OLLSON
Environmental Health Management

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EXHIBIT
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June 1, 2016

Julie Fedorchak, Chair
Randy Christmann, Commissioner
Brian Kalk, Commissioner
North Dakota Public Service Commission
600 E Bouldevard Ave #408
Bismark, ND 58505

RE: North Dakota Public Service Commission, Oliver III Wind Energy Center, Application for Certificate of Site Compatibility, Case Nos. PU-16-122/PU-16-123 Overview of Wind Turbine Siting and Health

Commissioners:

Ollson Environmental Health Management (OEHM) was retained by Oliver III Wind, LLC (Oliver III Wind) to provide an overview regarding potential health concerns related to living in proximity to wind turbines. I intend to appear before the North Dakota Public Service Commission (PSC) on June 1, 2016 to provide any clarification that is required. This letter report is an update to that provided to the PSC on March 30, 2016 for the Brady Wind Energy Center PSC hearing.

In summary, over the past decade there has been considerable research conducted around the world on the potential for wind turbines to adversely impact health. This independent research by university professors and government medical agencies has taken place in many different countries on a variety of models of turbines that have been in the community for a number of years. Based on scientific principles, and the collective findings of over 70 scientific articles, I believe that as proposed the Oliver III Wind Energy Center project is properly sited will not result in adverse health effects in the surrounding communities.

1.0 Qualifications of Dr. Christopher Ollson

My area of expertise is in the field of environmental health science. I am trained, schooled and practiced in the evaluation of potential risks and health effects to people and ecosystems associated with environmental issues. Since 2008, I have been engaged by a number of private companies to review the potential health effects that may be associated with living in proximity to wind turbines as part of their preparation of environmental assessment documentation. In 2014, I provided expert advice on wind turbines, health and proper siting requirements for the Vermont Public Services Department. Approximately one third of my practice on an annual basis has been devoted to better understanding the relationship between people, animals and wind energy.

I have been qualified to provide expert opinion evidence on wind turbines and potential health effects at a number of North American hearings, tribunals and legal cases. I have provided numerous presentations to County Commissions and Boards across the United States.

In addition to my consulting practice I hold an appointment of Adjunct Assistant Professor at the Royal Military College of Canada in the Department of Chemistry and Chemical Engineering and Adjunct Professor in the School of the Environment at the University of Toronto. In 2013, I was appointed to the Governing Council, and am Vice-Chair of the Academic Affairs Committee, of the University of Toronto Scarborough.

72 **PU-16-123** Filed: 6/1/2016 Pages: 17
Exhibit 29 – Overview of Wind Turbine Siting and Health by Dr. Christopher Ollson

71 **PU-16-122** Filed: 6/1/2016 Pages: 17
Exhibit 29 – Overview of Wind Turbine Siting and Health by Dr. Christopher Ollson

While at Intrinsik Environmental Sciences (2011-2015) I headed a research group on the potential effects of wind projects on health. These research efforts resulted in six published scientific peer reviewed papers:

Berger R.G., Ashtiani P., **Ollson C.A.**, Whitfield Aslund M., McCallum L.C., Leventhall G., Knopper L.D. 2015. *Health-based audible noise guidelines account for infrasound and low frequency noise produced by Wind Turbines.* Front Public Health. Vol 3, Art. 31

Knopper, L.D., **Ollson, C.A.,** McCallum, L.C., Aslund, M.L., Berger, R.G, Souweine, K., and McDaniel, M. 2014. *Wind turbines and Human Health.* Front. Public Health, Vol. 2, Art. 63

McCallum, L.C., Whitfield Aslund, M.L., Knopper, L.D., Ferguson, G.L., **Ollson, C.A.** 2014. *Measuring electromagnetic fields (EMF) around wind turbines in Canada: is there a human health concern?* Environmental Health 13(9), doi:10.1186/1476-069X-13-9.

Ollson, C.A., Knopper L.D. McCallum, L.C., Aslund-Whitfield, M.L. 2013. *Are the findings of 'Effects of industrial wind turbine noise on sleep and health' supported?* Noise & Health 15:63, 148-150.

Whitfield Aslund, M.L., **Ollson, C.A.,** Knopper, L.D. 2013. *Projected contributions of future wind farm development to community noise and annoyance levels in Ontario, Canada.* Energy Policy. 62, 44-50

Knopper, L.D. and **Ollson, C.A.** 2011. *Health Effects and Wind Turbines: A Review of the Literature.* Environmental Health. 10:78. Open Access. Highly Accessed.

2.0 Involvement with the Oliver III Wind Energy Center

Since the winter of 2016, I have been engaged by NextEra Energy Resources, LLC (NEER) to provide health expertise and advice on the suitability of siting wind projects in Morton and Oliver Counties. I have had the opportunity to visit the counties.

I am familiar with North Dakota *Administrative Code Article 69-06-08-01 Energy Conversion Facility Siting Criteria, the Morton County Land Use Code and the Oliver County Zoning Ordinance*.

This letter serves to provide background on issues that have been raised by the public and to address the suitability of both the Morton and Oliver County Ordinances and the PSC Exclusionary Area regulations to protect public health and safety. This letter provides information on:

- Audible noise
- Low Frequency Noise (LFN) / Infrasound (IS)
- Shadow Flicker
- Ice Throw / Blade Throw

To examine these issues it is first important to understand the proposed Project. I have reviewed the Oliver III Wind Energy Center – Application to the North Dakota Public Services Commission for a Certificate of Site Compatibility. Oliver III Wind is proposing to install up to 48 wind turbines using a combination of General Electric (GE) 2.1 MW and 7 GE 1.79 MW Xle turbines. Both models would be 262 feet (80 meters) to the hub; the 2.1 MW turbines would 453 feet to the tip of the upright blade, and the 1.79 MW turbines would be 427 feet.

As with any energy facility it is important that proper setbacks and guidelines are in place for wind turbines to ensure public health and safety. Table 1 is provides the list of setback requirements from both the Morton County Land Use Code and the North Dakota Public Services Commission. The suitability of these setbacks will be discussed in each of the following sections.

Table 1. List of Setback Requirements and Disturbances

Setback Type	Distance
PSC Exclusion Areas	
Interstate and state road rights-of-way	1.1 x turbine height (498.3 feet)
Centerline of county or maintained township roadways	1.1 x turbine height, plus 75 feet (573.3 feet)
Railroad rights-of-way	1.1 x turbine height (498.3 feet)
115kV or higher transmission lines	1.1 x turbine height (498.3 feet)
Property line of non-participating landowners	1.1 x turbine height (498.3 feet)
Occupied residences	1,400 feet
Morton County Setbacks	
Inhabited structures and facilities (residence, commercial building or publicly-used structure), or state and county park	1.25 x turbine height (566.25 feet) or 1,320 feet, whichever is greater
Public roads	1.1 x turbine height plus 75 feet (573.3 feet)
Above ground communication and electrical lines	1.1 x turbine height plus 75 feet (573.3 feet)
Railroad right-of-way	1.1 x turbine height plus 75 feet (573.3 feet)
Section lines	100 feet
Wind Energy Facility Perimeter	1.5 x turbine height (679.5 feet for the 2.1 MW turbines and 640.5 feet for the 1.79 MW turbines)
Property line of non-participating landowners	1.5 x turbine height (679.5 feet) (unless variance is granted)
Other	
GE-provided setback from barns, abandoned houses, and roads (more conservative than PSC setback)	1.5 x turbine height (679.5 feet)

3.0 Background

Wind-based energy production has been identified as a clean and renewable resource that does not produce any known emissions or harmful wastes. As a result, wind power has become the fastest growing source of new electric power generation, with several countries achieving high levels of wind power capacity.

Over 60 studies have been published worldwide to examine the relationship between wind turbines and possible human health effects. Based on the findings and scientific merit of these studies they have lead health and medical authorities to state that when sited properly (i.e., based on distance and/or noise guidelines and setbacks), wind turbines are not causally related to adverse effects. In fact, since I last appeared before the North Dakota PSC an additional seven peer-reviewed papers have been published by Health Canada in the field.

3.1 Audible Sound (Noise)

The requirements for audible noise levels for Oliver III Wind are captured both at the county and state level. Morton County Land Use Code ensures that sustained noise level does not exceed 65 dBA during the day and 60 dBA at night. However, the North Dakota Administrative Code Article 69-06-08-01(4) specifies that sound levels within one hundred feet of an inhabited residence or a community building from a wind turbine may not exceed 50 dB, unless waived in writing by the owner. In addition, the Morton County Land Use Code requires a minimum 1,320 foot setback from occupied houses, industrial and municipal buildings. However, PSC has a minimum setback distance design criteria of a minimum of 1,4000 from such buildings that was used in this application. In fact the closest dwelling to a wind turbine for Oliver III Wind was 1,510 feet. These regulations are appropriate to ensure that Oliver III Wind will not impact the health of local residents. I understand that there was one participating landowner that had a modeled sound level above 50 dBA 100 feet from their home; however, they have signed a waiver.

The following are the sound and distance levels from the nearest occupied homes:

Status	Receptor	Distance to Nearest Turbine (ft)	Modeled Sound Level (dBA)
Participating	810021	1,510	51
	6006	3,012	47
Non-Participating	6004	2,350	46

There are numerous studies that have explicitly examined the relationship between levels of wind turbine noise and various self-reported indicators of human health and well-being (e.g., Health Canada 2014; Bakker et al. 2012; Janssen et al. 2011; Pedersen 2011; Pedersen and Persson Waye 2004; 2007). These studies have researched a wide range of wind turbine models, manufacturers, heights and noise levels. They were conducted over several years, in some cases over 10 years, after wind turbines became operational. The study of wind turbine health concerns began in Europe in the early 2000s and most recently examined in Canada.

It is important to understand that from a health perspective it is not the height of the turbines, or the noise output at their hub, that is the important. Rather, it is the resulting sound level at people's homes that is critical to ensure the protection of public health. Simply put, whether a developer selects a 453 foot wind turbine, or smaller model, the requirement to meet the 50 dB sound level 100 feet from a home remains the same.

What can be seen from these peer-reviewed articles (and many others) is that the relationship between wind turbines and human responses to them is extremely complex and influenced by numerous variables. Key points that have come out of these studies are:

- Adverse health effects have not been attributed to properly sited wind turbine projects;
- People tend to notice sound from wind turbines almost linearly with increasing sound pressure level (in other words, the louder the wind turbine at ground level the more people notice them);
- A proportion (typically less than 10%) of people that notice sound from wind turbines find it annoying (annoyance is not a medical condition);
- Noise-related annoyance can be within the range of existing levels of community noise related annoyance (e.g., rail, road and air traffic; animal noise);
- Annoyance is not only related to wind turbine noise but more strongly to subjective factors like attitude, visual cue, stress and expectations; and

- People who economically benefit from wind turbines often experience higher sound levels outside their homes than non-participants and have significantly decreased levels of annoyance compared to individuals that received no economic benefit.

The reported correlation between wind turbine noise and annoyance is not unexpected as noise-related annoyance (described by Berglund and Lindvall (1995) as a *"feeling of displeasure evoked by a noise"*) has been extensively linked to a variety of common noise sources such as rail, road, and air traffic (Berglund and Lindvall 1995; Laszlo et al. 2012; WHO Europe 2011).

Noise-related annoyance from these more common sources is prevalent in many communities. For instance, results of national surveys in Canada and the U.K. by Michaud et al. (2005) and Grimwood et al. (2002), respectively, suggested that annoyance from noise (predominantly traffic noise) may impact approximately 8% of the general population. Even in small communities in Canada (i.e., <5000 residents) where traffic is relatively light compared to urban centers, Michaud et al. (2005) reported that 11% of respondents were moderately to extremely annoyed by traffic noise. This same trend was noted in the Bakker *et al.*, 2012 study in the Netherlands where people living in close proximity to wind turbines reported being awoken more by people/animal noise (11.7%), rural traffic/mechanical noise (12.5%) than turbine noise (6.0%).

Because environmental noise above certain levels is a recognized factor in a number of human health issues, many jurisdictions where wind turbines are being constructed have established noise restrictions and/or minimum setback distances in order to mitigate potential noise-based health effects (as well as operational effects related to shadow flicker, ice throw and structural failure). In North Dakota this sound level has been set at 50 dB, 100 feet from homes.

Peer reviewed studies do not do not support a correlation between wind turbine noise exposure and any other response other than some annoyance. For example, various studies based on the results of two surveys performed in Sweden and one in the Netherlands (1755 respondents overall), found that no other measured variable (e.g., self-reported evaluations of high blood pressure, cardiovascular disease, tinnitus, headache, sleep interruption, diabetes, tiredness, and reports of feeling tense, stressed, or irritable) was directly related to wind turbine noise for all three datasets (Pedersen, 2011).

Likewise, the Health Canada (2014) study (1238 participants) found no correlation between wind turbine noise exposure and either self-reported indicators of health (i.e., self-reported sleep disturbance, use of sleep medication, diagnosed sleep disorders, migraines, tinnitus, dizziness, hypertension, perceived stress or any measure of quality of life) or objectively measured indicators of health (hair cortisol concentrations, blood pressure, resting heart rate or any of the measured sleep parameters). Further details on the Health Canada study are provided below.

In addition to the peer-reviewed studies it is important to understand how North Dakota specific guidelines have faired to ensure protection of health. According to the American Wind Energy Association (AWEA) the installed capacity of wind power in the State at the end of 2014 was 1,886 MW. This was achieved through 22 projects and 1,059 wind turbines located as close as 1400 feet from peoples homes for most of the projects approved by the North Dakota Public Service Commission. The North Dakota PSC was contacted earlier this year to inquire whether noise complaints or health concerns have been raised. PSC staff indicated that noise complaints from operating wind farms in North Dakota have been infrequent and resolved between the resident and developer. Given the number of operating wind turbines in North Dakota over the past decade and the evidence in the scientific literature, the North Dakota noise limit of 50 dB and NextEra minimum 1,400 foot setback are more than sufficient to protect neighbors of wind projects.

3.1.1 Relationship of Wind Turbine Noise and Distance as a Proxy

Jurisdictions across the United States that have wind turbine ordinances or regulations typically regulate noise levels at homes either by: setting a maximum sound level outside a dwelling that is not to be exceeded; by using a distance from nearest turbine to homes; or by a combination of both approaches. In my experience this is regulated at the dwelling and not at property boundaries.

Although distance can be used as a proxy for estimating a sound level it is not ideal. Using distance only does not account for project and site-specific issue; such as: model of turbine being selected and the sound power output of individual models, cumulative sound levels from the number of turbines that may be in proximity to a dwelling, the topography, terrain, and many other site-specific factors. This is why sound modeling for wind projects is critical in ensuring that the desired sound level at a dwelling is met under worst-case conditions.

In 2013, I coauthored a paper that examined the relationship of predicted sound levels with distance from the closest turbine to a dwelling (Whitfield Aslund, 2013). As can be seen in Figure 1 of the paper that at any given distance predicted sound levels at the homes could vary up to almost 10 dBA.

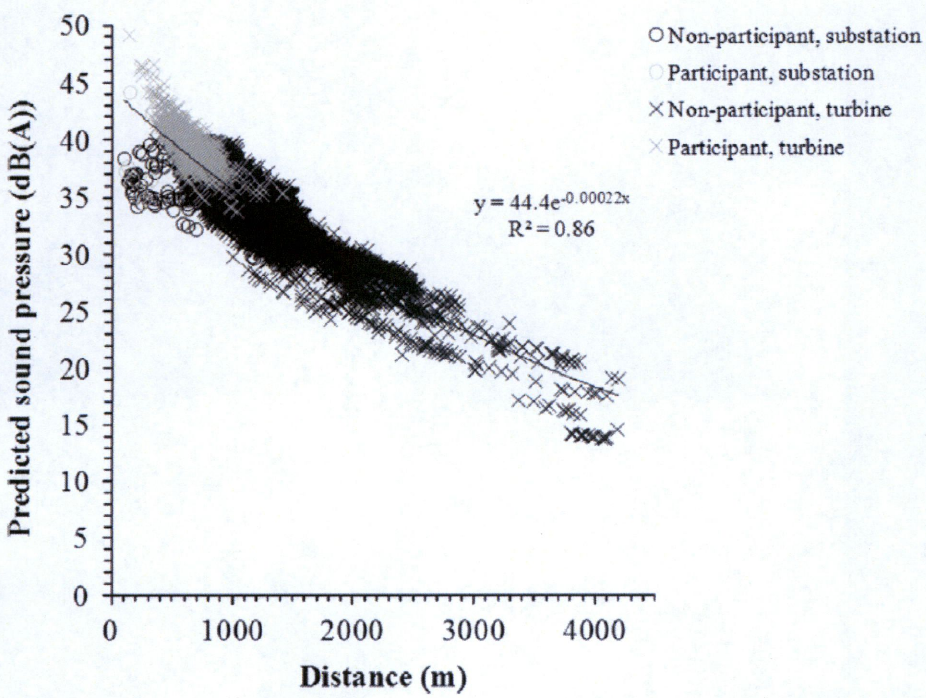

Fig. 1. Modeled sound pressure levels (dB(A)) for participating and non-participating receptors with respect to distance from nearest noise source (wind turbine, ×, or transformer substation, ○).

This research was conducted using data from Ontario, Canada. In my experience sound level modeling in the United States is more conservative that that of Ontario. In general, the same wind farm being modeled in North Dakota would likely have sound levels predicted that are 3-5 dBA higher than those predicted in Ontario. This is simply a function of additional conservative input parameters commonly applied by US practitioners. Therefore, a 50 dBA sound level from Figure 1 would be the equivalent of between 53 and 55 dBA for model results that are completed in North Dakota. Whitfield Aslund (2013) stated:

> "*However, although distance to the nearest noise source could explain a large portion (86%) of the total variance in predicted sound pressure levels, other sources of variation are also important; predicted sound pressure levels at a set distance varied by approximately 5-10 dB(A) and the distance at which a set sound pressure level was met varied by approximately 1000m (Fig 1.). These variations reflect differences in the noise model inputs such as the physical design and noise emissions ratings of the turbines (and transformer substations, if present) used in different projects and the total number of turbines (and transformer substations, if present) in the vicinity (<5 km) of the receptor location. Given that noise levels can vary substantially at a given distance, these data highlight the inadequacy of using 'distance to the nearest turbine' as a proxy for wind turbine noise exposure…*"

In addition, in 2012 Evans & Cooper published a paper "*Comparison of Predicted and Measured Wind Farm Noise Levels and Implications for Assessment of New Wind Farms*". In this paper the authors took sound level measurements at six active wind projects and at a distance as close as 1000 ft (300 m) to turbines. They determined:

> *"However, the degree of over-prediction appears dependent on the topography around the wind farm. At sites with a relatively flat topography or a steady slope from the turbines to the measurement sites, the over-prediction can be in the order of 3 to 6 dB(A). However, at sites where there is a significant concave slope from the turbines down to the measurement sites, these commonly used prediction methods are typically accurate, with the potential of marginal under-prediction in some cases."*

During the Brady Wind Energy Center PSC hearing I testified that at approximately 1000 feet from a wind turbine one could experience a 55 dBA sound level. I wish to clarify that this was meant to be an approximate distance at which one could potentially experience such a sound level from modeled results. However, it certainly was never meant to be an exact distance or estimate. In my experience through review of numerous noise modeling reports at 1000 ft (300 m) it is possible that a 55 dBA level could be reached. In addition, I wish to reiterate that my concern was only related to an existing dwelling where I would not support a wind project having sound levels that would exceed 55 dBA and not the distance to a property line. However, these predicted sound levels should be conducted using the standard wind farm sound modeling approaches and not relying on distance.

Based on the above research, it is possible given site-specific conditions that sound levels at 1000 ft from the closest turbine could vary from <45 dBA and perhaps as high as 55 dBA.

For Oliver III Wind the wind farm project it is governed by a maximum sound level from wind turbines of 50 dBA within 100 feet of a home by PSC and a minimum setback distance of 1,400 feet from a home. With those design criteria only one home was modeled to experience a sound level of 51 dBA and the property owner signed a waiver.

I remain of the opinion that proper siting of wind projects should only take into account existing dwellings and ideally based on predicted sound levels, rather than a distance based setback, given the variance in sounds levels that can occur. Instituting a 1000 foot setback to property lines would afford no greater protection to residents health than is already provided by both the North Dakota PSC and Morton County rules. The Oliver III Wind project was designed in a manner that is consistent with county and state regulations for dwellings. One cannot predict where future homes will be built.

3.2 Low Frequency Noise (LFN) and Infrasound (IS)

Low frequency noise (LFN) / infrasound (IS) are terms used to describe sounds that are produced at frequencies too low to be heard by the human ear at frequencies of 0 to 20 Hz (IS) and 20 to 200 Hz (LFN). LFN/IS are not unique to wind turbines. More common sources include road traffic, refrigerators, ocean waves, thunder, and even the wind itself.

There has been recent speculation by some that low frequency noise or infrasound emitted from wind turbines could be the cause of health concerns reported by some living in proximity to wind projects. To that end, I along with Mr. Payam Ashtiani of Aercoustics Engineering Ltd. and Dr. Geoff Leventhall recently published a peer-reviewed article entitled "*Health-based Audible Noise Guidelines Account for Infrasound and Low Frequency Noise Produced by Wind Turbines*" in the journal Frontiers in Public Health (Berger et al., 2015).

The purpose of this paper was to investigate whether current audible noise-based guidelines for wind turbines account for the protection of human health given the levels of infrasound and low frequency noise typically produced by wind turbines. New field measurements of indoor IS and outdoor LFN at locations between 400 m (1300 ft) and 900 m (2950 ft) from the nearest turbine, which were previously underrepresented in the scientific literature, were reported and put into context with existing published works. Our analysis showed that indoor IS levels were below auditory threshold levels while LFN levels at generally accepted setback distances were similar to background LFN levels. Collectively, these data in conjunction with previous reports indicate that levels of IS and LFN are not sufficient to induce adverse health effects; therefore health-based audible noise guidelines are suitable for the protection of human health.

This work is consistent with the study undertaken by Epsilon Associates, Inc., published in 2011 (O'Neal, 2011) at a NEER wind farm in Texas. Additionally, it should be noted that Health Canada (2014) recently found that there was "*no additional benefit in assessing LFN as C- and A-weighted levels were so highly correlated (r=0.94) that they essentially provided the same information*".

Table 2. Infrasound Measurements (Turnbull, 2012)

Noise Source	Measured Level (dB(G))
Clements Gap Wind Farm at 85m	72
Clements Gap Wind Farm at 185m	67
Clements Gap Wind Farm at 360m	61
Cape Bridgewater Wind Farm at 100m	66
Cape Bridgewater Wind Farm at 200m	63
Cape Bridgewater Wind Farm ambient	62
Beach at 25m from high water line	75
250m from coastal cliff face	69
8km inland from coast	57
Gas fired power station at 350m	74
Adelaide CBD at least 70m from any major road	76

In 2012, Turnball *et al.* published a paper titled *Measurement and Level of Infrasound from Wind Farms and Other Sources* to put this issue into context with other LFN/IS sources. The study was conducted in Australia around wind turbines and other common sources of infrasound. The Clements Gap Wind Farm is comprised of 27 Suzlon S88 2.1 MW wind turbines and the Cape Bridgewater Wind Farm that is comprised of 29 Repower MM82 2.0 MW wind turbines. They determined that infrasound from wind turbines reached ambient (background) levels within 200 m (650 ft) to 360 m (1200 ft). The levels were found to be lower than those measured around beaches, gas fired plants and major roadways (Table 2). These findings are consistent with other scientific papers in the field.

Therefore, the hypothesis that low frequency noise or infrasound are a causative agent in health effects is not supported by the scientific and medical literature. Although IS and LFN are emitted from wind turbines and their contribution above background sources can be measured, the levels are typically within background levels at homes and are well below levels that could induce health impacts. The PSC requirement of a 1,400 foot setback from residents is more than sufficient to protect public health from this issue.

3.3 Shadow Flicker

The main health concern associated with shadow flicker is the risk of seizures in those people with photosensitive epilepsy. Harding et al. (2008) and Smedley et al. (2010) have published the seminal studies dealing with this concern. Both authors investigated the relationship between photo-induced seizures (i.e., photosensitive epilepsy) and wind turbine blade flicker (also known as shadow flicker). Both studies suggested that flicker from turbines that interrupt or reflect sunlight at frequencies greater than 3 Hz pose a potential risk of inducing photosensitive seizures in 1.7 people per 100,000 of the photosensitive population. For turbines with three blades, this translates to a maximum speed of rotation of 60 revolutions per minute (rpm).

Modern turbines commonly spin at rates well below this threshold and are typically below 20 rpm. The Oliver III Wind turbines include the GE 2.1 MW and 1.79 MW that have rotational speeds of 18.5 rpm and 17.5 rpm.

In 2011, the Department of Energy and Climate Change (United Kingdom) released a consultant's report entitled "Update of UK Shadow Flicker Evidence Base". The report concluded that:

> *"On health effects and nuisance of the shadow flicker effect, it is considered that the frequency of the flickering caused by the wind turbine rotation is such that it should not cause a significant risk to health.*

Therefore, there are no requirements to limit shadow flicker for health concerns.

Neither North Dakota, nor Morton or Oliver Counties, currently set forth a standard for shadow flicker. Therefore, Oliver III Wind is generally using an industry guideline of no more than 30 hours of shadow flicker per year at an occupied residence.

The origins of this industry standard are traced to Germany in 2002. The German Territorial Committee for Emissions control released the document "Hinweise zur Ermittlung und Beurteilung der optischen Immissionen von Windenergieanlagen, Länderausschuss für Immissionsschutz [Notes on the identification and evaluation of optical emissions from wind turbines], (in German)." The standard was based on limiting the annoyance of local residents. level is often cited as being below one that would result in annoyance of local residents. They subsequently codified this formal shadow flicker guideline as part of the *Federal Emission Control Act* (Haugen, 2011).

Although shadow flicker from wind turbines is unlikely to lead to a risk of photo-induced epilepsy there has been little if any study conducted on how it could heighten the annoyance factor of those living in proximity to turbines. It may however be included in the notion of visual cues.

In 2016, Health Canada published a paper "*Estimating annoyance to calculated wind turbine shadow flicker is improved when variables associated with wind turbine noise exposure are considered*" (Voicescu et al., 2016). By using the questionnaires of over 1200 people living as close as 800 feet from a turbine they attempted to determine if they could predict the percentage of people that were highly annoyed by varying levels of hours of shadow flicker (SF) a year or number of minutes on a given day. However, although annoyance did tend to increase with increasing minutes a day they could not find a statistical relationship:

> *"For reasons mentioned above, when used alone, modeled SF_m results represent an inadequate model for estimating the prevalence of HA_{WTSF} as its predictive strength is only about 10%. This research domain is still in its infancy and there are enough sources of uncertainty in the model and the current annoyance question to expect that refinements in future research would yield improved estimates of SF annoyance."*

Therefore, there is nothing in the scientific literature that suggests that shadow flicker should be limited to less than 30 hours a year. For Oliver III Wind there are two participating residents that will experience shadow flicker >30 hours a year; however, they have signed waivers with the company. There are only six non-participating residents that would experience any shadow flicker at their residences. Four of these could experience less than six hours of shadow flicker over the course of the whole year. The remaining two would experience 24 hours and 16.5 hours. It is also important to note that 24 hours a year represents 0.3% of the total hours in a year. In addition, shadow flicker only occurs intermittently and typically only for a few minutes at any given time.

Given that shadow flicker can theoretically be experienced at distances of up to 8,000 feet it would not be practical to eliminate all potential for shadow flicker on neighboring properties. The internationally recognized guideline of no more than 30 hours a year appears to be adequate to reduce annoyance levels on neighboring properties.

3.4 The Health Canada Wind Turbine Noise Study, November 6, 2014.

This study was initiated in 2012 and was a partnership between Health Canada and Statistics Canada that involved understanding the potential impacts of wind turbine noise on health and wellbeing of communities in Southern Ontario (just north of New York) and Prince Edward Island. A total of 1238 households participated in the study, making it the largest and most comprehensive study ever undertaken around the world. Health Canada's summary brochure contains the following statement:

> *The* ***Wind Turbine Noise and Health Study*** *is a landmark study and the most comprehensive of its kind. Both the methodology used and the results are significant contributions to the global knowledge base and examples of innovative, leading edge research.*

As set out in the Summary and Michaud (2015), the following were not found to be associated with wind turbine noise:

- Hair cortisol concentrations, blood pressure, resting heart rate or any of the measured sleep parameters (i.e., sleep latency, sleep time, rate of awakenings, sleep efficiency).
- Self-reported sleep disturbance, use of sleep medication, or diagnosed sleep disorders.
- Self-reported migraines, tinnitus, dizziness, diabetes, hypertension, perceived stress or any measure of quality of life.

Annoyance (which is not a medical condition) was found to be statistically associated with increasing levels of wind turbine noise. However, the associations between wind turbine noise annoyance and self-reported and measured health effects were not dependent on the particular levels of noise, or particular distances from the turbines, and were also observed in many cases for road traffic noise annoyance. Rather, the percentage of highly annoyed people living in vicinity of wind turbines was dependent not only on noise, but other factors for example visual cue. Health Canada's findings are consistent with the past decade of research in the field of wind turbine noise and community health. Nowhere in Health Canada's official material on this study do they suggest that living in proximity to wind turbines poses serious harm to people's health.

At the 6th International Meeting on Wind Turbine Noise Glasgow April 2015 Dr. David Michaud, principal investigator of the Health Canada study presented a paper "*Wind Turbine Noise and Health Study: Summary of Results*" . This conference paper provides greater details on the statistics and graphs of the Health Canada findings. It concludes by stating:

> *Including both self-reported and physically measured health effects together provides a more complete overall assessment of the potential impact that exposure to wind turbines may have on health and well-being. The overall conclusion to emerge from the study findings is that the study found no evidence of an association between exposure to WTN and the prevalence of self-reported or measured health effects beyond annoyance. Collectively, the findings related to annoyance suggest that health and well-being effects may be partially related to activities that influence community annoyance, over and above exposure to WTN. Therefore, efforts that aim to identify and mitigate high levels of annoyance with wind turbines may have benefits that go beyond annoyance.*

The findings of this study are in the final stages of being published in the scientific peer-reviewed literature as a series of papers.

3.4.1 Health Canada Peer-Reviewed Published Paper on Sleep 2016

In January, 2016 Dr. David Michaud and his colleagues published their first peer-reviewed scientific article on their findings of the Health Canada study with respect to wind turbines and sleep:

> *Michaud et al., 2016. Effects of Wind Turbine Noise on Self-Reported and Objective Measures of Sleep. Sleep, Vol. 39, No. 1*

The journal *Sleep* is a well-respected scientific publication in this area of research. The paper presents the findings of the Health Canada study of wind turbine noise on sleep. The sample size was the entire 1,238 participants from the overall study. It is the largest and most comprehensive of its kind ever undertaken for wind turbine noise.

The following excerpt from the paper discusses study objective:

> *The current study was designed to objectively measure sleep in relation to WTN exposure using actigraphy, which has emerged as a widely accepted tool for tracking sleep and wake behavior. The objective measures of sleep, when considered together with self-report, provide a more comprehensive evaluation of the potential effect that WTN may have on sleep.*

The following excerpt explains that the Health Canada study findings were consistent with a sleep study in Europe with sound levels of up to 54 db(A) at people's homes:

> *. . . sleep disturbance reported as a result of transportation noise exposure occurs at sound pressure levels that exceed WTN [wind turbine noise] levels calculated in the current study. Study results concur with those of Bakker et al. (2002), with outdoor WTN levels up to 54 dB(A), wherein it was concluded that there was no association between the levels of WTN and sleep disturbance when noise annoyance was taken into account.*

Therefore, their findings are consistent with credible previously published literature in the field.

4.0 Physical Health and Safety

Concerns have been raised that the Morton County Ordinance and the PSC Exclusionary Areas are not sufficient to ensure the protection of public health and safety from issues such as ice throw and blade failure. The PSC Exclusionary Areas and Morton County Ordinance are consistent with other jurisdictions and with the GE Power & Water setback considerations (GE Power & Water, 2013) (Table 3).

Table 3. GE Setback Considerations

Setback Distance from center of turbine tower	Objects of concern within the setback distance

All turbine sites (blade failure/ice throw):
1.5 x (hub height + rotor diameter)
	- Public use areas
	- Residences
	- Office buildings
	- Public buildings
	- Parking lots
	- Public roads
	  - Moderately or heavily traveled roads if icing is likely
	  - Heavily traveled roads if icing is not likely
	- Passenger railroads

All turbine sites (tower collapse): 1.1 x tip height[1]	- Public use areas - Residences - Office buildings - Public buildings - Parking lots - Public roads - Private roads - Railroads - Sensitive above ground services[2]
All turbine sites (rotor sweep/falling objects): 1.1 x blade length[3]	- Property not owned by wind farm participants[4] - Buildings - Non-building structures - Public and private roads - Railroads - Sensitive above ground services

All of these setbacks were developed to ensure protection of public health and safety. In fact the Morton County Ordinance in some cases is more restrictive than the manufacturers suggestions..

The following describes the suitability of the Morton County Ordinance for projection from ice throw and blade failure. Overall, these setback distances are not meant to be protective of the fact that these issues can occur, rather the infrequent events under which they happen and the odds that an individual would be harmed.

4.1 Ice Throw

In 2007, Garrad Hassan Canada Inc. was commissioned by the Canadian Wind Energy Association (CanWEA) to undertake a probabilistic risk evaluation of the likelihood of ice fragment throw from wind turbines would strike a member of the public. They used a hypothetic 2.0 MW turbine with the same hub height (80 m) as those proposed by Oliver III Wind. They examined meteorological conditions in Ontario, Canada, which are similar to winter environment in North Dakota. Three scenarios were examined – Scenario A House, Scenario B Road and Scenario C Individual. The setback distances they used were consistent or less than those found in the Morton County Ordinance. Their findings are provided in Table 4.

Table 4. Ice Throw Strike Probabilities (Garrad Hassan, 2007)

Scenario A House	Scenario B Road	Scenario C Individual
• $1000\ ft^2$ house • 1000 ft from turbine • 1 ice strike per 62,500 years	• north-south road is situated directly west of a turbine at 650 ft • 100 vehicles at 40 mph • 1 vehicle strike per 100,000 years	• ever-present individual between 65 ft to 1000 ft from turbine • 1 strike in 500 years

The results indicate an extremely low probability that an individual or vehicle would ever be struck. Therefore, setback distances provided in the Morton County Ordinance and PSC Exclusionary Area are more than sufficient to protect public health and safety from risk of ice throw.

4.2 Blade Failure

With respect to turbine failure, the Garrad Hassan report (2007) determined that the risk of a failure of a piece of a blade is 1 in 4,000 turbines per year and that the risk of a full blade failure is 1 in 2,400 turbines a year. They also reported that maximum distance for an entire blade to travel was 150 m (500 feet) and for a blade fragment 500 m (1640 feet).

In 2011, Rogers et al. published a paper titled "*A method for defining wind turbine setback standards*". Their analysis suggests an overall probability of blade failure of approximately 1 chance in 3800 turbines. They report that a blade fragement could be thrown as far as 463 m (1,500 feet). However, they did not conduct an analysis of the probability that someone might actually be struck by such a fragment.

In 2013, MMI Engineering Ltd undertook a study titled "Study and development of a methodology for the estimation of the risk and harm to persons from wind turbines" for the United Kingdom government. They studied a 2.3 MW wind turbine with a hub height of 80 m, the same as that proposed for Oliver III Wind. Through their probabilistic assessment they determined that risk of fatality from wind turbine blade fragment throw is low in comparison to other societal risks. It was roughly equivalent to the risk of fatality from taking two aircraft flights a year.

Given the very low probability of risk of fatality or injury from blade failure the Morton County and PSC Exclusionary Areas are deemed sufficient to protect public health and safety.

5.0 Government Agency Reviews

A number of reviews of potential health effects associated with wind turbines have been written in recent years for governments and governmental agencies (Chatham-Kent Public Health Unit, 2008; Chief Medical Officer of Health Ontario, 2010; Australian Government, National Health and Medical Research Council, 2010; Australian Senate, 2011; Massachusetts Department of Environmental Protection (MassDEP) and Massachusetts Department of Public Health (MassDPH), 2012, South Australia Environmental Protection Agency, 2013).

It is important to recognize that of these reviews, all of which include medical doctors, none classified the self-reported annoyance issues of residents as a pathological medical entity. Overall, governmental health agencies agree that noise from wind turbines is not loud enough to cause hearing impairment and are not causally related to adverse effects, however, they acknowledge that wind turbines can be a source of annoyance and suggest that impacts can be minimized by following the guidelines I have discussed in this report. The following are a number of the international reviews that have been conducted:

- National Health and Medical Research Council in Australia. *Wind Turbines and Health: A Rapid Review of the Evidence*. Canberra, ACT: Commonwealth of Australia (2010). p. 1–11.
- Chief Medical Officer of Health Ontario. *The Potential Health Impact of Wind Turbines*. Chief Medical Officer of Health (CMOH) report. Toronto, ON: Queen's Printer for Ontario (2010). p. 1–14.
- Massachusetts Department of Environmental Protection and Department of Public Health. *Wind Turbine Health Impact Study: Report on Independent Expert Panel*. Department of Environmental Protection and Department of Public Health (2012).
- Merlin T, Newton S, Ellery B, Milverton J, Farah C. *Systematic Review of the Human Health Effects of Wind Farms*. Canberra, ACT: Australia National Health and Medical Research Council (2014).

6.0 Conclusions

Over the past decade there has been considerable research conducted around the world on the potential for wind turbines to adversely impact health. This independent research by university professors and government medical agencies has taken place in many different countries on a variety of models of turbines that have been in the community for a number of years. Based on scientific principles, and the collective findings of over 70 scientific articles, I believe that as proposed the Oliver III Wind Energy Center project is properly sited will not result in adverse health effects in the surrounding communities.

Sincerely,

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