

**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

1 **I. INTRODUCTION AND QUALIFICATIONS**

2
3 **Q. Please state your name, employer, and business address.**

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

7
8 **Q. Briefly describe your educational and professional background and your
9 current work for RSG.**

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

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

25
26 **II. PURPOSE OF TESTIMONY**

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

30 A. RSG conducted acoustic modeling of the Project's proposed layout, and prepared an
31 associated Sound Level Assessment ("Report"), which is provided in Appendix E of
32 the Project's Energy Facility Permit Application ("Application").
33

34 **Q. What is the purpose of your testimony?**

35 A. The purpose of my testimony is to discuss the methodology and results of the
36 acoustic modeling RSG conducted for the Project. In addition, I will discuss how the
37 modeling demonstrates that the Project will comply with applicable acoustic
38 regulations and commitments made by Crocker Wind Farm, LLC ("Crocker").
39

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

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

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

45

46 **III. WIND TURBINE SOUND AND APPLICABLE STANDARDS**

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

50 A. When in motion, wind turbines emit audible sound by way of two primary
51 mechanisms. First, mechanical sound is produced by mechanical and electrical
52 equipment within the nacelle. In modern wind turbines, the design of the nacelle
53 reduces the amount of sound heard outside of the nacelle. Second, "aerodynamic
54 noise" is produced by the blades passing through the air. In addition to the turbines,
55 the transformer located at the Project's collector substation will also emit sound.
56

56

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

59 A. The human ear perceives the magnitude (level) of a sound, but also its pitch
60 (frequency), and the time-varying nature of level and frequency. Normal human

61 hearing is sensitive to sound fluctuations over an enormous range of pressures, from
62 about 20 micropascals (the “threshold of audibility”) to about 20 pascals (the
63 “threshold of pain”). The frequency of a sound is the rate at which it fluctuates in
64 time, expressed in Hertz (“Hz”), or cycles per second.

65

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

76

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

81

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

84 A. Sound pressure levels at the base of a 1.5 megawatt (“MW”) or greater wind turbine
85 are typically between 55 and 60 dBA. For comparison, typical conversational speech
86 between two people standing three feet apart is between 55 and 65 dBA, so one
87 could hold a conversation at the base of a wind turbine. As sound spreads from a
88 turbine, the sound level diminishes. At 50 dBA, it would sound approximately half as
89 loud as conversational speech, and between 30 and 40 dBA it is comparable to
90 background sound levels in a quiet rural area.

91

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

94 A. There are no federal sound level regulations specific to wind energy conversion
95 facilities. Also, it is my understanding that South Dakota has not adopted statewide
96 noise regulations.

97
98 **Q. Has Clark County established a sound level requirement for wind energy**
99 **facilities to be located in that county?**

100 A. Yes. Per Section 4.21.03(13) of the Clark County Zoning Ordinance, Clark County
101 imposes the following requirement for wind energy facilities: "Noise shall not exceed
102 50 dBA, average A-weighted Sound pressure including constructive interference
103 effects at the perimeter of the principal and accessory structures of existing off-site
104 residences, businesses, and buildings owned and/or maintained by a governmental
105 entity."

106
107 **Q. Based on your expertise, could you explain what the phrase "noise level shall**
108 **not exceed 50 dBA, average A-weighted Sound pressure including**
109 **constructive interference effects" means?**

110 A. The referenced phrase appears to have been written by a lay person, but it most
111 closely aligns with a sound level limit of 50 dBA using an equivalent continuous
112 sound level metric (LEQ). The LEQ metric is commonly used in community noise
113 standards and ordinances including wind turbine ordinances, and is an appropriate
114 metric in the context of the referenced ordinance. Additional information on the LEQ
115 metric is found in Appendix A of the Report, attached as Appendix E to the
116 Application.

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118 **IV. ACOUSTIC ANALYSIS**

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120 **Q. Was the Report provided as Appendix E to the Application prepared by you or**
121 **under your supervision and control?**

122 A. Yes.

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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.

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

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

165
166 **Q. Could you provide an overview of the methodology used in conducting the**
167 **acoustic modeling analysis for the Project?**

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

175
176 Modeling was completed for each of the four representative turbine models
177 presented in the Application. Although turbines would be constructed at only a
178 subset of the 120 locations identified in the Application, modeling was conducted for
179 each turbine model at all 120 locations to ensure that any location selected would
180 meet applicable noise requirements. In addition, each model run included sound
181 emissions from the transformer at the Project substation.

182
183 Sound levels from the proposed turbines were calculated at 69 discrete receivers
184 (residences) that surround the Project. The model was developed using a software

185 program called Cadna-A. The model takes into account source sound power levels,
186 surface reflection and absorption, atmospheric absorption, geometric divergence,
187 meteorological conditions, walls, barriers, berms, and terrain. Two distinct receiver
188 heights are included in the analysis: four meters and 1.5 meters. The four meter
189 (13-foot) receiver height is representative of the height of a second-story window.
190 The 1.5-meter (five-foot) receiver height represents average listening height outside
191 of homes.

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

195

196 **Q. Could you summarize the results of the analysis?**

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

202

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

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

212

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

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

223

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

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

233

234 **V. CONCLUSION**

235

236 **Q. Does this conclude your direct testimony?**

237 A. Yes.

238

239 Dated this 15 day of December, 2017.

240

241



242 Eddie Duncan