnitude values resulting in numbers that are more manageable and meaningful for discussion. Sound pressure is converted to sound levels in units of decibels ("dB"), which can be weighted and expressed in different ways. The most common weighting scale used in environmental noise analysis and regulation is the A-weighted decibel ("dBA"). This weighting mechanism emulates the human ear's varying sensitivity to the frequency of sound. The human ear is much more sensitive to medium frequencies than to very low or very high frequencies. The A-weighted level represents the sum of the energy across the normal audible frequency spectrum for humans (20 to 20,000 Hz), weighted by frequency as the human ear would do.

In terms of human perception, a 10 dB change in sound levels is a perceived doubling or halving of loudness. A 5 dB change is considered "clearly noticeable," and a 3 dB change is considered "just noticeable." Changes in broadband sound level of less than 3 dB are generally not considered to be noticeable.

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

A. Sound pressure levels at the base of a 1.5 megawatt ("MW") or greater wind turbine are typically between 55 and 60 dBA. For comparison, typical conversational speech between two people standing three feet apart is between 55 and 65 dBA, so one could hold a conversation at the base of a wind turbine. As sound spreads from a turbine, the sound level diminishes. At 50 dBA, it would sound approximately half as loud as conversational speech, and between 30 and 40 dBA it is comparable to background 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 South Dakota has not adopted statewide noise regulations.

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

A. Yes. Per Section 4.21.03(13) of the Clark County Zoning Ordinance, Clark County imposes the following requirement for wind energy facilities: "Noise 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. 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 referenced phrase appears to have been written by a lay person, but it most closely aligns with a sound level limit of 50 dBA using an equivalent continuous sound level metric (L_{EQ}). The L_{EQ} metric is commonly used in community noise standards and ordinances including wind turbine ordinances, and is an appropriate metric in the context of the referenced ordinance. Additional information on the L_{EQ} metric is found in Appendix A of the Report, attached as Appendix E to the Application.

IV. ACOUSTIC ANALYSIS

Q. Was the Report provided as Appendix E 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. Crocker retained RSG to prepare the Report to describe background sound levels in the Project area, and analyze and demonstrate that sound generated by the Project will comply with applicable noise standards. Consistent with these goals, the Report describes the results of RSG's measurement of existing background sound levels in the Project Area and describes the results of an acoustic modeling analysis we conducted that demonstrates that Project sound levels will meet Clark County's 50 dBA noise limit at off-site residences. No off-site businesses or buildings owned and/or maintained by a governmental entity are present within the area modeled.

Q. Please discuss your analysis of existing background sound levels in the Project Area.

A. We conducted background sound level monitoring throughout the area to quantify the existing sound levels and to identify existing sources of sound around the Project. Three locations were monitored to determine the existing background sound level. The locations of the three monitoring sites are identified in the Report. Monitoring locations were selected to represent different areas and different soundscapes (i.e., unique sound characteristics) within the Project Area.

Monitors were installed at each site on November 9, 2016, and they collected data continuously for seven days. Equivalent average (L_{EQ}), upper 10th percentile (L_{10}), median (L_{50}), and lower 10th percentile (L_{90}) sound levels were calculated. These metrics quantify how the sound level varies with time over the monitoring period and are used to quantify the character of the area as it pertains to sound. In addition to sound level data, wind speed data was collected at each monitoring location to screen out periods where high winds would have caused pseudo-noise over the microphone. Additional detail regarding the monitoring conducted is provided in the Report.

Q. What were the results of your monitoring and analysis of the existing background sound levels?

A. Common sources of sound included agricultural equipment, farm animals and pets, vehicles, birds, airplane overflights, and geophonic sounds, such as wind in the trees or ground cover. Daytime sound levels throughout the Project Area generally ranged between 41 and 50 dBA, while nighttime sound levels were generally between 36 and 52 dBA. Background sound levels varied among the monitoring locations. For two of the monitor locations (Monitor B & C), the overall equivalent continuous sound level (L_{EQ}) at nighttime was 36 dBA, while at Monitor A, the nighttime sound level (L_{EQ}) was 52 dBA due to a nearby fan for agricultural use, which ran fairly consistently.

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

A. Our modeling utilized conservative assumptions and was conducted in accordance with the international standard (ISO 9613-2), which is used for projecting outdoor sound levels from specific sources. Specifically, ISO 9613-2 assumes downwind sound propagation between every source and every receiver; consequently, all wind directions, including the prevailing wind directions, are taken into account. This is a conservative method because, in the model, all receivers are downwind, a scenario that does not physically occur.

Modeling was completed for each of the four representative turbine models presented in the Application. Although turbines would be constructed at only a subset of the 120 locations identified in the Application, modeling was conducted for each turbine model at all 120 locations to ensure that any location selected would meet applicable noise requirements. In addition, each model run included sound emissions from the transformer at the Project substation.

Sound levels from the proposed turbines were calculated at 69 discrete receivers (residences) that surround the Project. The model was developed using a software program called Cadna-A. The model takes into account source sound power levels, surface reflection and absorption, atmospheric absorption, geometric divergence, meteorological conditions, walls, barriers, berms, and terrain. Two distinct receiver heights are included in the analysis: four meters and 1.5 meters. The four meter (13-foot) receiver height is representative of the height of a second-story window. The 1.5-meter (five-foot) receiver height represents average listening height outside of homes.

Further discussion of the methodology used is provided the Report (*see* Appendix E of the Application).

Q. Could you summarize the results of the analysis?

A. For all turbine models, projected sound levels from the Project are 50 dBA or less at all participating residences, and 41 dBA or less at all non-participating residences. The average sound level across all residences is 39 or 40 dBA, depending on the turbine model. Thus, the results show the Project will comply with the Clark County noise requirement.

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. Yes. There are a number of studies that support the accuracy and assumptions used in the Report. For example, the Research Study on Wind Turbine Acoustics ("RSOWTA") conducted for the Massachusetts Clean Energy Center and the Massachusetts Department of Environmental Protection compared modeling results with monitoring results for a range of conditions for five different wind turbine installation sites and found the same parameters used in the Report to be accurate.

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

A. The Massachusetts Clean Energy Center's RSOWTA, showed that the same parameters used in the Report resulted in model results (L_{EQ1hr}) that were nearly identical (within one dB) to the monitoring results, with the exception of one outlier where monitored level exceeded the modeled level. Another study (Cooper, J. and Evans, T., "Accuracy of noise predictions for wind farms," *Proceedings of the 5th International Conference on Wind Turbine Noise*, 2013), showed that, for sites of similar topography as the Project, the same modeling parameters used in the Report resulted in measured sound levels within one dB of the modeled sound levels.

Q. Are you aware of any potential impacts that could be caused by the Project due to low frequency and infrasonic sound?

A. No. The majority of audible aerodynamic sound from wind turbines is broadband at the middle frequencies, roughly between 200 Hz and 1,000 Hz. Infrasound from the project is expected to be below the threshold of audibility, and low frequency sound for the worst-case modeled receivers are below the criteria to prevent "moderately perceptible vibration and rattle" in lightweight wall and ceiling constructions. Additional information on infrasound and low frequency noise is discussed in Appendix D of the Report.

V. CONCLUSION

Q. Does this conclude your direct testimony?

A. Yes.

Dated this 15 day of December, 2017.

Eddie Duncan