

**BEFORE THE PUBLIC UTILITIES COMMISSION  
OF THE STATE OF SOUTH DAKOTA**

**IN THE MATTER OF THE APPLICATION BY PREVAILING WIND PARK, LLC  
FOR A PERMIT FOR A WIND ENERGY FACILITY IN BON HOMME, CHARLES MIX,  
AND HUTCHINSON COUNTIES, SOUTH DAKOTA, FOR PREVAILING WIND  
PARK ENERGY FACILITY**

**SD PUC DOCKET EL18-026**

**PRE-FILED SUPPLEMENTAL DIRECT TESTIMONY OF DR. MARK ROBERTS  
ON BEHALF OF PREVAILING WIND PARK, LLC**

August 10, 2018

1 **I. INTRODUCTION AND QUALIFICATIONS**

2

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

4 A. My name is Dr. Mark Roberts. I am employed by Exponent, Inc. (“Exponent”), and  
5 my office is located at 525 West Monroe Street, Suite 1050, Chicago, Illinois 60661.

6

7 **Q. Please describe your educational and professional background.**

8 A. I am a Principal Scientist in the Chicago office of Exponent, a scientific research and  
9 consulting company headquartered in Menlo Park, California. I have worked at  
10 Exponent since November 2003.

11

12 Prior to working at Exponent, I held a series of positions with advancing  
13 responsibility in the areas of public health, occupational medicine, and academia. I  
14 was employed at the Oklahoma State Department of Health from 1972 to 1990 and  
15 held a series of positions culminating in my appointment as the State Epidemiologist,  
16 a post that I held from 1979 to 1982, followed by the position of Consulting  
17 Medical/Environmental Epidemiologist from 1983 to 1990. In both of these  
18 capacities, I directed epidemiologic investigations consisting of a broad range of  
19 health concerns, from food-borne outbreaks to cancer clusters.

20

21 I was a faculty member of the Department of Preventive Medicine at the Medical  
22 College of Wisconsin from 1990 to 1997, and I completed my tenure as Associate  
23 Professor and Acting Chairman of the Department. I have also served as Corporate  
24 Medical Director for several global companies. While on faculty at the Medical  
25 College of Wisconsin in Milwaukee, Wisconsin, I was contract Medical Director for  
26 Wisconsin Centrifugal, a foundry in Waukesha, Wisconsin. In this role, I supervised  
27 the health monitoring programs, both company-mandated and Occupational Safety  
28 and Health Administration (“OSHA”) required, in addition to the day-to-day clinical  
29 aspects of the employee health service. My responsibilities included biological  
30 surveillance of employee population as well as worksite reviews and inspections.

31

32 I earned an M.S. in Education in 1972, an M.P.H. in Epidemiology and Biostatistics  
33 in 1974, and a Ph.D. in Epidemiology and Biostatistics in 1979. I completed medical  
34 school in 1986, an internship in Family Medicine in 1987, and a residency/fellowship  
35 in Occupational and Environmental Medicine in 1990.

36  
37 I am a Fellow of the American College of Occupational and Environmental Medicine.  
38 I have unrestricted licenses to practice medicine in Oklahoma and Wisconsin. In  
39 addition to my employment experience, I am a past member (2000–2007, 2008–  
40 2011) of the Board of Directors, Vice President (2013-2014), and President (2015-  
41 2016) of the American College of Occupational and Environmental Medicine in  
42 Arlington Heights, Illinois. I have been a member of the Board of Directors of Vysis,  
43 Inc. in Downers Grove, Illinois and the Board of Scientific Counselors for the Agency  
44 for Toxic Substances and Disease Registry in Atlanta, Georgia. In addition, I have  
45 served as an active participant on numerous state and national professional  
46 committees. My statement of qualifications is attached as Exhibit 1.

47  
48 **Q. Did you previously provide prefiled testimony in this docket?**

49 A. No.

50  
51 **II. PURPOSE OF TESTIMONY**

52  
53 **Q. What is the purpose of your Direct Testimony?**

54 A. The purpose of my testimony is to (i) give an overview of public health and  
55 epidemiology principles implicated by an inquiry into the health effects of wind  
56 turbines; (ii) generally assess health claims that have been attributed to wind  
57 turbines in light of the peer-reviewed and published scientific literature; and (iii)  
58 specifically address health concerns relating to infrasound, vertigo, and  
59 “vibroacoustic disease” raised during the public input hearing for the proposed  
60 Prevailing Wind Park (“Project”).

61

62 **Q. Please provide a brief summary of the opinions you are offering in your Direct**  
63 **Testimony.**

64 A. My opinions can be summarized as follows:

- 65 1. Wind turbines, as a cause of specific adverse health effects, have not been  
66 proven by peer-reviewed, published scientific literature;
- 67 2. The tried and true scientific method of developing a hypothesis, testing that  
68 hypothesis, publishing the results and having others attempt to repeat the  
69 research has not demonstrated that wind turbines are a causative agent of  
70 specific adverse health effects;
- 71 3. An accumulation of anecdotal testimony from persons living near a wind  
72 turbine does not constitute an epidemiological study and is not sufficient to  
73 determine causation;
- 74 4. Several well-respected governmental agencies charged with protecting public  
75 health have evaluated the available evidence and have concluded that wind  
76 turbines are not a cause of adverse health effects; and
- 77 5. The published literature has shown some association between wind turbine  
78 noise emissions and annoyance. However, the level of annoyance is often  
79 more closely tied to visual impacts and attitudes regarding wind turbines than  
80 to actual sound levels. While annoyance is at times associated with various  
81 symptoms, it is not a disease. Instead, those varied symptoms represent a  
82 normal physiological response.

83  
84 **Q. What exhibits are attached to your Direct Testimony?**

85 A. The following Exhibits are attached to my Direct Testimony:

- 86 • Exhibit 1: Statement of Qualifications.
- 87 • Exhibit 2: Australian National Health and Medical Research Council (2010).  
88 *Wind Turbines and Health: A Rapid Review of the Evidence*. This report was  
89 updated in 2014 and 2015.
  - 90 • Exhibit 2a: Australian National Health and Medical Research  
91 Council (2014). *Review of Additional Evidence for NHMRC*

92 *Information Paper: Evidence on Wind Farms and Human*  
93 *Health – Final Report.*

94 • Exhibit 2b: Australian National Health and Medical Research  
95 Council (2015). *NHMRC Statement: Evidence on Wind*  
96 *Farms and Human Health.*

97 • Exhibit 2c: Australian National Health and Medical Research  
98 Council (2015). *Systematic Review of the Human Health*  
99 *Effects of Wind Farms.*

100 • Exhibit 3: French National Agency for Food Safety, Environment and Labor  
101 (“ANSES”) (2017). *ANSES Opinion regarding the expert appraisal on the*  
102 *“Assessment of the health effects of low-frequency sounds and infrasounds*  
103 *from wind farms.”*

104 • Exhibit 4: Wisconsin Wind Siting Council (2014). *Wind Turbine Siting – Health*  
105 *Review and Wind Siting Policy Update.*

106 • Exhibit 5: Joseph Rand and Ben Hoen (2017). *Thirty Years of North American*  
107 *wind energy acceptance research: What have we learned? Energy Analysis*  
108 *and Environmental Impacts Division, Lawrence Berkeley National Laboratory,*  
109 *Electricity Markets and Policy Group.*

110 • Exhibit 6: Public Service Commission of Wisconsin (2015). *Review of Studies*  
111 *and Literature Relating to Wind Turbines and Human Health. Prepared for the*  
112 *Wisconsin State Legislature.*

113 • Exhibit 7: Massachusetts Departments of Environmental Protection and  
114 Public Health (2012). *Wind Turbine Health Impact Study: Report of the*  
115 *Independent Expert Panel.*

116 • Exhibit 8: Letter, Kim Malsam-Rysdon, Secretary of Health, South Dakota  
117 Department of Health (Oct. 13, 2017), *In the Matter of the Application by*  
118 *Crocker Wind Farm, LLC for a Permit of a Wind Energy Facility and a 345 kV*  
119 *Transmission Line in Clark County, South Dakota, for Crocker Wind Farm,*

120 Docket No. EL17-055. available at:  
121 <https://puc.sd.gov/commission/dockets/electric/2017/el17-055/DK4.pdf>.

122

123 **III. OVERVIEW OF PUBLIC HEALTH AND EPIDEMIOLOGY PRINCIPLES**

124

125 **Q. What is the practice of Occupational and Environmental Medicine?**

126 A. Occupational and Environmental Medicine is a medical subspecialty that is  
127 recognized by the American Board of Medical Specialties and is one of the  
128 population-based specialties of Preventive Medicine. Specialists in this area are  
129 physicians with advanced training in prevention-based medical care of populations.  
130 Occupational and Environmental Medicine focuses on environment/health  
131 interactions, including workplace-related illnesses and injuries, and workplace  
132 effects on non-work-related conditions. Occupational and Environmental Medicine  
133 physicians are also trained to assess the possible causes of a worker's health  
134 condition. This specialty draws heavily on the key tenets of epidemiology,  
135 biostatistics, industrial hygiene, risk assessment, and toxicology. I relied extensively  
136 on my training in this field to reach my conclusions noted above.

137

138 **Q. What is epidemiology?**

139 A. Epidemiology is the study of distribution and dynamics of factors in populations. It is  
140 considered the cornerstone methodology in all of public health research, and is  
141 highly regarded in evidence-based medicine for identifying risk factors for disease  
142 and determining optimal treatment approaches to clinical practice. Epidemiology is  
143 the scientific study of factors affecting the health and illness populations, and in this  
144 capacity, it serves as the foundation and logic of interventions made in the interest of  
145 the public's health and preventive medicine.

146

147 Epidemiological studies are generally categorized as descriptive, analytic (aiming to  
148 examine associations and commonly hypothesized causal relationships), and  
149 experimental (a term often equated with clinical or community trials of treatments  
150 and other interventions). Case reports and case series are not epidemiological

151 studies because they have no comparison group. Epidemiology addresses whether  
152 an agent can be linked to a cluster of cases, but not whether an agent caused a  
153 specific individual's disease. So while epidemiologists cannot diagnose individuals,  
154 they can establish the defining characteristics of clusters of illnesses, such as the  
155 point in time at which a given pathogen from a specific source began to cause  
156 problems and when it stopped.

157  
158 In this case, epidemiologic methods are the appropriate tool to guide the  
159 determination of whether wind turbines are the cause of disease in people living  
160 nearby. The practice of medicine, in contrast, is devoted to preventing, alleviating or  
161 treating diseases and injuries in individuals. Concerned with disease in populations,  
162 epidemiology is used to determine what is sometimes called "general causation."  
163 However, it does not establish the cause of an individual's disease, which is  
164 sometimes referred to as "specific causation."

165

166 **Q. How are "epidemiology methods" used to determine causation?**

167 A. Epidemiology is the basic methodology used to characterize a health condition  
168 among groups of people. Epidemiology incorporates the methods needed to identify  
169 associations and, ultimately, is used to determine causation. Epidemiological  
170 research starts with a scientific hypothesis, which is then investigated and the  
171 information is critically reviewed and shared with the scientific community by being  
172 published. The totality of this research then forms the material to answer the  
173 question, "Is there an association between exposure and the health condition?"  
174 Mere association is not the same as causation. Two things can be associated, but  
175 one does not necessarily cause the other. Determination of causation is a higher  
176 level of data assessment including assessment of the totality of published literature  
177 relevant to the subject and requires transparent analysis of the data before it is  
178 concluded that the observed association is actually causal. Not all associations turn  
179 out to be causal. If the data is not carefully reviewed, a causal relationship may be  
180 erroneously assigned to the relationship, which is why peer review is so critical to  
181 the process.

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**Q. Can you provide more detail about what the terms “association” and “causation” mean, as used in epidemiology?**

A. There have been clinical observations (case reports and series) that stimulated a number of now classic epidemiology research efforts identifying important associations and ultimately the determinants of causal relationships. Case studies and case reports, however, cannot be used to determine causation. A causal association can only be established by the evaluation of well-designed and executed epidemiologic studies that have undergone peer review, in addition to research from other disciplines (e.g., exposure, toxicology). A landmark discussion of the process of moving from a disease being associated with a risk factor to concluding the association is causal was put forth by Sir Austin Bradford Hill in 1965. It was during this time that a number of papers, including the Surgeon General Report in 1964, began to more formally delineate the scientific process for concluding that an exposure is causally related to a disease.

The process of moving from “association” to “causation” is a complex process, but a key point emphasizing the process was made by Sir Bradford Hill when he started his discussion of causation by stating:

Disregarding then any such problem in semantics we have this situation. Our observations reveal an association between two variables, perfectly clear-cut and beyond what we would care to attribute to chance. What aspects of that association should we especially consider before deciding that the most likely interpretation of it is causation?

Hill 1965. Sir Bradford Hill’s nine criteria for causation have been described in a number of ways. They are commonly referred to as strength, consistency, specificity, temporality, biological gradient, plausibility, coherence, experiment, and analogy. Hill 1965.



213 **Q. Are Hill’s nine criteria still valid today?**

214 A. Yes. The criteria presented by Sir Bradford Hill are most often referred to as the  
215 guidance used to progress in a scientifically defensible manner from a claim of  
216 association to one of causation.

217

218 **Q. Please describe some recent examples of how initial studies moved from**  
219 **association to causation and the ultimate results of those research efforts.**

220 A. Beyond the classic studies of lung cancer and smoking, we now know that there is  
221 an increase in lung cancer from secondhand smoke and from radon exposures. It  
222 seems that not a week goes by that we do not hear about a new disease association  
223 often related to cancer or heart disease. Take butter for example, it has fallen in and  
224 out of favor multiple times over the years. It is only a “proven causation” when the  
225 science provides clear documentation of the magnitude of the association.

226

227 **Q. Why is it important that scientific research be published in peer-reviewed**  
228 **scientific journals?**

229 A. In this computer age, we are awash in “information” without clear evidence of its  
230 validity. With the advent of the internet, views, opinions, hypotheses, and mere  
231 speculation can be made to appear just as valid as sound science, but without the  
232 rigor of critical and objective review. For example, an internet search on August 2,  
233 2018 using the terms “wind turbine health” returned 14.2 million results. Thus, when  
234 making decisions about potential impacts to human health, such as determining  
235 whether wind turbines are a cause of a clinically recognized human condition or  
236 disease, it is vitally important that we rely on sound science and recognized scientific  
237 methods, as supported by peer-reviewed scientific articles. The act of submitting an  
238 article for publication in a peer-reviewed journal indicates that there is a rigorous  
239 process of review and analysis to assess its scientific merit, its contribution to the  
240 scientific body of knowledge in the specific area, and its pertinence to the area  
241 covered by the journal. The growth of research and the number of researchers has  
242 increased the competition for publication space in journals worldwide. Unfortunately,  
243 this growth has also led to publication resources that are not as rigorous in their

244 review process, which can result in opinion pieces being published with the  
245 appearance of a science basis (i.e., pseudo-science).

246  
247 Today, manuscripts get reviewed at the journal editor level and those that are judged  
248 worthy of consideration (approximately 25 percent) are sent to the peer review panel  
249 members, and roughly 10 percent of those get accepted for inclusion in the journal.  
250 The peer review publication process carefully scrutinizes the major aspects of the  
251 manuscript down to checking the numbers in the tables. Wind turbines have  
252 generated a large amount of interest and information as evidenced by the millions of  
253 results an internet search of “wind turbine health” will yield. However, volumes of  
254 unscientific material should not be taken as proof of causation. Many of the opinions  
255 voiced are not supported by review using a rigorous application of the scientific  
256 method of discovery.

257

258 **Q. What is the scientific method of discovery?**

259 A. In the process of an idea or an observation being assimilated into the science  
260 knowledge base, it must first come to someone’s attention. That can be an astute  
261 observation or a series of events that catches the attention of a science-minded  
262 individual (a researcher). The individual weighs the observation against what they  
263 know and makes a decision to investigate the observation further.

264  
265 The attention of the scientific community is alerted to the opinion based on an  
266 observation, which is usually in the form of case reports or case series. It should be  
267 recognized by all that case reports and case series are merely observations. Case  
268 reports or case series are seldom if ever accepted for publication by the leading  
269 science journals, partially due to the fact that case reports are seen as observations  
270 without quantification or other indication of validity. This quantification or validation  
271 comes from the careful scientific study of the opinion using well-designed  
272 epidemiologic studies and sound scientific methods.

273

274 A well-designed epidemiologic study allows the researcher to make comparisons  
275 between those with and those without the condition or effect in order to determine if  
276 an association is apparent. That is, those that are “exposed” are more likely to  
277 manifest the health condition than the “non-exposed” or the “expected number.” A  
278 good example of this is the investigation of a foodborne outbreak where  
279 epidemiologists compare the rate of occurrence of objective indications of illness in  
280 those persons who ate the suspect food item to the rate of similar illness among  
281 those that did not eat the suspect food item. The key to this step in the scientific  
282 method is that there is a comparison group to compare objective signs of illness. A  
283 comparison group is not present in a case report or a series, where the researcher is  
284 speculating (also known as a hypothesis) but cannot make a statement about the  
285 risk (strength of the association). In an epidemiological study, a method of  
286 comparison is included that will allow the researcher to evaluate the strength of the  
287 association. Furthermore, one epidemiological study does not prove causation. The  
288 researcher who publishes the first epidemiological study is the one that alerts his or  
289 her peers and hopefully stimulates them to do more research to explore the  
290 association. Once a sufficient body of knowledge has been produced, then the  
291 question of causation can be addressed either by governmental agencies or  
292 professional organizations.

293  
294 Thus the scientific knowledge base is strengthened by the collective work of different  
295 researchers, using different epidemiological methods, in different study populations  
296 combining their research. This body of research around the original observation is  
297 then evaluated to see if there is sufficient scientific information to support that a  
298 cause for the condition has been identified and is scientifically justifiable.

- 299
- 300 **Q. Why utilize scientific methodology when there are case studies and/or**  
301 **personal testimonials asserting that wind turbines can cause adverse health**  
302 **effects?**
- 303 A. The scientific methodology is an accepted process used to evaluate  
304 epidemiologically-based evidence, and make sound, scientifically supportable

305 decisions. There have been numerous examples where an agent first thought to be  
306 the cause of a disease was not confirmed to be so as a result of the scientific  
307 process of hypothesis generation, research, and peer review. For example, in the  
308 following instances associations between an exposure and disease were disproven:  
309 coffee and pancreatic cancer (ACS 2011); silicone breast implants and autoimmune  
310 diseases (Hölmich et al. 2007); saccharin and bladder tumors (NCI 2009); Bendectin  
311 and birth defects (McKeigue et al. 1994). In some instances, an alternative cause is  
312 proven: spicy food and ulcers (turns out many are caused by bacteria) (NIH 2010).  
313 Clearly, initial observations and hypotheses are not always supported by more  
314 thorough scientific investigation. Even strongly held beliefs by groups of people do  
315 not provide proof of causation and at times can be detrimental to the scientific  
316 process and to public health. A timely example of such a situation is the current  
317 belief by some that immunizations cause autism.

318  
319 The multiple governmental reviews and reports of public health officials show that  
320 concerns related to wind turbines' potential for adverse health effects have been and  
321 are being taken quite seriously. However, the subjective, non-specific complaints,  
322 which show a great deal of variability, are simply insufficient evidence that wind  
323 turbines are the cause of adverse human health effects.

324

325 **IV. ASSESSMENT OF HEALTH CLAIMS RELATED TO WIND TURBINES**

326

327 **Q. What have government agencies concluded about wind turbines?**

328 A. Several agencies (state, national and international) have concluded that wind  
329 turbines are not associated with adverse health effects in humans. Following are a  
330 few examples of those studies:

- 331 • In 2010, the Australian National Health and Medical Research Council  
332 conducted a review of the evidence and concluded that “wind turbines do  
333 not pose a threat to health if planning guidelines are followed.” Exhibit 2.  
334 The results of the 2010 Australian National Health and Medical Research  
335 Council study were confirmed in subsequent studies. In 2015, the

336 NHMRC concluded that there is no consistent evidence that wind farms  
337 cause adverse health effects in humans. See Exhibit 2a and Exhibit 2b.  
338 The 2014 NHMRC Final Report found no reliable evidence that wind  
339 turbine emissions cause adverse health effects by biological pathways.  
340 Exhibit 2c.

- 341 • In 2017, the French National Agency for Food Safety, Environment and  
342 Labor (“ANSES”) conducted a review of the available experimental and  
343 epidemiological data, and did not find any adequate scientific arguments  
344 for the occurrence of health effects related to exposure to noise from wind  
345 turbines, other than disturbance related to audible noise and a nocebo  
346 effect, which can help explain the occurrence of stress-related symptoms  
347 experienced by residents living near wind farms. Exhibit 3.
- 348 • In 2014, the Wisconsin Siting Council concluded that no association  
349 between wind turbines and health effects has been scientifically shown.  
350 Exhibit 4.
- 351 • Researchers at the Lawrence Berkeley National Laboratory similarly found  
352 no link between wind turbines and adverse health effects. Exhibit 5.
- 353 • The Public Service Commission of Wisconsin (2015) concluded that:  
354 “Presently, the recent literature on this subject continues to reach  
355 conclusions similar to those identified in the 2014 WSC report. The studies  
356 have found an association between exposure to wind turbine noise and  
357 annoyance for some residents near wind energy systems. Some studies  
358 show this as a causal relationship between wind turbines and annoyance.  
359 There is more limited and conflicting evidence demonstrating an  
360 association or a causal relationship between wind turbines and sleep  
361 disturbance. There is a lack of evidence to support other hypotheses  
362 regarding human health effects caused by wind energy systems.” Exhibit  
363 6.
- 364 • An independent expert panel for Massachusetts (2012) found that there  
365 was limited evidence supporting an association between wind turbines  
366 and annoyance or possible sleep disturbances. However, the panel

367 concluded that “there is insufficient evidence that the noise from wind  
368 turbines is *directly (i.e., independent from an effect on annoyance or*  
369 *sleep)* causing health problems or disease.” Exhibit 7 (italics in original).

370

371 **Q. You conducted a review of the peer literature on health effects attributable to**  
372 **sound. What did it show as it relates to sound generated by wind turbines?**

373 A. My analysis and review of the peer reviewed, published literature did not identify  
374 scientific works that provide objective support for the claims being made regarding  
375 wind turbines. The peer reviewed, scientific research involving the health effects of  
376 sound levels (from various sources) is extensive. Research on health effects  
377 associated with human exposure to sound has evolved from the study of physical  
378 damage (e.g., hearing loss) to the study of psychological effects and other non-  
379 specific physical symptoms. Research has focused on both the frequency and  
380 amplitude of sound, within and outside of the audible range of human hearing.

381

382 Most of the available literature examines noise exposures at the workplace, as high  
383 levels of noise exposure are one of the most established forms of occupational  
384 injury. Noise exposures outside the workplace have not been studied as extensively  
385 yet may be just as damaging (e.g., chain saws, leaf blowers, power saws and lawn  
386 mowers). However, there has been research on exposures to highway traffic noise,  
387 commercial airport noise, and a variety of other community noise sources that can  
388 provide valuable insight into the evaluation of sound generated by the operation of  
389 wind turbines. This body of research has identified a number of health-related  
390 associations with high levels of industrial sound in the workplace. However, this  
391 same science has not identified a causal link between any specific health condition  
392 and exposure to the sound patterns generated by contemporary wind turbine  
393 models, perhaps because they generate far lower decibel levels than most  
394 vocational sources. This same science has determined that there is a range of  
395 sounds (some would say noise) that is clearly described by some as annoying.  
396 There have been illnesses, symptom complexes, and other health events attributed  
397 to wind turbines. This is to be expected given the circumstances and emotions that

398 often surround the presence of wind turbine farms. This is a common phenomenon  
399 that is associated with activities that may be perceived as a social disruption or  
400 conflict of personal rights by a subset of the population.

401  
402 Despite the attribution of various health events to wind turbines, there has not been  
403 a specific health condition documented in the peer-reviewed published literature to  
404 be recognized by the medical community or professional societies as a disease  
405 caused by exposure to sound levels and frequencies generated by the operation of  
406 wind turbines.

407  
408 **Q. Has the State of South Dakota addressed claims of an association between**  
409 **wind turbines and health effects?**

410 A. The State of South Dakota has not specifically studied alleged health effects and  
411 wind turbines. However, the Department of Health was asked to opine on the issue  
412 in another docket, *In the Matter of the Application by Crocker Wind Farm, LLC for a*  
413 *Permit of a Wind Energy Facility and a 345 kV Transmission Line in Clark County,*  
414 *South Dakota, for Crocker Wind Farm, Docket No. EL 17-055. The South Dakota*  
415 *Secretary of Health, Kim Malsam-Rysdon, submitted a letter consistent with my*  
416 *testimony (Exhibit 8):*

417 The South Dakota Department of Health has been requested to comment  
418 on the potential health impacts associated with wind facilities. Based on  
419 the studies we have reviewed to date, the South Dakota Department of  
420 health has not taken a formal position on the issue of wind turbines and  
421 human health. A number of state public health agencies have studied the  
422 issue, including the Massachusetts Department of Public Health<sup>1</sup> and the  
423 Minnesota Department of Health<sup>2</sup>. These studies generally conclude that  
424 there is insufficient evidence to establish a significant risk to human  
425 health. Annoyance and quality of life are the most common complaints  
426 associated with wind turbines, and the studies indicate that those issues  
427 may be minimized by incorporating best practices into the planning  
428 guidelines.

429

<sup>1</sup> <http://www.mass.gov/eea/docs/dep/energy/wind/turbine-impact-study.pdf>

<sup>2</sup> [www.health.state.mn.us/divs/eh/hazardous/topics/windturbines.pdf](http://www.health.state.mn.us/divs/eh/hazardous/topics/windturbines.pdf)

430 **Q. Based on your review of the available scientific literature, are there potential**  
431 **adverse health effects from the sound of wind turbines?**

432 A. No, because the levels of sound and infrasound from wind turbines are significantly  
433 lower than those that have been shown to cause harm. Substantial research has  
434 been done on sound level exposures to humans. This body of scientific research  
435 has identified a number of health-related links to high level industrial sound in the  
436 workplace. For example, OSHA has set a limit of 90 A-weighted decibels (“dBA”)  
437 based on a finding that exposure to levels of noise above 90 dBA in the workplace  
438 can cause hearing damage and set an 85 dBA level as the set point of initiation of a  
439 hearing protection program in the workplace. However, as I noted earlier, this same  
440 science has not identified a causal link between any specific health condition and  
441 exposure to the sound patterns generated by contemporary wind turbine models. In  
442 addition to my own conclusions, several other respected organizations and agencies  
443 have reached similar conclusions, as I have described previously herein.

444

445 **V. SPECIFIC HEALTH ISSUES RAISED AT PUBLIC INPUT MEETING**

446

447 **Q. Did you attend the public input meeting that was held on July 12, 2018?**

448 A. No, but I have been made aware that the following health concerns were raised by  
449 commenters at that meeting:

450

- 451 • Infrasound;
- 452 • Vertigo; and
- 453 • “Vibroacoustic Disease”.

454

455 In addition, I understand that some members of the public expressed concern that  
456 potential health impacts could occur and/or be amplified because Prevailing Wind  
457 Park, LLC (“Prevailing Wind Park”) proposes to use turbine models that are in  
458 excess of 500 feet. I will address each of these issues in more detail below.

459

460 **Q. Please describe the concern related to infrasound as you understand it.**



461 A. Based on comments made at the public input hearing, I understand that some  
462 commenters expressed concern regarding the potential for infrasound to generally  
463 cause negative health consequences.

464

465 **Q. What is infrasound?**

466 A. Infrasound, sometimes referred to as low frequency sound, is sound that is between  
467 0 hertz (“Hz”) and 20 Hz. Although the human hearing threshold has been found to  
468 be as low as 4 Hz in an acoustic chamber, a level of 20 Hz is commonly considered  
469 the low end of the range of hearing.

470

471 **Q. What is your response to comments regarding infrasound?**

472 A. I am not aware of any reliable evidence providing any link between infrasound and  
473 adverse health effects. Multiple health experts have confirmed this point.  
474 Specifically, infrasound at frequencies lower than 20 Hz are audible at very high  
475 levels (110+ dBA), and these sounds may occur from man-made but also many  
476 natural sources, such as meteors or volcanic eruptions. Anthropogenic (i.e., human-  
477 caused) sources, which often are the predominant type of sound, can also generate  
478 infrasonic noise and include machinery, ventilation, large combustion processes and  
479 naturally occurring winds.<sup>3</sup> In addition, heart sounds are in the range of 27 to 35  
480 dBA at 20-40 Hz<sup>4</sup> and lung sounds are reported in the range of 5-35 dBA at 150-600  
481 Hz.<sup>5</sup> Note that these sources are in the range of sound produced by wind turbines.  
482 Thus, infrasound – both man-made and naturally-occurring – are all around us.

483

484 **Q. Please describe the concern related to vertigo as you understand it.**

<sup>3</sup> Berglund, B., Hassmen, P., and Job, R. F. (1996). Sources and effects of low-frequency noise. *Journal of the Acoustical Society of America*. 99(5), (2985-3002); Leventhall, G. (2007). *What is infrasound?* 93(1-3), (130-137); Sienkiewicz, Z. (2007). Rapporteur report: Roundup, discussion and recommendations. *Progress in Biophysics and Molecular Biology*. 93(1-3), (414-420).

<sup>4</sup> Sakai, A., Feigen, L. P., and Luisada, A. A. (1971). *Frequency distribution of the heart sounds in normal man*. *Cardiovascular Research*. 5(3), (358-363).

<sup>5</sup> Fiz, J. A., Gnitecki, J., Kraman, S. S., Wodicka, G. R., and Pasterkamp, H. (2008). Effect of body position on lung sounds in healthy young men. 133(3), (729 -736).

485 A. As I understand the comments at the public input hearing, there was a concern  
486 expressed that the operation of wind turbines may cause (or has caused) vertigo in  
487 some individuals. Vertigo is the sense that your environment is spinning. It is a form  
488 of dizziness. Vertigo is caused by problems in the brain or inner ear, including  
489 sudden head movements, inflammation within the inner ear due to a viral or bacterial  
490 inner ear infection, Meniere's disease, tumors, decreased blood flow to the base of  
491 the brain, multiple sclerosis, head trauma and neck injury, migraine headaches, or  
492 complications from diabetes.

493

494 **Q. What is your response to comments regarding vertigo?**

495 A. Based on my review of the scientific literature, I am not aware of any causal  
496 relationship between wind turbines and vertigo. Published population-based studies  
497 indicate that dizziness (including vertigo) affects between 15 percent and 20+  
498 percent of adults yearly. Vertigo associated with the inner ear accounts for about a  
499 quarter of dizziness complaints. Studies indicate that the prevalence rises with age  
500 and is about two to three times higher in women than in men. As noted above, there  
501 are many health conditions associated with vertigo, but there appears to be no  
502 single cause, and there has been no scientific study associating wind turbines and the  
503 development of vertigo.<sup>6</sup>

504

505 **Q. Please describe the concerns related to “vibroacoustic disease” as you**  
506 **understand them.**

507 A. Based on my review of the comments made at the public input hearing, I understand  
508 that some commenters expressed concern about the Project’s potential to cause  
509 “vibroacoustic disease,” a condition asserted to exist for aircraft maintenance  
510 workers by certain researchers in Portugal.

511

512 **Q. What is your response to comments regarding vibroacoustic disease?**

<sup>6</sup> The Epidemiology of Dizziness and Vertigo, Handbook of Clinical Neurology, 2016; 137:67-82 (Chapter 5).

513 A. Vibroacoustic disease has primarily been studied in aircraft maintenance workers  
514 and has been described by certain Portuguese researchers as a chronic,  
515 progressive, medical condition where there is a thickening of blood vessels which  
516 impedes the normal flow of blood and there is thickening of the membrane around  
517 the heart and of the heart valves. Aircraft maintenance workers routinely work in  
518 environments with high-intensity sound greater than 110 dBA, coupled with low-  
519 frequency sounds below 100 Hz, which are commonly encountered when working in  
520 the vicinity of aircraft.

521  
522 A majority of the published work involving vibroacoustic disease has originated from  
523 certain researchers in Portugal and has not been significantly replicated by other  
524 research groups. Dr. Alver-Pereira (the primary researcher) has testified that she  
525 has concerns about the potential of an association between the sound of wind  
526 turbines and vibroacoustic disease, but she has not reconciled the difference in the  
527 intensity of the low frequency sound she has studied in aircraft maintenance workers  
528 and the low intensity of sound produced by wind turbines. In addition, Dr. Alver-  
529 Pereira has not performed a scientific sound study of wind turbine noise in her work  
530 on vibroacoustic disease. Based on my work and review of reliable scientific  
531 literature, I am not aware of any link between wind turbines and what Dr. Alver-  
532 Pereira describes as vibroacoustic disease.

533

534 **Q. With respect to concerns regarding turbine height, does the fact that**  
535 **Prevailing Wind Park proposes to use a turbine model over 500 feet alter any**  
536 **of the opinions or conclusions you have provided in this testimony?**

537 A. No, the proposed turbine model's height does not alter my opinions or conclusions.

538  
539 **Q. Do you have any other responses to comments made at the July 12, 2018,**  
540 **public input meeting?**

541 A. Yes. I understand that Dr. Jamin Hübner, who holds a Th.D. in Systematic  
542 Theology,<sup>7</sup> submitted what he termed “A Partial Bibliography of Academic Literature  
543 Demonstrating Adverse Health Effects of Industrial Wind Turbines.” In general, the  
544 submission is an aggregation of statements taken from articles and provides little  
545 synthesis of the findings of the articles. As I have previously discussed in this  
546 testimony, numerous state, national, and international governmental bodies have  
547 concluded that wind turbines are not associated with a specific adverse health effect  
548 in humans. Dr. Hübner’s document is not an accurate representation of the current  
549 state of the science in this area. A more detailed review of the articles which Dr.  
550 Hübner has selectively chosen, and from which he has selectively pulled quotes,  
551 illustrates that these articles often do not support Dr. Hübner’s stated conclusion that  
552 the literature “demonstrate[s] adverse health effects of industrial wind turbines.”  
553 Rather, this literature concludes the opposite.

554  
555 For example, Dr. Hübner’s document refers to a report I co-authored for the  
556 Wisconsin Public Service Commission in 2009 related to low frequency sound;  
557 however, the document quotes the report out of context and, as such, misrepresents  
558 the conclusion we reached. The portion of our literature review quoted by Dr.  
559 Hübner summarizes diverse studies generally related to low frequency sound and  
560 the workplace. If Dr. Hübner had read further in the literature review, he would have  
561 seen the following discussion:

562  
563 The literature, both scientific and lay, clearly indicates the  
564 diversity of concerns regarding the presence of wind turbines  
565 near residences and communities. The science of sound is  
566 robust and has identified a number of health-related links to  
567 high level industrial sound in the workplace. *This same*  
568 *science has not identified a causal link between any specific*  
569 *health condition and exposure to the sound patterns*

<sup>7</sup> See <http://jwc.edu/teams/jamin-hubner/> (last accessed August 10, 2018).

570           *generated by wind turbines of the type used today, perhaps*  
571           *because they generate far lower decibel levels than most*  
572           *vocational sources.* However, the same science has  
573           determined that there is a range of sounds (some would say  
574           noise) that is clearly described by some as annoying. The  
575           process of being annoyed is a universal response that is not  
576           specific to wind turbines. The nonspecificity of annoyance  
577           leads to confusion and concern that the peer reviewed  
578           published scientific literature has not been able to  
579           adequately clarify.


580  
581           In addition, our literature review concluded: “Based on the literature review that was  
582           conducted for this white paper, ***there was not any scientifically peer-reviewed***  
583           ***information found demonstrating a link between wind turbines and negative***  
584           ***health effects.***” As such, Dr. Hübner’s citation of my literature review as support for  
585           his assertion that wind turbines cause negative health impacts is misplaced.

586  
587 **VI. CONCLUSION**

588  
589 **Q. Does this conclude your Direct Testimony?**

590 A. Yes.

591  
592 Dated this 10<sup>th</sup> day of August, 2018.

593  
594  


595  
596 Dr. Mark Roberts