**Ex. A11**

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

**IN THE MATTER OF THE APPLICATION BY DEUEL HARVEST WIND ENERGY LLC FOR ENERGY FACILITY PERMITS OF A WIND ENERGY FACILITY AND A 345-KV TRANSMISSION LINE IN DEUEL COUNTY, SOUTH DAKOTA FOR THE DEUEL HARVEST NORTH WIND FARM**

**SD PUC DOCKET EL18-053**

# PRE-FILED SUPPLEMENTAL DIRECT TESTIMONY OF DR. JEFFREY ELLENBOGEN ON BEHALF OF DEUEL HARVEST WIND ENERGY LLC

February 14, 2019

## I. INTRODUCTION

**Q. Please state your name and business location.**

A. My name is Dr. Jeffrey Ellenbogen. My business is located in Baltimore County, Maryland.

**Q. Did you previously provide Direct Testimony in this docket?**

A. No.

**Q. Please describe your background and current employment.**

A. I am a medical physician with a license to practice medicine in Maryland. I have a bachelor's degree from the University of Michigan, a medical degree from Tufts University, and a master's in medical science from Harvard Medical School. I finished my medical doctorate in 2000, received my medical license in 2001, and have been practicing medicine since that time. Between 2013 and 2018, I served as a practicing attending physician at Johns-Hopkins Hospital, specializing in neurology and sleep medicine. In January 2018, I left Johns-Hopkins Hospital to dedicate myself full-time to my consulting business, Ellenbogen Consulting, LLC, which focuses on sleep and brain health.

I am providing testimony on behalf of Deuel Harvest Wind Energy LLC ("Deuel Harvest Wind Energy"). My statement of qualifications is attached as **Exhibit 1**.

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

A. The purpose of my Supplemental Direct Testimony is to respond to comments submitted in the docket regarding the potential impact of wind turbines on human health, particularly with respect to sleep. I provide testimony regarding my participation in an evaluation of the potential health impacts of wind turbines on humans sponsored by the 2012 Massachusetts Department of Environmental Protection and the Massachusetts Department of Public Health (together, the "Massachusetts Agencies"). I also discuss how I had the opportunity to test the

findings of the study through independent medical exams I performed on four individuals who alleged health impacts from wind turbines.

**Q. Are you sponsoring any exhibits with your Supplemental Direct Testimony?**

A. Yes. I am sponsoring the following exhibits:

- Exhibit 1: Statement of Qualifications.
- Exhibit 2: *Wind Turbine Health Impact Study: Report of Independent Expert Panel* (January 2012).
- Exhibit 3: Michaud, D. S. *et al*., Self-reported and measured stress related responses associated with exposure to wind turbine noise. *J. Acoust. Soc. Am.* 139, 1467-1479, doi:10.1121/1.4942402 (2016).
- Exhibit 4: Michaud, D. S. *et al*., Exposure to wind turbine noise: Perceptual responses and reported health effects. *J. Acoust. Soc. Am.* 139, 1443-1454, doi:10.1121/1.4942391 (2016).
- Exhibit 5: Michaud, D. S. *et al*., Effects of Wind Turbine Noise on Self-Reported and Objective Measures of Sleep. *Sleep* 39, 97-109, doi:10.5665/sleep.5326 (2016).

## II. WIND TURBINE HEALTH IMPACT STUDY

**Q. In the course of your work, have you had the opportunity to study alleged health impacts of wind turbines?**

A. Yes. In 2011, the Massachusetts Agencies approached me and asked me to join a group of professionals to evaluate the potential health impacts of wind turbines on humans. As a result of that evaluation, the state released the document attached as Exhibit 2, titled *Wind Turbine Health Impact Study: Report of Independent Expert Panel* (January 2012) ("Massachusetts Study" or "Study").

**Q. Please describe the purpose of the Massachusetts Study.**

A. The Massachusetts Agencies charged the panel of professionals with performing an independent evaluation of the scientific and medical literature regarding wind

turbines and their potential impact on human health, as well as to solicit information from the public to hear about any potential issues not already reflected in the literature. The Massachusetts Agencies asked us to ensure that we did not leave any stones unturned with respect to potential plausible medical problems that could be a consequence of wind turbines. Specifically, we were charged with the following tasks:

- Identify and characterize attributes of concern and identify any scientifically documented or potential connection between health impacts and wind energy turbines;
- Evaluate and discuss information from peer-reviewed scientific studies, other reports, popular media, and public comments received by the Massachusetts Agencies concerning the nature and type of health complaints commonly reported by individuals who reside near existing wind farms;
- Assess the magnitude and frequency of any potential impacts and risks to human health associated with the design and operation of wind energy turbines based on existing data;
- For the attributes of concern, identify best practices that could reduce potential human health impacts; and
- Issue a report summarizing findings.

**Q. Who else served on the panel that prepared the Study?**

A. In addition to me, the following individuals served on the Study panel ("Panel"):[1]

- Sheryl Grace, PhD; MS Aerospace & Mechanical Engineering, Associate Professor of Mechanical Engineering, Boston University;
- Wendy J. Heiger-Bernays, PhD; Associate Professor of Environmental Health, Department of Environmental Health, Boston University School of Public Health; Chair, Lexington Board of Health;

[1] The qualifications and affiliations are as of the date of the Massachusetts Study.

- James F. Manwell, PhD Mechanical Engineering; MS Electrical & Computer Engineering; BA Biophysics; Professor and Director of the Wind Energy Center, Department of Mechanical & Industrial Engineering University of Massachusetts, Amherst;
- Dora Ann Mills, MD, MPH, FAAP; State Health Officer, Maine 1996-2011; Vice President for Clinical Affairs, University of New England;
- Kimberly Sullivan, PhD; Research Assistant Professor of Environmental Health, Department of Environmental Health, Boston University School of Public Health; and
- Marc G. Weisskopf, ScD Epidemiology; PhD Neuroscience; Associate Professor of Environmental Health and Epidemiology, Department of Environmental Health & Epidemiology, Harvard School of Public Health.

**Q. What methodology did the Panel employ to prepare the Study?**

A. We conducted an extensive review of the scientific literature, as well as other reports, popular media, and public comments received by the Massachusetts Agencies. We met three times as a group and held additional conference calls to clarify points of discussion. An independent facilitator supported these discussions. Each Panel member provided written text based on the literature review and analyses and draft versions of the report were reviewed by each Panel member. The Panel reached consensus for the final report and its findings.

**Q. Did the Massachusetts Agencies direct you to arrive at a particular conclusion as a result of the Massachusetts Study?**

A. Absolutely not. Indeed, one of the commissioners directed us to be very broad in our approach. If there was a problem, he wanted to know about it. We understood that our purpose was to seriously consider and examine each of the potential concerns raised by the public as part of the Study.

**Q. Please summarize the overall conclusion of the Massachusetts Study.**

A. Overall, the Study concluded that claims of adverse health outcomes resulting from wind turbines are not supported by scientific facts. The Study included specific findings related to several topics, including, but not limited to, noise and shadow flicker.

**Q. Please explain the Study's key finding with respect to noise.**

A. We concluded that there was insufficient evidence that noise from wind turbines is directly causing health problems or disease. Most epidemiological literature on human response to wind turbines relates to self-reported annoyance, and this response appears to be a function of some combination of the sound itself, the sight of the turbine, and attitude towards the wind turbine project. We recognize that, for some people, wind turbines annoy them, be it the sound, sight, presence, or complex notions of economics, but there were no direct physiological effects on health in humans from wind turbines. None of the limited epidemiological evidence reviewed suggested an association between noise from wind turbines and a wide range of topics we considered: pain, stiffness, diabetes, high blood pressure, tinnitus, hearing impairment, cardiovascular disease, and/or headache/migraine.

In addition, claims that infrasound from wind turbines directly impacts the vestibular system have not been demonstrated scientifically. The vestibular system is a physical system that is responsible for helping a person figure out where he or she is in space – *i.e.*, balance and position sense. There was concern among people that this system could be affected by the vibrations produced by a wind turbine. We did not find evidence in the human or animal scientific literature to support that vibrations of the kind produced by a wind turbine could influence the vestibular system.

The study also specifically evaluated the merits of "wind turbine syndrome," and found no basis for a set of health effects from wind turbines.

**Q. Please explain the Study's finding with respect to shadow flicker.**

A. The panel thoroughly examined the potential for health effects from shadow flicker. Beyond annoyance, the only credible concern raised was the potential for shadow flicker to produce seizures from a phenomenon sometimes referred to as "photic stimulation." After careful examination, the Panel concluded that shadow flicker does not pose a risk for eliciting seizure as a result of photic stimulation.

To explain in more detail, photic-stimulated epilepsy (i.e., seizures that result from flashes of light) is a phenomenon in which seizures occur as a result of exposure to flashing light. These flashes need to occur at frequencies greater than 5 hertz ("Hz"), usually substantially higher, meaning, in order to cause a seizure, there needs to be flashes of light more than 5 every second. Because of the nature of the speed and size of wind turbines, the frequency of any shadow flicker will be about 0.5-1 Hz, which is well below the range that would elicit a seizure even in someone who is vulnerable to photic stimulation seizures. It is my professional opinion as a neurologist that shadow flicker from wind turbines does not cause seizures. First, flicker of any kind does not cause seizures in the general population. In fact, flicker can only cause seizures in the minority of people who have epilepsy. Second, even among those who have epilepsy for which their seizures are sensitive to photic stimulation, the frequency of shadow flicker from wind turbines is not at the frequency that induces seizures.

**Q. Have other studies since the Massachusetts Study reached similar conclusions regarding noise and shadow flicker?**

A. Yes. As Dr. Mark Roberts testified in his Supplemental Direct Testimony, repeated, peer-reviewed scientific studies from numerous organizations and agencies across numerous countries around the world have similarly found no association between wind turbines and health effects. For example, a very large study that resulted in numerous published articles, "Health Canada," was published in 2016. Three of these articles are attached to my testimony as Exhibits 3, 4, and 5. In it, researchers examined self-reported and objective measures of health-related outcomes

associated with wind turbine noise ("WTN") of more than one thousand people "exposed to outdoor calculated WTN levels up to 46 [A-weighted decibels ("dBA")]." They concluded that this exposure to noise from wind turbines "had no apparent influence on any of these endpoints." The potential for annoyance from wind turbines was acknowledged by the Health Canada study. These authors also discuss that shadow flicker does not elicit seizures. I discuss the Health Canada study in greater detail in section IV of my testimony below.

## III. INDEPENDENT MEDICAL CLAIMS

**Q. Since the Massachusetts Study was released, have you had the opportunity to test the Study's conclusions?**

A. Yes. From a medical and scientific point of view, wind turbine-caused illness, or what has been called "wind turbine syndrome," does not exist. The Massachusetts Panel and many other experts around the world have reached the same conclusion. However, some people in the community feel that it does, likely due to its promotion by a book called *Wind Turbine Syndrome*. As a result, there are people who have raised concerns, despite expert opinion to the contrary. There was a group of people who raised such a concern with a wind farm in Michigan and brought a lawsuit against the owner, and I had the opportunity to collect a full history and perform independent medical examinations of four individuals (two couples). I also had the opportunity to view their neighborhoods. In each independent medical examination, I was able to independently assess the person's specific medical concerns, and address their potential underlying causes.

**Q. Please describe the results of these independent medical examinations.**

A. In all four instances, I concluded that these people were not getting the medical treatment they needed because they were incorrectly attributing the cause of their health problems to wind turbines.

The first individual was a 53-year old industrial designer who complained of insomnia and palpitations in his chest at night and was convinced that the wind turbine near his house was causing these problems. In examining and talking with him, I understood that in recent years, he had gained a substantial amount of weight and experienced snoring and sleep apnea. Based on my evaluation, I concluded this gentleman almost certainly had obstructive sleep apnea. In addition, I understand that this person wound up later having medical tests that showed an abnormal heart rhythm unrelated to the wind farm.

The second individual was a 45-year-old science teacher at a junior high school who was worried about wind turbine syndrome, so she left her job in her home neighborhood and took a new job that required a substantial commute, resulting in her waking up at approximately 4:30 a.m., a full two hours earlier than what had been her typical pattern. Her ensuing sleepiness, anxiety, and forgetfulness were most likely attributable to her substantial sleep deprivation, not the wind turbines.

The third individual was a 52-year-old bookkeeper who complained of headaches. I measured her blood pressure, and it was very high. Untreated high blood pressure often causes headaches. She had a history of depression that was untreated at the time of my evaluation. She also had substantial snoring at night, which could easily have been untreated, obstructive sleep apnea. She acknowledged all of this, but did not pursue treatment because of the focused assumption that she had wind turbine syndrome.

Finally, the fourth individual was a 60-year-old farmer with balance problems and sleep problems. Regarding his balance, upon examination, I determined that he had a serious neuropathy. This resulted in an inability to feel his feet, which was causing his difficulty with balance. In addition, this individual acknowledged he had a substantial alcohol problem, which is one of the leading causes of neuropathy. Alcohol can also impact balance by causing degeneration of the cerebellum, an area of the brain that helps with balance and coordination. Regarding his sleep, the issues he was experiencing were no different than those diagnosed several decades

earlier for which he was given antidepressant medication and sedatives, both of which he stopped taking more recently. His sleep problem was recently made worse by an increase in his alcohol consumption at night, which caused him to need to urinate in the middle of the night. Further, he had pain in his shoulders that he described as disruptive to his sleep. Taken together, there was no worsening of his chronic sleep problem after the wind turbines were installed in his neighborhood, and there were compelling reasons for his disrupted sleep that did not involve wind turbines.

**Q. What did you conclude from these independent medical examinations?**

A. Each of these individuals attributed their health problems to wind turbines. However, wind turbines were not the cause of the identified health issues, and in my opinion, the misapplied blame to wind turbines prevented these individuals from seeking and obtaining much-needed medical treatment for their underlying conditions.

**Q. Did you provide testimony in the lawsuit that these individuals brought?**

A. No. The case settled soon after I completed the independent medical examinations.

## IV. ANALYSIS OF THE "HEALTH CANADA" RESEARCH RELATED TO HEALTH EFFECTS AND WIND TURBINES

**Q. Are there any rigorous, recent, peer-reviewed scientific studies looking at the potential effects of wind turbines on human health?**

A. Yes. The largest, most definitive study is the Health Canada study.

**Q. What was the purpose of the Health Canada study?**

A. The purpose of the Health Canada study was to rigorously examine a large population of people living near wind turbines to assess whether human exposure to noise from wind turbines leads to negative health-related consequences.

**Q. When was the Health Canada study conducted?**

A. The study was conducted in 2013. Data analysis and associated, peer-reviewed, scientific journal articles (including Exhibits 3, 4, and 5 to this testimony) became publically available in several publications in 2016, all in well-regarded, peer-reviewed, clinically minded, scientific journals.

**Q. Where was the Health Canada study conducted, and why were these locations selected?**

A. The study took place among people living on Prince Edward Island or in southwestern Ontario. These locations were chosen because of their relative similarities among people, similarities of the topography, and the presence of operating wind turbines (315 in Ontario and 84 on Prince Edward Island).

**Q. Was there oversight of the Health Canada study's design?**

A. Yes. Health Canada's Scientific Advisory Board reviewed the design, as did experts from the World Health Organization. The study design was also subjected to a 60-day public consultation and Research Ethics Board.

**Q. Was there a control condition in the Health Canada study?**

A. Yes, those with less than 25 dBA exposure served as the control group. These people had similar demographics to the remaining participants of the study. The members of this control group were compared against those with 25 dBA exposure or more to assess whether there was a statistically significant difference in their health.

**Q. What was the methodology of the Health Canada study?**

A. This large, cross-sectional, epidemiological study examined well over 1,000 people living near wind turbines. Participants were asked about a range of health-related questions (subjective measures), and participants were physically examined for a range of health-related metrics (objective measures). Specifically, the study was an "exposure-response" design. In this method, examiners look to see if an increase in the occurrence of any health problem had a relationship to sound levels from wind

turbines. Said another way, health problems are a part of life and will be discovered in any large population. The objective of the Health Canada study was to see if any health problem resulted from or was associated with wind turbine noise. Simply put, if noise from wind turbines caused a problem, the occurrence of that problem should increase as the noise from the wind turbines increases.

**Q. What subjective measures were examined by the Health Canada study?**

A. Study participants were asked about a wide range of conditions, including migraines, tinnitus, dizziness, sleep disturbance, sleep disorders, quality of life, and perceived stress.

**Q. Were any of the subjective measures related to noise levels from wind turbines?**

A. No, meaning that the results of the study did not show any relationship between wind turbine noise and these conditions.

**Q. What objective measures were examined by the Health Canada study?**

A. Study participants were physically examined for a range of health-related metrics, including stress (via hair cortisol measures), cardiovascular outcomes (heart rate, blood pressure), and sleep.

**Q. Were any of the objective measures correlated to noise levels from wind turbines?**

A. No, meaning that the results of the study did not show any relationship between wind turbine noise and these conditions. Specifically, Health Canada did measure sleep disruption, and it found no association between sleep and noise from wind turbines.

**Q. Did the Health Canada study make any findings about the effects of wind turbine noise?**

A. Yes. Study participants reported an increased annoyance with increasing noise levels. Meaning, the noisier the turbine, the likelier a resident was to be annoyed.

**Q. Is annoyance an adverse health effect?**

A. No. Annoyance is not a health effect. Annoyance is a feeling – an emotional response – related to a stimulus. Some argue that annoyance can lead to adverse health effects. That may be true in certain, severe circumstances. However, the Health Canada study does not support that conclusion with respect to wind turbine noise. Specifically, as I discussed previously, the Health Canada study did not find adverse health effects related to wind turbine noise among the many studied, either subjectively or objectively. In other words, though some may become annoyed with wind turbines, that annoyance appears to be restricted to annoyance alone, as it was not shown to amount to any measured health outcome.

**Q. What was the range of noise exposure from wind turbines among those participating in the Health Canada study?**

A. Less than 25 dBA and up to 46 dBA at the location of the dwelling.

**Q. What conclusions do you draw from the Health Canada study?**

A. This rigorous study demonstrated no relationship between noise from wind turbines and a wide variety of subjective and objective measures of adverse health outcomes. More simply, the most comprehensive study of the effect of wind turbine noise on human health to date did not show adverse health effects at sound levels up to 46 dBA at the receptor.

## V. SPECIFIC HEALTH ISSUES RAISED IN PUBLIC COMMENTS

**Q. Apart from the issues already discussed in your testimony, are you aware of any public comments submitted in this docket thus far regarding wind turbines, sleep, and health concerns?**

A. Yes. The following articles regarding wind turbines, sleep, and human health were submitted or referred to in public comments:

- A report compiled by Carmen Krogh, PSCPharm, titled “Industrial Wind Turbines and Health: Wind Turbines Can Harm Humans if too Close to Residents” (the “Krogh Report”).
- A report by Jerry L. Punch and Richard R. James titled “Wind Turbine Noise and Human Health: A Four-Decade History of Evidence that Wind Turbines Pose Risks” (the “Punch and James Report”).

**Q. Please describe the Krogh Report.**

A. The report is a document compiled and annotated by a retired pharmacist, Carmen Krogh. The document involves a mixture of topics and a variety of forms of source material. Many of the sources used in the document point to theoretical concern for health effects of wind turbines, often from the position of commentary or editorial. There are a couple of research papers included in this document that examine sleep or circadian biology, but they do not refer to wind turbines. There is even a theory paper by a psychologist about sleep and suicide. The words “wind,” “turbine,” “sound” or “noise” do not appear in that paper.

**Q. Is the Krogh Report peer-reviewed?**

A. Though the top of the page reads “PEER REVIEWED,” which implies a higher level of scrutiny to the source material cited, in fact, many of the citations are not peer reviewed, or at the lowest level of peer review. For example: What Audiologist Should Know, by J. Punch and R. James and D. Pabst appears to be a layperson magazine that would not be peer reviewed. And there are several papers listed that were never published in peer-reviewed journals, but were merely written documents accompanying presentations at various meetings.

**Q. In your professional opinion, is the Krogh Report reliable?**

A. No. The document entirely ignores recent work, including numerous publications by Health Canada (see above) that rigorously studied human health in the context of wind turbines, and showed no effect of turbines on human health. Further, in my opinion, Ms. Krogh is not a credible expert regarding potential health effects of wind

turbines. She is not a clinical psychologist, physician, clinician, sound expert, or physiologist. She has an undergraduate degree in pharmacy, and has published some theory and commentary about the potential effects of wind on human health, a topic she is clearly passionate about. Even so, she appears to be a layperson in the areas of wind turbines, noise, infrasound, and human health.

**Q. What is your response to the Krogh Report?**

A. This document is outdated, biased, and compiled by a layperson. It has no value in a meaningful discussion about the relationship, or lack thereof, between wind turbines and human health.

**Q. Please describe the Punch and James Report.**

A. The document is a flawed attempt to discredit sources that refute claims that wind turbines impact human health. The document is not published in traditional scientific or clinical publications.

The Punch and James Report includes several comments regarding “Ellenbogen et al Wind Turbine Health Impact Study” (the “Ellenbogen Paper”). As one of the authors of that paper, I am well-positioned to evaluate their critique of it. Mr. James and Dr. Punch endorse features of the Ellenbogen Paper, and discredit others, each, in turn when supporting their position (that wind turbines cause adverse health effects). For example, providing no context, they put forth a statement from my paper that “scientific evidence is lacking” regarding the conclusion that wind turbines cause adverse health effects. Then, relying on documents from “National Wind Watch,” they accuse the Ellenbogen Paper of “misrepresenting the evidence” regarding this conclusion. However, the citations from National Wind Watch which Mr. James and Dr. Punch reference to counter the Ellenbogen Paper’s conclusion are not “scientific evidence.” They have not been peer-reviewed and are not otherwise reliable.

**Q. What is your response to the Punch and James Report?**

A. This document by Mr. James and Dr. Punch is a biased and unsupported review by authors who are not medical experts. Although Mr. James and Dr. Punch appear to present the report as peer-reviewed, it is not. Rather, they have acknowledged that they withdrew the report from peer-review:

> The editor of Noise & Health offered an additional review cycle by a second reviewer. We chose instead to withdraw the manuscript from consideration because we were unwilling to either shorten it considerably or to mischaracterize the literature on the subject at hand.[2]

In other words, after critique by the peer-review process led to lack of acceptance without substantial revisions, the authors chose to withdraw the article from acceptable peer-review standards. They instead turned to their colleagues for review – which is not an acceptable standard of peer review:

> This paper has been reviewed both by the anonymous Noise & Health reviewer and by three other reviewers who have substantial professional experience in the area of wind turbine noise. We gratefully acknowledge the helpful contributions of Keith Johnson, Esq., Michael Nissenbaum, MD, and Daniel Shepherd, PhD.
>
> Mr. Johnson provided a review from the perspective of an attorney who represents interveners in wind turbine siting cases. Dr. Nissenbaum provided a review from the perspective of a medical professional and expert in how ionizing and non-ionizing radiation affects humans. Dr. Shepherd provided a review from the perspective of a psychoacoustician with experience in how wind turbine sound affects people. Each of these reviewers' comments on earlier versions of our manuscript led to the final document. The opinions or assertions contained herein, however, are the personal views of the authors and are not to be construed as reflecting the views of Michigan State University or Central Michigan University.

[2] *See* https://hearinghealthmatters.org/hearingnewswatch/2016/wind-turbines-noise-and-health/ (last access Feb. 13, 2019).

I note, however, that a law degree is not a science degree and, notably, Mr. Johnson is described as representing opponents to wind projects. Further, Dr. Nissenbaum is on the Board of Directors of "The Society for Wind Vigilance," which is a well-known and decidedly anti-wind group.[3] Rather than refer to their report as peer review, as they do, it would be more accurate to refer to the report as a written document with input from colleagues. This does not qualify as peer review.

**Q. Overall, in your professional opinion, do the documents referenced above show a connection between wind turbines and adverse human health effects?**

A. No. They represent outdated theory and conjecture, written by three authors that are not qualified to identify or refute connections between wind turbines and human health.

## VI. CONCLUSION

**Q. Does this conclude your Supplemental Direct Testimony?**

A. Yes.

Dated this 14th day of February, 2019.

Dr. Jeffrey Ellenbogen

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[3] See http://www.windvigilance.com/home/advisory-group (last accessed Feb. 13, 2019).