OFFICIAL FILING
BEFORE THE
PUBLIC SERVICE COMMISSION OF WISCONSIN

Application of Highland Wind Farm, LLC, for a Certificate of Public Convenience and Necessity to Construct a 102.5 MW Wind Electric Generation Facility and Associated Electric Facilities, to be Located in the Towns of Forest and Cylon, St. Croix County, Wisconsin

Docket No. 2535-CE-100

REHEARING DIRECT TESTIMONY OF PAUL D. SCHOMER

Q. Would you please state your name and address?

A. My name is Paul D. Schomer. My business address is 2117 Robert Drive, Champaign, Illinois 61821.

Q. Have you previously provided testimony in this proceeding?

A. Yes. I evaluated the Highland application for noise level exceedances and testified on the probable adverse impacts to the health and safety of the Town of Forest residents. I also participated in the Shirley Wind infrasound study conducted in December 2012 to evaluate the cause of adverse health effects from the same or similar large wind turbines that are proposed in this docket.

Q. What is the purpose for your testimony?

A. I intend to testify on the new proposal by Highland to mitigate its exceedance of the PSC 128 Nighttime Noise Standards of 45 dBA.

Q. What materials have you reviewed?

A. In addition to the original application materials, exhibits, and testimony from the prior proceedings, I have now reviewed the testimony and exhibits of Tim Osterberg, Michael Hankard, JoAnne Blank, and Jesse Stowell with respect to their proposal to rely on

proprietary software of the wind turbine manufacturers to curtail the violation of PSC 128 sound limits. I have also reviewed the recent filings from Mr. Hankard and Mr. Osterberg on the effect of a 40 dBA daytime sound limit and Highland's assurances that all sound limits imposed will be met if the project is built.

Q. Is curtailment a viable strategy to reduce power and sound for wind turbines?

A. Curtailment can be done on a limited, turbine-by-turbine basis for a variety of reasons such as reducing power during low demand periods, performing maintenance on the turbine, and responding to high wind events. Power reduction occurs by simply reducing the speed of the rotor through feathering the blades and spilling wind – much like a sailboat reduces speed by adjusting sails. Reducing rotor speed will tend to reduce sound levels, but there is no guarantee. Under some conditions, feathering the rotors to reduce rotor speed may actually increase sound levels.

Q. To your knowledge has a wind farm ever been designed with a curtailment strategy in the United States?

A. No. Wind turbines and wind farms are designed to operate at maximum capacity. It makes little sense to invest in larger turbines and then reduce power output to comply with noise limit regulations. The solution to Highland's design flaws is to use smaller turbines, which would allow the turbines to operate at full power as they were designed, and comply with all applicable noise regulations. Relying on untested software to predict when noise limits are being exceeded for a particular residence within a large wind farm, and expecting that the software will successfully reduce noise levels to maximum limits for each affected residence, is ludicrous.

Q. Are you familiar with other methods employed to use curtailment as a mitigation strategy for wind turbines?

A. Yes. I consulted with Michael Hankard in his efforts to reduce noise from a 49-turbine wind farm to two "neighboring" residences in Oregon.

Q. How does the Oregon project compare with the proposal now being made by Highland and Mr. Hankard here?

A. They are very different in scope and design. Mr. Hankard presented a paper on this subject to the Acoustical Society of America in Canada this year. His paper has been provided in his July 19, 2013 supplemental direct testimony as Ex.-HWF-Hankard-13 (PSC Ref. # 187658). One principal difference is that Mr. Hankard's proposed solution was designed to mitigate violations of Oregon noise limits at two residences, rather than the far more extensive incorporation of a mitigation plan into the design of the wind farm. Additionally, the mitigation plan in Oregon involved obtaining real time noise data from noise monitors at each of the two residences, wind speed and direction at each of the noise monitors, and wind speed reported by the wind turbines at hub height. Software developed by Mr. Hankard used these various inputs to develop a real time protocol and procedure to initiate the mitigation plan. When conditions indicate that a curtailment is required, a warning is placed on the screen of the operator of the wind farm, who is located in Chicago, IL. Within 30 minutes of such warning, the ten turbines nearest to these two residences are being shut down.

Here, Highland is proposing to use the curtailment function built into each turbine to mitigate predicted noise violations to 30 residences produced by the cumulative noise of an entire wind farm. Highland's mitigation plan would be on a trial and error basis,

with no real time noise data at each affected residence. This proposal is infinitely more complex. Yet, Highland proposes to collect no real time data, and instead rely on proprietary turbine software rather than an operator to reduce power and noise to acceptable levels.

Q. In your opinion, is Highland's curtailment mitigation strategy in the public interest?

A. No, absolutely not. To permit this wind farm with mitigation as the principal means of protecting the public would not be in the public interest. The solution is to build the wind farm with smaller, quieter turbines that will run at maximum capacity without requiring curtailment. Highland is proposing a grand experiment with the Town residents as the guinea pigs. The proposed turbines are too big and emit too much noise energy. In the wake of the severe health impacts experienced by some residents in the Town of Glenmore, which has similarly large turbines, it is troubling that Highland refuses to consider a full redesign of this project.

Q. Do you have any criticisms of the proposal suggested by Michael Hankard?

A. Yes. Mr. Hankard and I worked on a project in Oregon in which wind turbine noise exceeded the state noise limits at two "neighboring" residents.[1] These wind turbines were just 1.5 MW, but the noise they produced was in excess of Oregon regulation.

In order to mitigate the noise problems with these turbines, Mr. Hankard developed a clever mitigation strategy to shut down the ten nearest turbines to these houses. The on-site data, which includes the acoustic levels, the wind speed and direction at each residence, and specific turbine operating parameters, are all transferred in real time to the central office in Chicago. There, software determines the conditions

[1] There are only five houses within many miles of this wind farm. Two of the five houses are the two discussed above; two of the houses are not in violation of the Oregon regulation; and the fifth house is owned by the landowner who sold all the land for development of the wind farm. He uses this house for some of his farm help.

under which the sound is predicted to be too high, and issues a warning to the operator that he should initiate a shutdown of the ten turbines.

Q. How does the curtailment mitigation strategy purposed by Mr. Hankard in the Highland farm differ from the system he created in Oregon?

A. The starkest difference is that the Highland curtailment proposal relies exclusively on automated programming of proprietary software. There is no ground truth of noise levels at each residence. As I understand it, the only data relied upon by the software would be from the wind speed anemometer on each turbine, which would then be programmed to reduce power output at 8 meters per second. There would be no ground truth, such as real time microphones collecting data, to determine whether the curtailment is effective at all residential facilities. Mr. Hankard does propose limited ground truth in three locations accumulating data sporadically. However, this is not nearly as effective as continuously accumulating data through all seasons and wind conditions. Additionally, none of these data are going directly to a wind farm operator that can immediately adjust the wind turbines to maintain acceptable noise levels.

Q. Do you believe that Mr. Hankard's suggestion of using curtailment as a strategy to bring Highland into conformance PSC 128 noise limits is in the public interest?

A. In my opinion, no. The current proposal simply tries to squeeze a square peg into a round hole. As I have testified previously, the wind turbines suggested in this proceeding are simply too large for the layout of the Project, producing too much noise.

Q. Is the proposed mitigation plan workable?

A. Anything is possible, but the real question here is whether it is worth the long-term risk to area residents – who will have to live with this experiment for the next 30 years. Since

there will be no real time noise data collected at each residence as the experiment unfolds, the burden will shift to the residents to prove that the noise limits are being exceeded. The problem is that the turbines proposed by Highland are too big, and their acoustic emission levels are too high, to meet current PSC regulations. Highland proposes a complex solution to a problem with a simple solution: the use of smaller turbines that produce less noise and require no curtailment.

Q. Are you still concerned about the health impacts of large mega turbines such as those proposed in the Town of Forest?

A. Yes. There is significant evidence from all over the world that large turbines placed too close to residences cause very serious health problems. While the research is underway, there is continuing focus on balancing the size and output of wind turbines with public health. I do not believe that the right balance has yet been struck. The wind industry continues to claim that there is no known link between wind turbine noise and health effects.

In a recent paper, which is being submitted as Ex.-Forest-Schomer-20, I show that for a small group of specially selected people, the probability that motion sickness-like symptoms experienced by wind farm residents are unrelated to wind turbine noise is less than two in a million. This analysis proves that it is virtually certain that these individuals are adversely affected with serious health effects that result from the acoustic emission of nearby wind turbines. This changes the dynamic of the situation. Since it can no longer be said that there are no known health effects related to wind farms, it follows that the industry must prove that there will be no adverse health effects from

what they plan to do, or that the industry must state what the adverse health effects will be.

Q. Is there a sound scientific basis for imposing a 40 dBA noise limit for day and night, as proposed by the PSC, for the six homes that are identified as "sensitive"?

A. Yes. George and David Hessler have coauthored an article that recommended a noise limit of 40 dBA for wind farms, which has been shown to virtually eliminate noise related complaints and health problems. I have done independent work and concluded that 39 dBA should be the maximum limit to avoid annoyance and health impacts from wind turbine noise. A recent paper that George Hessler and I coauthored, which is being submitted as Ex.-Forest-Schomer-21, explains how we independently arrived at these limits of 40 and 39 dBA.

Q. Where was your article presented?

A. It was presented at the Acoustical Society of America/International Congress of Acoustics that occurred in Montreal in June of 2013. Michael Hankard presented his paper in the same technical session at this conference.

Q. Have some jurisdictions adopted the 39 or 40 dBA maximum limit?

A. Jurisdictions all over the world have adopted a wide range of limits. Europe and South Australia tend to have limits in the range of 35 dBA, sometimes even as low as 30 dB. On the other extreme, some jurisdictions have a limit of 55 dBA. George Hessler and I wrote this paper together because we thought it was important to show to the scientific community that we arrived at essentially the same answer, even though we used different methods and approaches to get there.

Q. Did the Massachusetts wind turbine study, upon which the environmental assessment relied, support these noise limits?

A. Yes. It supported the same 40 dBA limit at night.

Q. Have the Massachusetts study's conclusions on adverse health effects from wind turbines held up to recent scrutiny?

A. No. In a paper to be presented and to be published in December 2013, which is being submitted as Ex.-Forest-Schomer-22, we show that the Massachusetts study's conclusions about the lack of connection between human health and infrasound and wind turbine noise are flat out wrong.

Q. Do you believe that a 40 dBA limit is needed to avoid adverse health effects from audible and infrasound?

A. Yes. All the experts in this proceeding agree that the louder the turbines are in audible noise and the larger the turbines are in structure, the more infrasound will be produced. The larger mega turbines seem to correlate very starkly with health impacts. It is significant that in a wind farm with only eight turbines, three families have left their homes in the Town of Glenmore. As I testified earlier, if this farm is built as designed, it is likely that the same result will occur – with or without curtailment.

Q. Without ground truth to accurately measure sound levels at all locations, how would the wind turbine operator or the PSC be informed that noise limits are exceeded?

A. Without ground truth data, no one will know whether noise levels are exceeded. The burden of proof would shift to property owners to prove the cause of their problems.

Q. What is your reaction to Mr. Hankard's suggestion to use wind speed and direction to calculate the wind turbine noise emission levels?

A. To my knowledge, it has never been used anywhere for wind turbine noise assessment, and is completely untested in practical use. It introduces a new form of average levels where 50% or more could end up not meeting the limit – at least part of the time. The noise model used in this case, ISO 9613-2, already takes directionality into account by requiring a downwind prediction in all directions. Reducing predicted sound levels further with a directivity analysis makes any prediction model less conservative.

This proposal institutes averages that change with direction, but otherwise have the same effect as the averaging inherent in the use of impedance coefficients greater than 0,0,0 in ISO 9613-2. It recreates a situation where many residences exceed the limit for large percentages of the time. Also, this novel approach immeasurably complicates the noise impact analysis for each home. Not all the residences will have the same juxtaposition to the wind at any given wind speed and direction. When the wind shifts, these directivity analyses will change. Given the infinite number of variables concerning wind speed and direction, predicting noise levels at each residence will become very complex. Additionally, the conservative value of ISO 9613-2 always predicting the "downwind" solution will be lost if Mr. Hankard's directivity analysis is adopted.

Q. Does Mr. Hankard's directivity analysis assure that the Highland mitigation curtailment plan will work?

A. No. Mr. Hankard's statement that the radiation pattern of the wind turbines is a dipole is an over simplification and does not appear to be justified by his own data.

For instance, Ex.-HWF-Hankard-9 (PSC Ref. # 186229) does little to support Mr. Hankard's assertion that he can apply a directivity pattern without introducing significant new uncertainty. According to the data in Ex.-HWF-Hankard-9 (PSC Ref. # 186229), the most common "directivity" value for the first study listed is -3 dB, which occurs at 45^{o}, 135^{o}, 180^{o}, and 270^{o} with -4 dB at 90^{o}. Yet the first study in Ex.-HWF-Hankard-9 (PSC Ref. # 186229) indicates virtually no change in sound with wind direction and does not support Mr. Hankard's assertion. If any of the wind turbines in Forest operate in a similar fashion to Ex.-HWF-Hankard-9 (PSC Ref. # 186229), then the measured levels would be smaller than predicted. In contrast, if some of the turbines at Forest follow the second study presented in Ex.-HWF-Hankard-9 (PSC Ref. # 186229), then noise levels at two of the turbines would be under predicted by 1 dB. This directivity factor needs substantial research to demonstrate that it will not increase uncertainty and error. No persuasive data are shown that the individual turbines in the Town of Forest will instantaneously respond to wind direction and take on this pattern in all directions.

The second study Mr. Hankard presents in Ex.-HWF-Hankard-9 (PSC Ref. # 186229) has directivity values of 0,0,+1, and +1 dB at the 45^{o}, 135^{o}, 235^{o}, and 315^{o} angles to the wind. Mr. Hankard's method would subtract 1 dB at each of these directions, when according to the second study 1 dB should be added, yielding a net error of 2 dB. If this directivity pattern is so prevalent, and the wind turbine manufacturers want to report the loudest direction per IEC 61400-11, why does the IEC 61400-11 standard call for measurements in four directions instead

of just one? This proposed change by Mr. Hankard makes no practical sense. Subtracting some generalized average can only introduce new error.

Q. Does Mr. Hankard's proposal to assess wind direction to determine sound levels at each residence assure that the problems encountered at Shirley will not be repeated?

A. No. While this directivity effect might reduce audible sound in some cases, infrasound flows in all directions and its amplitudes are not reduced by which direction the sound originates. Adverse health effects from infrasound will not be abated by directivity. This is another reason to stick with ISO 9613-2 and IEC 61400-11, each as is, and not venture into the unknown.

Q. Mr. Hankard treats the inputs to and predictions from ISO 9613-2 as absolute maximum noise levels. Is this the case?

A. No, it is not the case. I have closely examined the data presented in Ex.-HWF-Hessler-3 (PSC Ref. # 172233) in this matter, which attempted to measure the accuracy of noise level predictions made by using ISO 9613-2. The Hessler data show that turbine noise tends to be louder at night. These data result from two weeks of continuous measurements at 1000 feet in three directions (north, south and east) from the east end of an east-west line of wind turbines in 10-minute intervals. Averaging the daytime data (7 AM to 10 PM) reveals values of 31, 30, and 30 dB for the three directions. During the night (11 PM to 5AM) the average noise levels increase by 6 dB to 37, 37, and 36 dB from the same three locations. This same "nighttime" effect is likely to occur in the Town of Forest. Although

data collection of turbine noise levels during various times of the year would likely produce different average sound levels, the important point is that there is a significant increase in noise levels at night which is between 3 and 6 dB.

Q. How does this relate to the requirement that nighttime levels not exceed 45 dBA?

A. What this means is that it would be misleading to use a 24 hour noise prediction for a wind farm to calculate the nighttime levels. The 24 hour prediction averages lower daytime levels with higher sound levels at night. The reality is that the night-only levels will be on the order of 3 dB louder than the 24 hour prediction.

Q. How does all of this apply in the current matter?

A. This means that Highland must take into account the "nighttime" effect revealed in the Hessler data by developing mean values and standard deviations empirically in the Town of Forest area in sufficient quantity for the sources and receivers to generalize to the entire wind farm. In the alternative, Highland must assume a conservative stance by predicting that the effective nighttime emissions will be 4 dB greater than those currently stated.

Q. Has Mr. Hankard adequately explained the procedure used to reduce the turbine noise levels to verify the reliability of his calculations?

A. No. Ex.-HWF-Hankard-11 (PSC Ref. # 186231) fails to include critical information necessary to understand its reliability. Ex.-HWF-Hankard-11 (PSC Ref. # 186231) shows turbine noise levels dropping by up to 6 dBA with no explanation of how the reductions were selected, how long they will be in effect

and why these turbines were curtailed while others were not. Eight solution sets are reported to exist for the eight compass wind directions, north through northwest, but only one of the eight solution sets is given. Also it is stated that these eight solution sets are sufficient for all wind directions.

But, once again, no data are provided to substantiate this assertion. Further, the rate at which the solution set is changed is not explained. Is it updated once per second? Once per minute? Once per hour? What triggers a change? How long does a change take to effect? The unanswered questions are almost limitless. It is impossible to judge the veracity of a procedure when we are not told what the procedure is.

Q. Are there issues with any of the other testimony?

A. Yes. Mr. Stowell testified that this mitigation scheme is not stable, and is therefore not suitable for the long term. Specifically, he reports that the curtailment scheme will slip in and out of compliance. A system that slips in and out of compliance is unsatisfactory.

Q. Are bigger wind turbines better for people?

A. The history of wind turbines, as young as they are, is one of ever increasing size. Current units go from 1.5 to 3.5 MW, and bigger units can be expected in the future. Larger turbines may have the advantages of greater efficiency and net profit but they create more problems for people living close by. There is strong evidence that the very low infrasound frequencies produced by large wind turbines are the sources of acoustic emission that are adversely affecting people. As the

power generated by wind turbines grows, the blades grow and hence the tip's speed is reduced to avoid too high an advancing blade tip Mach number.

According to a paper by van den Berg (2004), which is being submitted as Ex.-Forest-Schomer-22, the increase due to a typical nighttime wind profile (the change in velocity with altitude) was 5 dB for a wind turbine with a 58 m hub height, and up to 15 dB for a turbine with a 98 m hub height. That is, the increase in low frequency energies in size and magnitude may be substantial because of this blade-loading, wind-gradient effect, much greater than what is predicted for constant blade loading. The conclusion is that unless mitigation methods and strategies can be developed and implemented, bigger turbines are not necessarily better. They may actually be much worse for people.

Q. Have all your opinions been given to a reasonable degree of professional certainty?

A. Yes

Q. Does this conclude your testimony?

A. Yes.