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

I. INTRODUCTION AND QUALIFICATIONS

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

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

Q. Please describe your educational and professional background.

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

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

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

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

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

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

A. No.

II. PURPOSE OF TESTIMONY

Q. What is the purpose of your Direct Testimony?

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

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

A. My opinions can be summarized as follows:

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

Q. What exhibits are attached to your Direct Testimony?

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

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

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

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

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

- Exhibit 3: French National Agency for Food Safety, Environment and Labor ("ANSES") (2017). *ANSES Opinion regarding the expert appraisal on the "Assessment of the health effects of low-frequency sounds and infrasounds from wind farms."*
- Exhibit 4: Wisconsin Wind Siting Council (2014). *Wind Turbine Siting – Health Review and Wind Siting Policy Update*.
- Exhibit 5: Joseph Rand and Ben Hoen (2017). *Thirty Years of North American wind energy acceptance research: What have we learned? Energy Analysis and Environmental Impacts Division*, Lawrence Berkeley National Laboratory, Electricity Markets and Policy Group.
- Exhibit 6: Public Service Commission of Wisconsin (2015). *Review of Studies and Literature Relating to Wind Turbines and Human Health. Prepared for the Wisconsin State Legislature*.
- Exhibit 7: Massachusetts Departments of Environmental Protection and Public Health (2012). *Wind Turbine Health Impact Study: Report of the Independent Expert Panel*.
- Exhibit 8: Letter, Kim Malsam-Rysdon, Secretary of Health, South Dakota Department of Health (Oct. 13, 2017), *In the Matter of the Application by Crocker Wind Farm, LLC for a Permit of a Wind Energy Facility and a 345 kV Transmission Line in Clark County, South Dakota, for Crocker Wind Farm*,

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

III. OVERVIEW OF PUBLIC HEALTH AND EPIDEMIOLOGY PRINCIPLES

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

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

Q. What is epidemiology?

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

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

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

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

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

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

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.

Q. Are Hill's nine criteria still valid today?

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

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

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

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

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

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

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

Q. What is the scientific method of discovery?

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

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

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

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

Q. Why utilize scientific methodology when there are case studies and/or personal testimonials asserting that wind turbines can cause adverse health effects?

A. The scientific methodology is an accepted process used to evaluate epidemiologically-based evidence, and make sound, scientifically supportable

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

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

IV. ASSESSMENT OF HEALTH CLAIMS RELATED TO WIND TURBINES

Q. What have government agencies concluded about wind turbines?

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

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

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

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

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

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

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

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

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

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

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

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

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

[1] http://www.mass.gov/eea/docs/dep/energy/wind/turbine-impact-study.pdf

[2] www.health.state.mn.us/divs/eh/hazardous/topics/windturbines.pdf

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

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

V. SPECIFIC HEALTH ISSUES RAISED AT PUBLIC INPUT MEETING

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

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

- Infrasound;
- Vertigo; and
- "Vibroacoustic Disease".

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

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

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

Q. What is infrasound?

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

Q. What is your response to comments regarding infrasound?

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

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

[3] 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).

[4] 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).

[5] 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).

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

Q. What is your response to comments regarding vertigo?

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

Q. Please describe the concerns related to "vibroacoustic disease" as you understand them.

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

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

[6] The Epidemiology of Dizziness and Vertigo, Handbook of Clinical Neurology, 2016; 137:67-82 (Chapter 5).

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

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

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

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

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

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

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

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

[7] *See* http://jwc.edu/teams/jamin-hubner/ (last accessed August 10, 2018).

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

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

VI. CONCLUSION

Q. Does this conclude your Direct Testimony?

A. Yes.

Dated this 10th day of August, 2018.

Dr. Mark Roberts