

**BEFORE THE STATE OF NORTH DAKOTA  
PUBLIC SERVICE COMMISSION**

**RUSO WIND PARTNERS, LLC  
RUSO WIND PROJECT - WARD AND MCLEAN COUNTIES  
SITING APPLICATION**

**CASE NO. PU-19-28**

**PRE-FILED TESTIMONY OF CHRIS HOWELL  
ON BEHALF OF RUSO WIND PARTNERS, LLC**

May 29, 2019

76 PU-19-29 Filed 06/17/2019 Pages: 15  
Exhibit 31 - Pre-filed testimony of Chris Howell  
Ruso Wind Partners, LLC

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Ruso Wind Partners, LLC

1 **I. INTRODUCTION AND QUALIFICATIONS**

2

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

4 A. My name is Chris Howell. I am an Associate Noise Specialist and Project Manager  
5 in the Environmental Services division at Burns & McDonnell Engineering Company,  
6 Inc. ("Burns & McDonnell"). My business address is 9400 Ward Parkway, Kansas  
7 City, Missouri 64114.

8

9 **Q. Briefly describe your background and qualifications.**

10 A. I am the noise lead for Burns & McDonnell. In that role, I specialize in generation  
11 and noise analyses, and also manage general environmental permitting teams. I  
12 have extensive experience conducting noise modeling for large-scale wind farms in  
13 multiple states. I have 17 years of professional experience, 15 of which have been  
14 with Burns & McDonnell. I have a Bachelor of Science degree in Mechanical  
15 Engineering and am a member of the Institute of Noise Control Engineering. A copy  
16 of my curriculum vitae is provided as proposed Exhibit 31-A.

17

18 **II. PURPOSE OF TESTIMONY**

19

20 **Q. What are Burns & McDonnell's role and your role with respect to the Ruso**  
21 **Wind Project ("Project")?**

22 A. Burns & McDonnell was retained to conduct shadow flicker and sound modeling. I  
23 conducted acoustic modeling of the Project's proposed layout and prepared an  
24 associated Sound Study, which is provided in Appendix R of the Project's  
25 Application for a Certificate of Site Compatibility ("Application") (Exhibit 1). I also  
26 conducted supplemental acoustic modeling, as set forth in the Additional Sound  
27 Modeling Results (Exhibit 18).

28

29 **Q. What is the purpose of your Testimony?**

30 A. The purpose of my testimony is to discuss the methodology and results of the  
31 acoustic modeling conducted for the Project. In addition, I will discuss how the

33 modeling demonstrates that the Project will comply with applicable acoustic  
34 regulations.

35 **Q. What proposed hearing exhibits are you sponsoring in your Testimony?**

36 A. I am sponsoring the following proposed hearing exhibits:

- 37 • Exhibit 1: Application (Section 6.5 and Appendix R)
- 38 • Exhibit 18: Additional Sound Modeling Results

39  
40 **III. WIND TURBINE SOUND AND APPLICABLE STANDARDS**

41  
42 **Q. Please provide an overview of the sound that may be generated by modern  
43 utility-scale wind turbines, such as those that will be used by the Project.**

44 A. The sound commonly associated with a wind turbine is described as a rhythmic  
45 “whoosh” caused by aerodynamic processes. This sound is created as air flow  
46 interacts with the surface of rotor blades. As air flows over the rotor blade, turbulent  
47 eddies form in the surface boundary layer and wake of the blade. These eddies are  
48 where most of the “whooshing” sound is formed. Additional sound is generated from  
49 vortex shedding produced by the tip of the rotor blade. Air flowing past the rotor tip  
50 creates alternating low-pressure vortices on the downstream side of the tip, causing  
51 sound generation to occur.

52  
53 Advancement in wind turbine technology has reduced distinct tonal sounds by  
54 reshaping turbine blades and adjusting the angle at which air contacts the blade.  
55 Pitching technology allows the angle of the blade to adjust when the maximum  
56 rotational speed is achieved, which allows the turbine to maintain a constant  
57 rotational velocity. Therefore, sound emission levels remain constant as the velocity  
58 remains the same.

59  
60 Wind turbines can create noise in other ways as well. Wind turbines have a nacelle  
61 where the mechanical portions of the turbine are housed. The current generation of  
62 wind turbines uses multiple techniques to reduce the noise from this portion of the

63 turbine: vibration isolating mounts, special gears, and acoustic insulation. In  
64 general, all moving parts and the housing of the current generation of wind turbines  
65 have been designed to minimize the sound generated.

66

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

69 A. Sound energy travels through air as a pressure wave. The human ear perceives the  
70 amplitude of the sound pressure wave, and also its frequency (pitch). Human  
71 hearing is sensitive to sound fluctuations over an enormous range of pressures, from  
72 about 20 micropascals (the “threshold of human hearing”) to about 20 pascals (the  
73 “threshold of pain”). The frequency of a sound is the rate at which it fluctuates in  
74 time, expressed in Hertz (“Hz”), or wave cycles per second.

75

76 The compressive decibel scale is used to make the numbers more manageable for  
77 discussion. Sound pressure is converted to sound levels in units of decibels (“dB”),  
78 which can be weighted and expressed in different ways. The most common  
79 weighting scale used in environmental noise analysis and regulation is the A-  
80 weighted decibel (“dBA”). This weighting mechanism emulates the human ear’s  
81 varying sensitivity to the frequency of sound. The human ear is much more sensitive  
82 to medium frequencies (1,000 to 8,000 Hz) than to very low or very high frequencies.  
83 The A-weighted level represents the sum of the energy across the normal audible  
84 frequency spectrum for humans (20 to 20,000 Hz), weighted by frequency as the  
85 human ear would do.

86

87 In terms of human perception, a 10-dB change in sound levels is a perceived  
88 doubling (or halving, if the sound is decreasing) of loudness. A 5-dB change is  
89 considered “clearly noticeable,” and a 3-dB change is considered “just barely  
90 noticeable.” Changes in broadband sound level of less than 3 dB are generally not  
91 considered to be noticeable.

92

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

96 A. Sound pressure levels at the base of a 1.5 megawatt ("MW") or greater wind turbine  
97 are typically between 55 and 60 dBA. For comparison, typical conversational  
98 speech between two people standing three feet apart is between 55 and 65 dBA, so  
99 one could hold a conversation at the base of a wind turbine. As sound spreads from  
100 a turbine, the sound level diminishes. At 45 to 50 dBA, it would sound approximately  
101 like conversational speech at home, and between 30 and 40 dBA it is comparable to  
102 background sound levels in a rural area.

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

105 A. There is no federal sound level regulation for wind turbines. The North Dakota  
106 Public Service Commission ("Commission") requires that sound produced by wind  
107 turbines not exceed 50 dBA within 100 feet of an inhabited residence or a  
108 community building, unless a waiver is obtained from the owner of the inhabited  
109 residence or the community building.

110  
111 **Q. Does Ward County have sound level requirements for wind energy facilities?**

112 A. No, Ward County does not have a sound level requirement for wind energy facilities.  
113

114 **IV. SOUND STUDY (EXHIBIT 1, APPENDIX R)**  
115

116 **Q. What was the purpose of the acoustic modeling and analysis discussed in the**  
117 **Sound Study (Exhibit 1, Appendix R)?**

118 A. The purpose of the Sound Study was to determine through analysis whether the  
119 sound generated by the Project will comply with applicable noise standards.  
120 Consistent with these goals, the Sound Study describes the results of the acoustic  
121 modeling analysis we conducted, which demonstrates that Project sound levels will  
122 comply with the Commission's sound level requirement.

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

126 A. Our modeling was completed using CadnaA, Version 2019, modeling software,  
127 which is a scaled, three-dimensional program that accounts for air absorption,  
128 terrain, ground absorption, and ground reflection for each piece of sound-emitting  
129 equipment and predicts downwind sound pressure levels.

130  
131 The modeling utilized conservative assumptions and was conducted in accordance  
132 with International Organization for Standardization (“ISO”) 9613-2, which is the  
133 international sound modeling standard used for predicting outdoor sound levels from  
134 specific sources. Specifically, ISO 9613-2 uses omnidirectional downwind sound  
135 propagation and worse-case directivity factors. In other words, the model assumes  
136 that each turbine transmits its maximum sound level in all directions at all times.  
137 Because CadnaA calculates the worst-case scenario for downwind sound  
138 propagation, predicted sound levels tend to be higher than what would actually  
139 occur.

140  
141 The modeling did not include attenuation for sound propagation through wooded  
142 areas, existing barriers, and shielding. Additionally, all turbines were assumed to be  
143 operating at maximum power output (and therefore, maximum sound levels) at all  
144 times to represent worst-case noise impacts from the wind farm as a whole. The  
145 model also assumed atmospheric conditions that are favorable to sound  
146 propagation. Specifically, the analysis assumed an atmosphere of ten degrees  
147 Celsius and seventy percent humidity. Although ground attenuation is expected to  
148 be high due to soft ground, we used a conservative ground attenuation value of 0.5.  
149 These assumptions further added to the conservativeness of the model, which was  
150 designed to conservatively estimate even worst-case modeled sound levels.

152 **Q. Did you use an uncertainty factor in your analysis? If not, why not?**

153 A. No. Based on past experience, the methodology used in this analysis is typically 1  
154 to 3 dBA more conservative than measured values. Use of an uncertainty factor  
155 would needlessly compound the already conservative assumptions.

156  
157 **Q. Has Mr. David Hessler previously had occasion to review the sound analysis**  
158 **methodology you just described?**

159 A. Yes. As part of the Prevailing Wind Park Energy Facility permit process in South  
160 Dakota, I prepared a sound analysis using this same methodology. Mr. Hessler was  
161 retained by the South Dakota Public Utilities Commission Staff to provide an  
162 analysis of my methodology. As part of that proceeding, Mr. Hessler testified that  
163 the "modeling methodology and assumptions [were] satisfactory."<sup>1</sup>

164  
165 **Q. What Project-specific information was incorporated into the modeling?**

166 A. For the initial analysis, modeling was conducted for the two turbine models being  
167 considered for the Project at that time: the Siemens Gamesa SG-4.5-145<sup>2</sup> and the  
168 Siemens Gamesa SWT-2.415-108. Although fewer turbines would be constructed,  
169 the initial modeling analysis was conducted at all 66 potential locations, with the  
170 Siemens Gamesa SG-4.5-145 at 55 turbine locations (42 primary and 13 alternate)  
171 and the Siemens Gamesa SWT-2.415-108 at 11 turbine locations (all primary).

172

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<sup>1</sup> See Testimony of David Hessler at 3, *In the Matter of the Application by Prevailing Wind Park, LLC for a Permit of a Wind Energy Facility in Bon Homme County, Charles Mix County and Hutchinson County, South Dakota, for the Prevailing Wind Park Project*, South Dakota Public Utilities Commission Docket EL18-026.

<sup>2</sup> Modeling was conducted using the Siemens Gamesa SG-4.5-145 Flexible Rating Performance Specifications. Those Specifications provide the sound level output range for between 4.2-4.8 MW, and the maximum sound level (associated with 4.8 MW) was incorporated into the modeling. As a result, the modeling is applicable to both the 4.5 MW and the 4.8 MW models.

173 **Q. Did you consider existing wind farms in you modeling?**

174 A. Yes. The modeling considered two existing neighboring wind farms. The New  
175 Frontier Wind Farm is located southeast of the Project and consists of 44 Vestas  
176 V126-3.45 WTGs. Prairie Wind Farms 1 is located northwest of the Project and  
177 consists of 82 GE-1.577 WTGs. Sound pressures were predicted using  
178 manufacturer-specified sound power levels for each wind-turbine. The New Frontier  
179 Wind Farm and the Prairie Wind Farms 1 turbines are identified with a prefix of "NF"  
180 and "PW," respectively, on the figures and charts provided with the Sound Study  
181 (Exhibit 1, Appendix R).

182  
183 Cumulative sound levels from 66 proposed turbines, as well as all 126 existing  
184 turbines at the New Frontier Wind Farm and Prairie Wind 1 Wind Farm, were  
185 calculated for each of the 68 identified discrete receptors (residences) that surround  
186 the Project.<sup>3</sup> These receptors were identified by the Applicant, and they correspond  
187 to the physical residence. Each receptor was assumed to have a height of 1.52  
188 meters (5 feet) above ground level.

189  
190 Further discussion of the methodology used is provided in the Sound Study (Exhibit  
191 1, Appendix R).

192  
193 **Q. Could you summarize the results of the Sound Study in Appendix R of the**  
194 **Application (Exhibit 1)?**

195 A. Based on the analysis, sound levels from the Project are predicted to be less than  
196 50 dBA at all inhabited residences. When taking into consideration the neighboring  
197 wind farms, the highest modeled sound level at a residence was 49.3 dBA. The  
198 source of the sound for that residence, however, was solely the existing New  
199 Frontier Wind Project. The highest modeled sound level at a residence attributable  
200 to the Ruso Wind Project turbines was 45.6 dBA.

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<sup>3</sup> Ruso Wind did not identify any community buildings in the Project Area.

202 To confirm that the predicted sounds levels 100 feet from any of the residences are  
203 also below the 50-dBA limit, we identified the worst-case receptor (Receptor 53),  
204 which had a predicted sound pressure level of 49.3 dBA. A new receptor was then  
205 placed 100 feet from Receptor 53 in the direction of the nearest turbine (i.e., closer  
206 to the turbine), where there were limited interfering structures, and the full model  
207 was re-run. The result was a predicted sound pressure level of 49.6 dBA at that  
208 receptor. Based on the analysis of this worst-case receptor, we concluded that there  
209 were no expected exceedances of the 50-dBA limit at 100 feet from the receptor.  
210 Any increase in sound level at 100-foot from any other receptor would be similar in  
211 magnitude to the 0.3-dBA increase modeled for Receptor 53. Further, considering  
212 that the highest sound level attributable to the Project (as opposed to an existing  
213 wind farm) was 45.6 dBA, the sound levels from the Project would be well below the  
214 50 dBA within 100 feet of a receptor. Thus, the analysis demonstrates the Project  
215 would comply with the Commission's sound level requirement.

217 **V. ADDITIONAL SOUND MODELING (EXHIBIT 18)**

218  
219 **Q. You have also provided Additional Sound Modeling Results (Exhibit 18). Can**  
220 **you explain what was modeled for this analysis?**

221 A. Yes. Ruso Wind identified three General Electric ("GE") turbine models that may  
222 potentially be used for the Project: GE-2.3-116 (80-meter hub height), GE-2.5-116  
223 (90-meter hub height), and GE-2.82-127 (89-meter hub height); and eliminated one  
224 primary turbine location from consideration. Ruso Wind asked that we run a sound  
225 analysis using the turbine that would result in the greatest potential impacts at all  
226 potential turbine locations.

227  
228 Based on that instruction, we re-ran the analysis using the GE-2.82-127 model for  
229 65 potential turbine locations. Of the three GE models under consideration by Ruso  
230 Wind, the GE-2.82-127 would have the greatest potential sound impact.

232 **Q. For purposes of your analysis for the Additional Sound Modeling Results**  
233 **(Exhibit 18), were there any changes to the turbine locations?**

234 A. No. The turbines remained in the same location as was previously modeled, except  
235 for the one removed. One minor change was that the turbine ID numbers changed  
236 between the initial layout modeled and the later layout.

237

238 It is my understanding that Ruso Wind subsequently removed two of the proposed  
239 alternative turbines from consideration. If anything, this makes the sound modeling  
240 that was performed more conservative.

241

242 **Q. In conducting your analysis for the Additional Sound Modeling Results**  
243 **(Exhibit 18), did you use the same methodology as you did in the Sound Study**  
244 **(Exhibit 1, Appendix R)?**

245 A. Yes. I used the CadnaA, Version 2019, modeling software, and included the same  
246 assumptions. Like before, my analysis also considered 126 turbines from the two  
247 existing wind farms located in the area.

248

249 **Q. Can you summarize the results of the Additional Sound Modeling Results**  
250 **(Exhibit 18)?**

251 A. Based on the analysis, if any of three proposed GE turbine models were used,  
252 predicted sound levels from the Project (i.e., the cumulative sound levels, including  
253 the two existing wind farms) are less than 50 dBA at 100 feet from all residences.  
254 The highest modeled sound level was 49.3 dBA at the receptor, which is the same  
255 as the highest sound level in the original Sound Study (Exhibit 1, Appendix R).  
256 Again, this is caused solely by the New Frontier wind turbines.<sup>4</sup> For the reasons  
257 discussed previously, the Project will comply with the Commission's 50-dBA limit  
258 within 100 feet of an inhabited residence or community building.

259

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<sup>4</sup> In the GE turbine model analysis, the highest modeled sound level at a receptor that is attributable to the Project (as opposed to an existing wind project) is 48.5 dBA.

● VI. MODELING ACCURACY

261  
262 **Q. Has Burns & McDonnell conducted post-construction sound studies to**  
263 **determine the accuracy of the modeling methodology used to predict sound**  
264 **levels generated by the Project?**

265 A. Yes. The methods used in this study to develop the potential sound impacts of this  
266 Project are consistent with those used in most of our predictive studies. We perform  
267 many acoustical studies per year, with nearly half requiring post-construction  
268 compliance demonstration. Both in-house and third-party monitoring has routinely  
269 demonstrated that our prediction methods are conservative, and monitoring results  
270 are typically between 1 and 3 dBA lower than our predictions.

271

272 **VII. CONCLUSION**

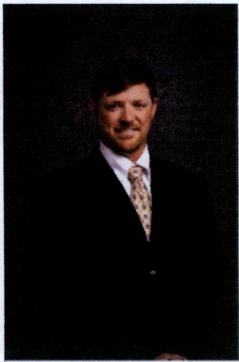
273

274 **Q. Does this conclude your Testimony?**

● 5 A. Yes.

# CHRIS HOWELL, INCE

## Project Manager



Mr. Howell is a Project Manager in the Environmental Services group, with a specialty in generation permitting and is also the Noise Lead. He manages the overall environmental permitting and licensing of complex facilities. He leads an experienced team of permitting specialists who conduct feasibility studies and assist clients with regulatory compliance and/or mitigation efforts. Chris has performed projects in all 50 of the United States, Puerto Rico, Canada, Mexico, Asia, Africa, and the Middle East. His clients range

from generation, transmission and distribution, to transportation and other industries. Many of his projects require public involvement and/or interaction with regulatory agencies and expert testimony. Mr. Howell is an Associate at Burns & McDonnell.

### EDUCATION

- ▶ BS, Mechanical Engineering, Kansas State University, 1999

### ASSOCIATIONS

- ▶ Institute of Noise Control Engineering

**17** YEARS WITH BURNS & MCDONNELL

**19** YEARS OF EXPERIENCE

### Ruso Wind Farm Permitting Studies | Ruso Wind Partners, LLC North Dakota | 2018 – Current

**Noise Lead:** Chris performed acoustical modeling for the proposed Ruso Wind Farm in North Dakota. The results of the study will be used by the client to pursue a special use permit for the project. Modeling was performed using CadnaA. Chris will be testifying before the North Dakota Public Service Commission.

### Philip Wind Farm Permitting Studies | Philip Wind Partners, LLC South Dakota | 2018 – 2019

**Noise Lead:** Chris performed acoustical modeling for the proposed Philip Wind Farm in South Dakota. The results of the study were used by the client to pursue a special use permit for the project. Modeling was performed using CadnaA. Written testimony was submitted for public hearings.

### Bitter Ridge Wind Farm | Scout Clean Energy Jay County Indiana | 2018 – Current

**Noise Lead:** Chris performed acoustical modeling for the proposed Bitter Ridge Wind Farm in Indiana. The results of the study will be used by the client to pursue a special use permit for the project. Modeling was performed using CadnaA.

### Prevailing Winds Wind Farm, Prevailing Winds LLC. South Dakota | 2016 and 2018

**Noise Lead.** Chris managed an ambient survey team, performed predictive noise modeling using CadnaA, and assisted Prevailing Winds with public testimony during the licensing and permitting phase of a 200-MW wind farm. The wind farm spanned three counties. Chris testified before the SDPUC and assisted Prevailing Winds in gathering data to bolster their application.

# CHRIS HOWELL, INCE

(continued)

## Big Blue River Wind Farm | Confidential Client

Henry County Indiana | 2018 – Current

**Noise Lead:** Chris performed acoustical modeling for the proposed Big Blue River Wind Farm in Indiana. The results of the study will be used by the client to pursue a special use permit for the project. Modeling was performed using CadnaA.

## Thunder Spirit | ALLETE Clean Energy

North Dakota | 2018

**Noise Lead:** Chris managed and performed an acoustical assessment for ALLETE Clean Energy during the development, design, and construction of the Thunder Spirit II Wind Farm. The noise assessment study consisted of predictive modeling using the CadnaA software.

## Big Sky Wind Farm Permitting Studies | Confidential Client

Illinois | 2018

**Noise Lead:** Chris managed a project team that performed ambient sound monitoring and the predictive modeling during for development of the proposed Big Sky Wind Farm. Chris helped with graphical representation of expected impacts and provided assistance for public meetings. The results of the study were used by the client to pursue a special use permit for the project.

## Mountain Breeze Wind Farm Permitting Studies | Confidential Client

Colorado | 2018

**Noise Lead:** Chris provided predictive modeling and micro-siting assistance during the development of the proposed Mountain Breeze Wind Farm. The results of the study will be used by the client to pursue a special use permit for the project.

## Nimbus Wind Farm Permitting Studies | Scout Clean Energy

Arkansas | 2018

**Noise Lead:** Chris performed predictive modeling during the development of the proposed Nimbus Wind Farm. The results of the study were used by Scout to pursue a special use permit for the project.

## Lone Tree Wind Farm, Leeward

Illinois | 2017

**Noise Lead.** Chris managed ambient monitoring and performed predictive noise modeling using CADNA to assist Leeward in the permitting and licensing phase for a proposed wind farm in Bureau County, IL. Octave band analysis and existing wind farms cumulative impacts were performed. Chris provided written and oral testimony in front of the zoning board.

## Milligan 1 and 3 Wind Farms, Aksamit

Nebraska | 2016

**Noise Lead.** Chris performed predictive noise modeling using CadnaA to assist Aksamit in the permitting and licensing phase of 374-MW of turbines in Saline County, NE.



## CHRIS HOWELL, INCE

(continued)

### Mendota Hills Wind Farm Repower, Leeward

Illinois | 2016

**Noise Lead.** Chris managed and ambient monitoring and predictive noise modeling using CadnaA to assist Leeward in the permitting and licensing phase for repowering an existing wind farm, using fewer, larger turbines. Comparisons were performed to the currently operating wind farm's impacts. Chris provided written and oral testimony for the project.

### Broken Bow 2 Wind Farm | Sempra U.S. Gas & Power

Nebraska | 2015

**Noise Lead:** Chris performed predictive modeling and commercial negotiation support for Sempra U.S. Gas & Power during development of a 75-MW wind energy project in central Nebraska.

### Energia Sierra Juarez Wind Farm, Sempra International

Baja California, Mexico | 2014

**Noise Lead.** Chris is performed predictive noise modeling using CadnaA to assist Sempra in the permitting and licensing phase of a 155-MW wind farm.

### Twin Groves Phases 4 & 5, Horizon Wind Energy

Illinois | 2009 And 2011

**Noise Lead.** Chris performed background noise monitoring and predictive noise modeling using CadnaA to assist Horizon in the permitting and licensing phase of a 500-megawatt wind farm. He successfully assisted with public testimony. Later, Chris assisted Horizon with the determining the noise implications that changing turbines would have to the already approved wind farm.

### Top Crop 3&4 Wind Farm, Horizon Wind Energy

Illinois | December 2011

**Noise Lead.** Chris performed ambient monitoring and predictive noise modeling using CadnaA to assist Horizon in the permitting and licensing phase of adding 300-MW of turbines to the existing TC1&2 Wind Farm. A cumulative analysis of various surrounding wind farms was completed the three counties as a whole using data from nearby, non-Horizon wind farms in conjunction with the Horizon project and various design options.

### Rail Splitter, Horizon Wind Energy

Illinois | 2008 and 2011

**Noise Lead.** Chris performed background noise monitoring and predictive noise modeling using CadnaA to assist Horizon in the permitting and licensing phase of a 500-megawatt wind farm. Later, Chris assisted Horizon in determining what cumulative noise impacts would occur when of adding WindBOOST technology.

### Bright Stalk, Horizon Wind Energy

Illinois | 2010

**Noise Lead.** Chris performed background noise monitoring and predictive noise modeling using CadnaA to assist Horizon in the permitting and licensing phase of a 400-megawatt wind farm. He also assisted with public testimony.

 **CHRIS HOWELL, INCE**  
(continued)

Meadow Lake Phases 1-5, Horizon Wind Energy  
Indiana | 2009 and 2011

**Noise Lead.** Chris performed background noise monitoring and predictive noise modeling using CadnaA to assist Horizon in the permitting and licensing phase of a 500-megawatt wind farm. Later, Chris assisted Horizon in determining what cumulative noise impacts would occur when adding WindBOOST technology.

Lompoc Wind Farm, Acciona  
California | July 2010

**Noise Lead.** Chris performed predictive noise modeling using CadnaA to assist Acciona in the permitting and licensing phase of a wind farm. He also created documentation regarding public interaction and action plans. He also developed a monitoring plan for the project and was to coordinate a team of specialists to carry out ambient noise monitoring. The project is currently on hold.

