BEFORE
THE OHIO POWER SITING BOARD

In the Matter of the Application of **SENECA WIND, LLC** for a Certificate of Environmental Compatibility and Public Need for a Wind-Powered Electric Generating Facility in Seneca County, Ohio.	)))))	Case No. 18-488-EL-BGN

DIRECT TESTIMONY OF

Dr. Christopher Ollson

on behalf of

Seneca Wind, LLC

August 6, 2019

I. Introduction

Q-1. Please state your name, current title, and business address.

A-1. My name is Christopher Ollson. My business address is 37 Hepworth Crescent, Ancaster, Ontario, Canada.

Q-2. What position do you currently hold?

A-2. I am the sole proprietor of Ollson Environmental Health Management. This consultancy provides expertise on environmental health challenges related to siting of energy projects (i.e., oil and gas, pipelines, gas plants, wind turbines, solar, transmission lines, and energy-from-waste). Clients include a mix of private sector companies and governments at all levels.

Q-3. Please describe your background and qualifications.

A-3. 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 associated with environmental health issues. I have been consulting on environmental health issues for over 20 years. My full curriculum vitae is found in Attachment CAO-1. My formal education includes:

- Doctorate of Philosophy, Environmental Science, Royal Military College of Canada, Kingston, Ontario, Canada, 2003.
- Master of Science, Environmental Science, Royal Military College of Canada, Kingston, Ontario, Canada, 2000.
- Bachelor of Science (Honours), Biology, Queen's University, Kingston, Ontario, Canada, 1995.

In addition to my consulting practice, I hold an appointment of Adjunct Professor in the School of the Environment at the University of Toronto. From 2013 - 2016, I was appointed to the Governing Council, and was Vice-Chair of the Academic Affairs Committee, of the University of Toronto Scarborough. I teach a graduate course at the University of Toronto in Environmental Risk Analysis, and have supervised a number of Doctoral students and Post-Doctoral Fellows.

Q-4. What is your experience with health issues related to wind turbines?

A-4. Approximately half of my current consulting practice on an annual basis is devoted to better understanding the relationship between people, animals and wind energy. For the past decade I have been engaged in research and reviewing the potential health effects that may be associated with living in proximity to wind turbines as part of their preparation of planning and permitting documentation. This led to my development of a research team at my former employer (Intrinsik), which included three Doctoral level staff, one Environmental Physician, and one Doctoral Candidate. These research efforts were first published in a peer-reviewed scientific article entitled:

> 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. Citations: 74

This is the most cited article by other authors in the field. Subsequently, this research team published the following five articles in peer-reviewed scientific journals:

- 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.

Q-5. Have you previously been qualified to provide expert opinion evidence regarding wind turbines and potential health effects?

A-5. Yes. 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.

In addition, from 2014 to 2017, I provided expert advice on wind turbines, health and proper siting requirements for the Vermont Public Services Department. I have also appeared before the Indiana State Senate Energy Committee Meeting on Wind Turbine Siting and twice before the North Dakota State Senate Energy and Natural Resources Committee.

Q-6. Have you previously provided testimony in support of siting energy projects in Ohio or other jurisdictions?

A-6. I have not previously testified before the Ohio Power Siting Board ("OPSB"). However, I have testified and been qualified as an expert at more than a dozen environmental review tribunals, commissions, hearings and court proceedings with respect to potential health concerns in living in proximity to wind turbines. In addition, I have appeared before numerous County Commissions across the United States for hearings on potential changes and development of wind turbine project local ordinances and in support of wind project applications.

Q-7. On whose behalf are you offering testimony?

A-7. I am testifying on behalf of the Applicant in the case, Seneca Wind, LLC ("Applicant" or "Seneca Wind") in support of the Seneca Wind Project.

Q-8. Has this testimony been prepared by you or under your direct supervision?

A-8. Yes.

Q-9. What is the purpose and scope of your testimony?

A-9. My testimony was prepared to evaluate whether or not the Seneca Wind Project ("the Project") will avoid adverse health impacts on the local community and to address

allegations made by the Intervenors that the operation of the Seneca Wind Project would adversely impact their health or quality of life.

Q-10. What documents did you review in preparing your testimony?

A-10. Seneca Wind Farm Application, including relevant updated analyses and assessments;

- Petition for Leave to Intervene of Seneca County Residents;
- Petition for Leave to Intervene of the Board of Education of Seneca East Local School District; and
- Staff Report of Investigation Seneca Wind Farm Case No. 18-0488-EL-BGN; July 3, 2019.

Q-11. In your testimony, will you refer to, or otherwise rely upon, any studies, publications, data or documents produced by persons other than yourself. If so, please cite these sources.

A-11. Included with my testimony is a list of scientific peer-reviewed articles and references to which I refer to or otherwise rely upon to reach my conclusions (Attachment CAO-2).

Q-12. What is your understanding of the proposed Seneca Wind Project?

A-12. The Seneca Wind Project is proposed to be located in Seneca County, Ohio. The project is situated in the areas of Attica, Bloomville and Republic, Ohio. There have been a number of project layouts that have been refined and the final layout reflected in the latest update in May 2019. The latest update includes construction of 77 proposed turbine locations over six potential turbine model layout and design scenarios. An additional 16 alternate locations were also included in both the sound and shadow flicker modeling analysis, although only 77 turbines will be constructed. Four different wind turbine models are being considered for use:

A-13.

Turbine Model	Hub Heights (ft)	Rotor Diameter (ft)	Total Height (ft)	Maximum Proposed Number of Turbines
GE 2.3-116	262 295 308	380	452 485 498	26
GE 2.8-127	374 367	417	582.5 575.5	67 *Limited number possibly used in a few select locations
SG 2.7-129	358	423	569.5	67 (alternative to GE2.8-127)
V 110-2.2	312	361	492.5	10 (alternative to GE2.8-127 or SG 2.7-129)

The sound and shadow flicker analyses indicate that there are 2,902 residences that are located within one mile of the Project. Based on the different wind turbine models potentially being employed, baseline ambient sound levels were identified as 46 dBA (GE turbines at 9 m/s) and 44 dBA (V turbines at 8 m/s). For the purposes of my report I have focused on the 46 dBA baseline sound level.

All residences were found to meet the OPSB sound requirements—the Project's sound modeling results yield the following results:

Participation Status	Closest Turbine ID	Distance to Closest Turbine (ft)	Maximum Predicted Sound Level (dBA)
Non-participating	71	1375	51
Participating	7	767	54

Q-13. In your opinion, are these sound level design standards consistent with guidelines or levels that are protective of public health?

A-14. Yes. The Ohio Administrative Code sets a design goal at 5 dBA over measured baseline, in this case 51 dBA for non-participating homes. This is consistent with other State and

County zoning ordinances in the Midwest that have a 50 dBA design goal for wind projects, these include:

North Dakota

Under the North Dakota Administrative Code (NDAC) Section 69-06-08-01(4):

> *A wind energy conversion facility site must not include a geographic area where, due to operation of the facility, the sound within one hundred feet of an inhabited residence or a community building will exceed fifty dBA. The sound level avoidance area criteria may be waived in writing by the owner of the occupied residence or the community building.*

The North Dakota language is explicit in detailing that the sound levels at the exterior of non-participating homes is 50 dBA. This is also consistent with the proposed design goal of the Seneca Wind Project.

Minnesota

Minnesota also has a no greater than 50 dBA sound limit under the *Minnesota Administrative Rules 7030.0040 Noise Standard* that is applied for wind turbines at the exterior of homes. The applicable level to wind turbines is Noise Area Classification 1 – Nighttime L_{50}: 50. Again this is entirely consistent with the Seneca Wind Project that uses a design goal of 51 dBA L_{eq} (which is same as L_{50}) at the exterior of homes.

Q-14. Does the use of an audible dBA sound standard also ensure protection for low-frequency and infrasound emitted from wind turbines?

A-15. Yes. This is detailed in the infrasound and low frequency noise section of my testimony.

Q-15. What are the shadow flicker design goals for the Project?

A-16. The Project will comply with Ohio's shadow flicker levels set forth in the Ohio Adm.Code 4904-4-09(H)(1), which states that the Project "shall be operated so that shadow flicker levels do not exceed thirty hours per year at any [residential] receptor."

Q-16. In your opinion, are these shadow flicker design standards consistent with guidelines or levels that are protective of public health?

A-17. Yes. As is detailed in my testimony, shadow flicker is not a health concern and the use of a 30 hour limit at non-participating residences is a common, almost universal standard, across the United States to limit the nuisance effect of shadow flicker.

Q-17. Can you provide a summary of your testimony?

A-18. Because the Project will limit the sound level at the exterior of non-participating homes to baseline plus 5 dBA, or 51 dBA and shadow flicker to no more than 30 hours a year, the Project will ensure the protection of neighboring residents.

Q-18. How is your testimony structured?

A-19. First, I will provide an overview of the specific health-related issues raised by particular Intervenors in their Petition to Intervene and by individuals participating in the public hearing. Then through the use of the scientific literature I will address these concerns, including: (1) audible sound (including sleep impacts), (2) infrasound and low frequency noise, (3) self-reported indicators of human health and well-being, and (4) shadow flicker.

II. <u>Alleged Health Impacts</u>

Q-19. Have you reviewed the various petitions to intervene in this matter?

A-20. Yes.

Q-20. Have you reviewed certain comments regarding health impacts raised at the public hearing held July 23, 2019?

A-21. Yes.

Q-21. What health impacts were raised by these individuals?

A-22. The Intervenors and public have raised a number of issues that claim that the use of the 51 dBA design goal, which is consistent with the Ohio Administrative Code, would result in "non-participating residents [being] subjected to the risk of incurring the adverse health effects – loss of sleep, fatigue, headaches, irritability, and the like – typically caused by such continual, excessive wind turbine noise." Local Residents' Pet. to Intervene at p. 7. The Intervenors provide three supporting references to this claim: the World Health Organization ("WHO") Night Noise Guidelines for the Europe (WHO, 2009), the WHO 2018 Environmental Noise Guidelines for the European Region (WHO, 2018), and the self-published book of Dr. Nina Pierpont "Wind Turbine Syndrome" (Pierpont, 2009). *See* Local Residents' Pet. To Intervene at p. 7-9. These references and their applicability will be addressed in my testimony.

The Intervenors go on to take issue with the established Seneca Wind Project baseline of 46 dBA as being too high. The development of this baseline acoustic level is beyond my expertise and is not the subject of my testimony. Instead my testimony assumes a Project design goal of 51 dBA, which was supported in the Staff Report, and comments on its potential to impact human health.

In their Petition to Intervene, the Intervenors raise the issue that a L_{90} sound measurement would be more applicable than the use of the Ohio Administrative Code average sound level or L_{eq}. Pet. To Intervene at p. 8. My testimony will provide comment on this issue to the extent that the scientific literature for investigation of potential health impacts living around wind turbines is almost universally based on a L_{eq} sound measurement.

It is my understanding that concerns were expressed during the local public hearing regarding low frequency noise (LFN) and infrasound that would be emitted from the wind turbines. My testimony provides the state of scientific knowledge on how setting an appropriate audible sound level acts as an appropriate surrogate to ensure protection of health from any exposure to LFN and infrasound.

It is my understanding that concerns have been raised regarding potential impacts from shadow flicker. My testimony will address issues surrounding shadow flicker and health.

I also understand concerns have been expressed by the School Board regarding potential impacts from the wind turbines on schools in the County I will address these concerns in my testimony.

Overall, my general observation is that the health concerns raised by the Intervenors and certain individuals at the local public hearing are not new or unique to the Seneca Wind Project. They are also not supported by the peer-reviewed scientific literature.

III. Literature Review

Q-22. Please describe the methodology you used to select the literature cited in your Testimony.

A-23. I sourced the literature from the following: 1) Scientific peer-reviewed studies published in scientific journals and 2) government agency reports. I place less, and in some cases no, weight on Internet sourced material and self-published material that has not been independently peer-reviewed or published.

Q-23. Please explain what is meant by "peer-reviewed" and why that terminology is important.

A-24. "Peer-reviewed" means that prior to publication the study was evaluated by scientific, academic, or professionals working in the field of health effects and wind turbines. The peer review process is considered a fundamental tenet of quality control in scientific publishing. As with any scientific undertaking it is important that evidence be critically evaluated and reviewed when forming an opinion in a transparent, systematic manner (Knopper and Ollson, 2011). To that end, I place a higher degree of weight on research

that has been published in credible scientific peer-reviewed journals. This is but the first step in the evaluation. Although a paper may have been published, that does not mean that it should not be critically reviewed, especially when considering what the entire body of the scientific field reveals. The second tier or level of evidence that I consider is government agency reports, consulting reports, and primary research. Often these reports are not published in the scientific literature, but can nonetheless be very informative.

IV. Audible, Low Frequency and Infrasound Noise

Q-24. Can you please provide an overview of the primary study you rely on with respect to noise, potential health impacts, and wind turbines?

A-25. In 2014, Health Canada released the findings of their Wind Turbine Noise ("WTN") and Health Study. This is the most comprehensive study of its kind to date and its results will be referenced a number of times in my testimony. Subsequently, Health Canada has released eight (8) peer-reviewed scientific publications with their results. This research will be discussed as appropriate throughout my testimony. The following provides a high-level overview of the study design.

This study was initiated in 2012 and was a partnership between Health Canada and Statistics Canada to understand the potential impacts of wind turbine noise on health and wellbeing of communities in Southern Ontario and Prince Edward Island. A total of 1238 households participated in the study, with an almost 80% response rate of all households within 6 miles (10 km) of projects investigated, making it the largest and most comprehensive study ever undertaken around the world. They published eight peer-reviewed papers from the study, often with Dr. Michaud as the first author.

Households were located between 820 feet (250 m) and 6 mi (10 km) from operational wind turbines. The A-weighted (dBA) sound levels (audible sound/noise) were grouped into 5 dBA increments with the loudest level in the study at the exterior of a home being 46 dBA Leq (highest nighttime level for this study).

Although these levels are lower than the typical Midwestern state standards of 50 dBA at the exterior of non-participating homes, they provide the best insight as to potential health concerns related to those living within audible range of a wind turbine.

In addition, the approach to modeling wind turbine sound used by the Project is more conservative than the approach used by Health Canada. A review of the Health Canada study results (Keith et al., 2016) reveals that there are three main differences between their approach and those commonly used in the United States: ground absorption factor; an uncertainty factor; and receptor (home) height:

- Health Canada presents the modeled sound levels with a standard deviation value of approximately ± 4 dBA at less than 1 km (3280 ft). In the United States the typical modeling approach includes a 2 dBA manufacturer's uncertainty as a +2 dBA to the sound level, which was used by Seneca Wind. Health Canada makes no adjustment; therefore the modeled U.S. sound level is higher by +2 dBA.

- The United States modeling approach, and that used by the Project, employs a ground absorption factor of 0.5 vs. the 0.7 used by Health Canada. Using a lower ground absorption factor number is more conservative and results in a higher sound level predicted at homes of +1 dBA.

- United States modeling is done either at 1.5 meter or 4 meter height receptors. Health Canada uses 4 m that is more conservative than 1.5 m. The use of a 1.5 m receptor height could result in a less conservative sound level than Health Canada of -1 dBA.

The differences in these input parameters would result in a 1-3 dBA higher modeled sound level at homes following the "United States modeling approach," which is employed by the Project, than those reported in the Health Canada study. In other words, the Health Canada reported 46 dBA sound level would be more the equivalent of 47 – 49 dBA at residences as modeled by the Seneca Wind Project.

Q-25. Can you please provide an overview of the scientific literature associated with wind turbine noise and sleep?

A-26. The critical effect from a health perspective in setting any nighttime sound source standard is to ensure that it is protective of sleep. Quality of sleep and sleep perception can be challenging to establish causation through self-reported surveys alone.

In 2006, the Institute of Medicine of the National Academies released the book "*Sleep Disorders and Sleep Deprivation: An Unmet Public Health Problem*" (IOM, 2006). At that time they reported that*:* "It is estimated that 50 to 70 million Americans suffer from a chronic disorder of sleep and wakefulness, hindering daily functioning and adversely affecting health." CITE. In 2006 the population of the United States was 298 million, resulting in an approximately 23% of Americans with sleep disorders. This needs to be considered within any review of the sleep literature with respect to wind turbines in the American context.

The following provides an overview of a number of wind turbine specific sleep studies in relation to nighttime noise levels at exterior of homes:

Michaud et al., 2016. Effects of Wind Turbine Noise on Self-Reported and Objective Measures of Sleep. Sleep, Vol. 39, No. 1 (Health Canada).

This paper presents the peer-reviewed published findings of the Health Canada study (2014) of wind turbine noise on sleep. The sample size was the entire 1,238 participants from the overall study for self-reported sleep quality over the 30 days using the Pittsburgh Sleep Quality Index (PSQI) and additional questions assessing the prevalence of diagnosed sleep disorders and the magnitude of sleep disturbance over the previous year. For the first time, objective measures for sleep latency, sleep efficiency, total sleep time, rate of awakening bouts, and wake duration after sleep were recorded using the wrist worn Actiwatch2® for 654 participants, over a total of 3,772 sleep nights. It is the largest and most comprehensive of its kind ever undertaken for wind turbine noise.

The following excerpt from the paper discusses the 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 importance of this study is that, for the first time, self-reported sleep concerns, Pittsburgh Sleep Quality Index (PSQI – a self-report questionnaire on sleep activity) results, and objective measures of sleep using actigraphy were investigated for wind turbine noise. This was investigated between all respondents in sound level groupings and between the two geographical locations of the provinces of Ontario and PEI.

This study found that: "There was no statistical difference observed in the mean PSQI scores between groups (P = 0.7497) as well as no significant difference between provinces (P = 0.7871) . . . Similarly, when modeling the proportion of respondents with poor sleep (PSQI > 5) in the logistic regression model, no statistical differences between WTN exposure groups (P = 0.4740) or provinces (P = 0.6997) were observed[.]" Moreover, "[t]*he prevalence of reported sleep disturbance was unrelated to wind turbine noise levels.*"

From the conclusions of the paper: "The potential association between WTN levels and sleep quality was assessed over the previous 30 days using the PSQI, the previous year using percentage highly sleep disturbed, together with an assessment of diagnosed sleep disorders. These self-reported measures were considered in addition to several objective measures including total sleep time, sleep onset latency, awakenings, and sleep efficiency. In all cases, in the final analysis there was no consistent pattern observed between any of the self-reported or actigraphy-measured endpoints and WTN levels up to 46 dB(A)."

The Health Canada findings on sleep are consistent with credible previously published peer-reviewed literature in this field.

Bakker et al. 2012. Impact of wind turbine sound on annoyance, self-reported sleep disturbance and psychological distress. Science of The Total Environment, Volume 425, 15 May 2012, Pages 42-51.

Bakker et al., (2012) completed the most compelling research, prior to the Health Canada Study (2014), into wind sound awakenings. This research reported the number or percentage of awakenings with those living in proximity to wind turbines in a rural setting. As can be seen in Table 7 from the Bakker paper, more people in rural environments are awakened by people/animal sound and traffic/mechanical sounds, than by the proximate wind turbines. In this study, people living in close proximity to wind turbines reported being awoken more by people/animal noise (11.7%) and rural traffic/mechanical noise (12.5%), than by turbine noise (6.0%). Sound levels in this study were as high as 54 dBA from wind turbines at the exterior of neighboring homes.

Table 7
Sound sources of sleep disturbance in rural and urban area types, only respondents who did not benefit economically from wind turbines.

Sound source of sleep disturbance	Rural		Urban		Total	
	n	%	n	%	n	%
Not disturbed	196	69.8	288	64.9	484	66.8
Disturbed by people/ animals	33	11.7	64	14.4	97	13.4
Disturbed by traffic/ mechanical sounds	35	12.5	75	16.9	110	15.2
Disturbed by wind turbines	17	6.0	17	3.8	34	4.7
Total	281	100	444	100	725	100

The Health Canada sleep study (Michaud et al., 2016) reviewed and concurred with the Bakker results, as well, finding: "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."

Jalali et al. 2016. Before–after field study of effects of wind turbine noise on polysomnographic sleep parameters. Noise Health; 18:194-205.

The first study to be published on before-after operation effect of wind turbine noise on objectively measured sleep was conducted in 16 participants living within 1.25 mi (2 km) to a five-wind turbine project in Ontario, Canada. The average indoor sound level in the bedrooms was reported as 31 dBA while the wind turbines were operational. For the first

time authors used portable polysomnography (PSG), which is a comprehensive system that objectively monitors people's sleep in their homes.

The authors concluded: "The result of this study based on advanced sleep recording methodology together with extensive noise measurements in an ecologically valid setting cautiously suggests that there are no major changes in the sleep of participants who host new industrial [wind turbines] in their community."

These findings are also consistent with the previous reported studies.

Q-26. What do the published findings reveal regarding sounds emitted by wind turbines and their potential impact on sleep?

A-27. The peer-reviewed scientific weight of evidence reveals that there is no association between exterior wind turbine sound levels from 46 dBA (equivalent to 47-49 dBA using U.S. predictive modeling approaches) to 54 dBA at homes and impact on sleep.

The maximum possible sound level for the Seneca Wind Project non-participants is 51 dBA, and, therefore residents should not experience sleep disturbance from sounds associated with wind turbines.

Q-27. Can you explain what is meant by infrasound and low frequency noise?

A-28. Infrasound is a term 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, at common everyday levels. It is typically measured and reported on the G-weighted scale (dBG). Low frequency noise (LFN), at frequencies between 20 to 200 Hz, can be audible. It is typically measured and reported on the C-weighted scale (dBC) to account for higher-level measurements and peak sound pressure levels.

Q-28. What do the published findings reveal regarding infrasound, low frequency noise, and a concern for health?

A-29. Universally wind turbine sound standards are set using audible dBA levels, as they are in Ohio, and approved based on modeling. Over the past couple of years there have been a limited number of researchers that have speculated that wind turbine infrasound and LFN could potentially be a cause of health impacts or sleep disturbance. The mere presence of

measured LFN and infrasound does not indicate a potential threat to health or an inability for people to sleep. The fact that one can measure infrasound and LFN from wind turbines at either the exterior or interior of a home does not mean that it is at a level that poses a potential health threat. In addition, just because there may be a distinct acoustical signature that allows sound engineers to distinguish between low levels of infrasound or LFN from turbines does not mean that it results in health impacts.

Although wind turbines are a source of LFN and infrasound during operation, these sound pressure levels are not unique to wind turbines. Common natural sources of LFN and infrasound include ocean waves, thunder, and even the wind itself. Anthropogenic sources include road traffic, refrigerators, air conditioners, machinery, and airplanes. Given the growing attention being paid to this issue several recent studies have been published.

Berger et al., 2015. *Health-based Audible Noise Guidelines Account for Infrasound and Low Frequency Noise Produced by Wind Turbines*" in the journal Frontiers in Public Health Vol 3, Art. 31.

The purpose of this paper that I co-authored was to investigate whether typical audible noise-based guidelines for wind turbines account for the protection of human health given the levels of infrasound and LFN typically produced by wind turbines. New field measurements of indoor infrasound and outdoor LFN at locations between 1,312 ft (400 m) and 2,952 (900 m) from the nearest turbine, which were previously underrepresented in the scientific literature, were reported and put into context with existing published works. The analysis showed that indoor infrasound levels were below auditory threshold levels, while LFN levels at generally accepted setback distances were similar to background LFN levels.

The paper discusses two guidelines for exposure to infrasound (dBG), although neither is specific to wind turbine noise. The Queensland Department of Environment and Resource Management's Draft *ECOACCESS Guideline- Assessment of Low Frequency Noise* proposed an interior infrasound limit of 85 dBG (Roberts, 2004). This value was derived based on a 10 dB protection level from the average 95 dBG hearing threshold (Watanabe, 1990) and previous Danish recommendations for infrasound limits (Jakobsen,

2001). The Japanese Handbook on Low Frequency Noise provides an infrasound reference value of 92 dBG at 10 Hz and 1/3 octave bands up to 80 Hz (Kamigawara, 2006). These values were derived from investigations that monitored complaints of mental and physical discomfort from healthy adults exposed to low frequency sounds in a room (Kamigawara, 2006).

These guidelines for infrasound would not be reached in homes situated near the Seneca Wind Power Project. Quite simply, the homes are located too far back from the turbines based on audible 51 dBA sound criteria to have the accompanying infrasound levels exceed these guidelines. In fact, these levels of infrasound are not reached even in close proximity to the wind turbines themselves.

Collectively, these data, in conjunction with previous reports, indicate that levels of infrasound and LFN are not sufficient to induce adverse health effects; therefore health-based audible noise guidelines are suitable for the protection of human health.

Infrasound Measurements Near Wind Turbines and other Sources (Turnbull, 2012).

In 2012, Turnbull *et al*. published a peer-reviewed paper titled *Measurement and Level of Infrasound from Wind Farms and Other Sources* to put this issue into context with other LFN and infrasound sources (Turnbull et al., 2012). The study was conducted in Australia around wind turbines and other sources of infrasound and included the Clements Gap Wind Farm and the Cape Bridgewater Wind Farm. The Clements Gap Wind Farm is comprised of 27 Suzlon S88 2.1 MW wind turbines and the Cape Bridgewater Wind Farm is comprised of 29 Repower MM82 2.0 MW wind turbines. They determined that infrasound from wind turbines reached ambient levels within 656 ft. (200 m) to 1,180 ft. (360 m). The levels were found to be lower than those measured around beaches, gas fired plants, and major roadways. Indeed, humans are regularly exposed to infrasound from several natural and engineered sources at levels exceeding those produced by wind turbines.

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

These findings are consistent with other scientific papers in the field.

Health Canada: Health Canada, 2014; Keith et al., 2016; Michaud et al., 2016.

With respect to low frequency noise (LFN) and infrasound it is important to understand that Health Canada's Wind Turbine Noise study (Health Canada, 2014; Keith et al., 2016; Michaud et al., 2016) also includes consideration of these sound levels and their impact on heath.

Keith et al., 2016 (part of the Health Canada Research): "The simple relationship between A- and C- weighted levels suggests that there is unlikely to be any statistically significant difference between analysis based on either C- or A-weighted data."

Michaud et al., 2016: "In the current study, low-frequency noise was estimated by calculating C-weighted sound pressure levels. No additional benefit was observed in assessing low frequency noise because C- and A-weighted levels were so highly correlated. Depending on how dB(C) was calculated and what range of data was assessed, the correlation between dB(C) and dB(A) ranged from r = 0.84 to r = 0.97."

Because LFN (dBC) and A-weighted (dBA) levels were so highly correlated, Health Canada's conclusions on the absence of direct or indirect health effects for audible wind turbine noise <46 dBA (equivalent of 48-49 dBA) are true also for the noise in the LFN

(dBC) range around the wind turbines they studied. In otherwords, one does not have to conduct additional studies on LFN to determine potential noise health related impacts or sleep disturbance from wind turbines. Therefore, exposure to these frequencies are inherently included in the findings that no sleep disturbance was found in people living with up to 46 dBA audible sound (Michaud et al., 2016).

McCunney et al. (2014), Wind Turbines and Health: A Critical Review of the Scientific Literature.

McCunney et al. (2014), published a study entitled "Wind Turbines and Health: A Critical Review of the Scientific Literature" in the Journal of Environmental and Occupational Medicine. This review came to similar findings of those published by others (e.g., Knopper and Ollson, 2011; MassDEP, 2012; Knopper et al., 2014; Merlin et al., 2014). This review conducted a significant review of infrasound and LFN levels from turbines and potential impact on health. Ultimately finding that: "Components of wind turbine sound, including infrasound and low frequency sound, have not been shown to present unique health risks to people living near wind turbines."

Ministry for the Environment, Climate and Energy of the Federal State of Bade Wuerttemberg in Germany, *"Low-frequency noise including infrasound from wind turbines and other sources"* (MECE, 2016).

In 2016 the Ministry for the Environment, Climate and Energy of the Federal State of Bade Wuerttemberg in Germany reported on their study "*Low-frequency noise including infrasound from wind turbines and other sources*" (MECE, 2016). The objective of the research was to collect field measurement of infrasound and low-frequency noise around six different turbines by different manufacturers ranging in size from 1.8 to 3.2 MW. Measurements were taken at 492 ft (150 m), 984 ft (300 m) and 2,296 ft (700 m) from wind turbines. Measurements of other common sources of infrasound and low frequency noise were also collected for comparative purposes.

This report found that levels of infrasound from wind turbines were similar to that of just the wind in an open field, while there was an increase in low frequency sound. The levels were considerably lower than either being in the interior of a car, near the roadside traffic

or in a home with oil heating. All infrasound levels (< 20 Hz) analyzed in the report were below the perception threshold and international standards.

Overall, the Ministry concluded: "Infrasound and low-frequency noise are an everyday part of our technical and natural environment. Compared with other technical and natural sources, the level of infrasound caused by wind turbines is low. Already at a distance of 150 m, it is well below the human limits of perception. Accordingly, it is even lower at the usual distances from residential areas. Effects on health caused by infrasound below the perception thresholds have not been scientifically proven. Together with the health authorities, we in Baden-Württemberg have come to the conclusion that adverse effects relating to infrasound from wind turbines cannot be expected on the basis of the evidence at hand."

Q-29. What do the published findings reveal regarding infrasound and low frequency noise emitted by wind turbines and their potential impact on health?

A-30. The hypothesis that low frequency noise or infrasound from wind turbines is a causative agent in health effects or sleep disturbance is not supported by the scientific and medical literature. Although infrasound and low frequency noise are emitted from wind turbines and their contribution above background sources can be measured close to wind turbines, the levels are typically within background levels at homes and are well below levels that could induce health impacts. Measurements at other wind farms are similar, if not lower, than natural and anthropogenic sources of infrasound that we are exposed to, and are below international guidelines on infrasound.

Given the setback distances to non-participating residences and modeled sound levels, the international research indicates that the Seneca Wind project will not impact the health or sleep of local residents.

IV. <u>Shadow Flicker</u>

Q-30. Does the scientific literature support the concern that shadow/flicker present health impacts?

A-31. The main health concern that has been raised with shadow/flicker is the potential risk of seizures in those people with photosensitive epilepsy. Photosensitive epilepsy affects

approximately 5% of people with epilepsy where their seizures can be triggered by flashing light. The Epilepsy Society first investigated this issue in the United Kingdom in the late 2000s. They polled their members and determined that no one had experienced an epileptic seizure living or being in proximity to a wind farm from shadow/flicker (Epilepsy Society, 2012).

Following on from this informal polling, two of the United Kingdom's academic experts in epilepsy published scientific research articles in the area. 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 shadow/flicker. Both studies indicate 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). The modern, utility scale wind turbines being proposed Seneca Wind Project at rates well below this threshold and are typically below 20 rpm. Therefore, shadow/flicker from these wind turbines is not at a flash frequency that could trigger seizures and not a concern supported in the peer-review scientific literature.

Further, 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 is nothing in the scientific literature that suggests that shadow flicker should be limited to protect health**.**

Q-31. Can you explain the origin of the 30 hour shadow flicker limit?

A-32. Two of the most comprehensive and widely cited published scientific review articles on this topic are Knopper & Ollson (2011) and McCunney et al. (2014). Both papers review the potential health impacts of shadow flicker and concluded that there are no health

effects associated with this issue living in proximity to wind turbines. Knopper & Ollson (2011) concluded:

> Although shadow flicker from wind turbines is unlikely 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 Ontario it has been common practice to attempt to ensure no more than 30 hours of shadow flicker per annum at any one residence.

Since 2011, there has only been one study conducted that examined the potential for shadow flicker to lead to increased annoyance for those living near wind turbines—the Health Canada published 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). This study, however, was inconclusive as it relates to the relationship between shadow flicker and annoyance.

That said I do believe that limits on shadow flicker are prudent to keep nuisance levels to a minimum at non-participating residences. Similar to Ohio, a number of U.S. Counties and States have adopted various ordinances and rules limiting shadow flicker on non-participating land.

The origins of this 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]." The standard was based on limiting the nuisance of local residents. This level is often cited as being below one that would result in nuisance of local residents. They subsequently codified this formal shadow flicker guideline as part of the *Federal Emission Control Act* (Haugen, 2011). Similar standards to this have been adopted internationally, with modifications, for shadow flicker.

I recognize that the shadow flicker modeled results for Seneca Wind Project indicate that there are 22 non-participants that exceed the 30 hour standard. Although these levels do

not pose a health risk, it is my understanding that the Project will adhere to the 30 hour standard.

IV. Other Potential Health Concerns

Q-32. Please provide an overview of the scientific literature associated with any other health concerns and indicate whether they are likely to manifest due to the operation of the Project.

A-33. There are numerous peer-reviewed studies that have explicitly examined the relationship between levels of wind turbine noise and various self-reported indicators of human health and well-being. These are summarized in the Knopper et al. 2015 and McCunney et al. 2014 literature reviews. These studies have included 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. In general, the peer-reviewed studies 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 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), other than annoyance that was directly related to wind turbine noise for all three datasets (Pedersen et al., 2011).

Michaud et al. 2016a. Exposure to wind turbine noise: Perceptual responses and reported health effects.

The Michaud et al. study provides the results of Health Canada's investigation into perceptual responses (annoyance and quality of life) and those of self-reported health effects by participants from the WTN and Health Study. Only the self-reported health effects results are discussed here. Health Canada developed a final questionnaire that consisted of socio-demographics, modules on community noise and annoyance, self-reported health effects, lifestyle behaviors, and prevalent chronic illness.

Health Canada reported that:

> The results from the current study did not show any statistically significant increase in the self-reported prevalence of chronic pain, asthma, arthritis, high blood pressure, bronchitis, emphysema, chronic obstructive pulmonary disease (COPD), diabetes, heart disease, migraines/headaches, dizziness, or tinnitus in relation to WTN exposure up to 46 dB. In other words, individuals with these conditions were equally distributed among WTN exposure categories.

This resulted in the overall conclusion of the paper that: "Beyond annoyance, results do not support an association between exposure to WTN up to 46 dBA and the evaluated health-related endpoints."

The results of the Health Canada research, which is supported by a decade of research by others, did not find an association between living in proximity to wind turbines and the potential health impacts asserted by the Intervenors to the Seneca Wind Project.

V. <u>Schools and Wind Turbines</u>

Q-33. Do you believe that the Seneca Wind Project will impact the local schools?

A-34. No. I agree with the general premise that high noise environments can negatively impact children's ability to learn. However, it is the level or magnitude of the sound in their learning environment that dictates this response. Therefore, context is required in terms of wind turbine sound levels at schools.

In 2008, Shield & Dockrell published a paper in the Journal of the Acoustical Society of America entitled "*The effects of environmental and classroom noise on the academic attainments of primary school children*". In this paper they describe the typical level of noise a child would experience in a primary school classroom:

> For much of the day in a primary school classroom, young children are exposed to the noise of other children producing "classroom babble" at levels typically of around 65 dBA LAeq, while the typical overall exposure level of a child at primary school has been estimated at around 72 dBA LAeq.

I understand that various schools are located nearby the Seneca Wind project. For the Project, the GE scenario predicts a sound level of 46 dBA, while the GE/SG scenario

resulted in 45 dBA wind turbine sound. These levels are well below that which would be expected in the classroom and on the school grounds.

Under either option, using the tallest hub height of 134 m, the school is anticipated to experience no more than 4:09 of shadow flicker per year. This is well below the Ohio limit of no more than 30 hours a year at a residence, let alone the school.

Given that the average sound level in a primary classroom (without external noise) is 65 dBA, and that the modeled sound level for the Project will not exceed 51 dBA for non-participating properties, the resulting sound would not be audible inside the classroom, even with windows open.

VI. Intervenors' Supporting Evidence regarding Wind Turbines and Health

Q-34. The Intervenors cite the work of Dr. Nina Pierpont on wind turbine syndrome and health concerns in their motion. Can you comment on this work and its applicability to the Seneca Wind Project?

A-35. In 2009, a self-published book entitled Wind Turbine Syndrome: A Report on a Natural Experiment by Dr. Nina Pierpont described "Wind Turbine Syndrome", the term Dr. Pierpont coined for the collection of symptoms reported to her by people residing near wind turbines. The book describes a case series study she conducted involving interviews of a small number of families experiencing self-reported adverse health effects they believed were attributable to living near wind turbines. People living in proximity to wind turbines were interviewed about their health, typically over the phone. Individuals self-reported symptoms generally included sleep disturbance, headache, tinnitus (ringing in the ears), ear pressure, dizziness, vertigo, nausea, visual blurring, tachycardia (rapid heart rate), irritability, problems with concentration and memory and panic episodes. Dr. Pierpont subscribed these symptoms to be associated with proximity to wind turbines, and specifically, to the infrasound emitted by the turbines.

However, since that time there have been a number of reviews and research articles that have sought to examine this claim. In 2012, the State of Massachusetts commissioned a report, Wind Turbine Health Impact Study: Report of Independent Expert Panel, which sought to evaluate these claims:

> Beyond traditional forms of scientific publications, the Panel also took great care to review other non-peer reviewed materials regarding the potential for health effects including information related to "Wind Turbine Syndrome" and provides a rigorous analysis as to whether there is scientific basis for it.

The panel, importantly, concluded that: ***"7. There is no evidence for a set of health effects, from exposure to wind turbines that could be characterized as a 'Wind Turbine Syndrome.'"***

This was consistent with scientific peer-reviewed literature that also could not find a scientific basis to conclude that wind turbine syndrome is an actual phenomenon.

To date, "Wind Turbine Syndrome" theories have not been subjected to rigorous scientific peer review. These studies are not scientifically defensible: they do not contain noise measurements, only measured distances from study participants to the closest turbines; they do not have adequate statistical representation of potential health effects; only limited rationale is provided for the selection of study participants (in some cases people living in proximity to turbines have been excluded from the study); they suffer from a small number of participants and appear to lack of objectivity as authors are also known advocates who oppose wind turbine developments.

Although theories on self-reported health conditions surrounding living in proximity to wind turbines have been put forth, they have not garnered acceptance in the international medical community. For example, a diagnosis of "Wind Turbine Syndrome" is not a recognized medical disease and are not classified in the World Health Organization's International Statistical Classification of Disease and Related Health Problems 11th revision – ICD 11. The ICD is:

> . . .the standard diagnostic tool for epidemiology, health management and clinical purposes. This includes the analysis of the general health situation of population groups. It is used to monitor the incidence and prevalence of diseases and other health problems, proving a picture of the general health situation of countries and populations.

Therefore, at this point it is important to examine the actual peer-reviewed scientific literature on potential health impacts living in proximity to wind turbines. I do not believe

that the self-published Pierpont work, though commonly cited by opposition groups, is not applicable to wind projects, and the Seneca Wind Project in particular.

Q-35. Can you discuss the World Health Organization criteria and its applicability to the Seneca Wind Project?

A-36. The WHO has released two versions of their Environmental Noise Guidelines for the European Region (WHO, 1999 and 2018). The Intervenors suggest that the Seneca Wind Project should adhere to the WHO 1999 night noise criteria of 40 dBA.

There are two WHO sound guidelines that are commonly cited or referred to in development of sound design goals:

(1) WHO 2009, Night Noise Guidelines for Europe: 40 dBA, Lnight 365 night avg.

(2) WHO 2018, Environmental Noise Guidelines for Europe: 45 dBA, Lden 365 night avg.

Although the WHO documents provided sound level guidelines, they are very different metrics from what is being used by the Project and that which is in the Ohio Administrative Code. The following discusses the scientific basis for setting these levels and how they should be used in comparison to wind turbine generated sound:

The WHO 2009 document provides a different metric, dBA $L_{night,outside}$ for their proposed sound guideline of 40 dBA:

> dBA $L_{night,\ outside}$ is the night-time noise indicator (Lnight) of Directive 2002/49/EC of 25 June 2002: the A-weighted long-term average sound level as defined in ISO 1996-2: 1987, determined over all the night periods of a year; in which: the night is eight hours (usually 23.00 – 07.00 local time), a year is a relevant year as regards the emission of sound and an average year as regards the meteorological circumstances, the incident sound is considered, the assessment point is the same as for Lden. See Official Journal of the European Communities, 18.7.2002, for more details.

This is a very important concept given that the WHO $L_{night,\ outside}$ value is for all sound levels averaged outside a home over the course of a year and not for any one given source like a wind turbine. For example, although wind generation would ideally be 365 nights a

year it is not and sound levels on any given night will vary. Thus, although a generally useful guideline to consider for overall sound levels one must be cautious in its application, as it is an apples-to-oranges comparison to wind turbine sound guidelines. The WHO (2009) also recognized that a 40 dBA $L_{night,\ outside}$ guideline would be very difficult to achieve in most communities. Therefore, they set an Interim Target (IT) of 55 dBA $L_{night,\ outside}$.

Similarly the WHO 2018 proposed guideline is based on very low confidence in the literature that they reviewed up until 2014. It does not account for all of the body of literature that has been published in the past five years and is solely based on potential annoyance. It does not conclude that there would be impacts on health of Europeans living in proximity to wind turbines.

To date, the research of wind turbine noise, health and annoyance has employed the use of modeling approaches similar to that of the Applicant's sound modeling scenarios using the ISO 9613-2 approach. My discussion on this peer-reviewed literature supports the Seneca Wind Project design goal of 51 dBA at the exterior of non-participating homes as being protective of sleep and health of local residents. It is also lower than the WHO interim guideline of 55 dBA Lnight, outside.

The sound levels in the reported scientific literature in my testimony are based on either a 1-hour average (Leq) or an annual average (Leq) of wind turbine sound at the exterior of homes. None of this research is focused on metrics like the L_{90} that was suggested for use by the Intervenors. Therefore, it would not be appropriate to use an L_{90} (where 90% of the sound levels exceed this value) for enforcing rules set forth in the Ohio Administrative Code.

II. <u>Conclusion</u>

Q-36. Can you provide your overall conclusion on the Seneca Wind Project?

A-37. 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 operation for numerous years. I believe that the peer-reviewed studies do not support a correlation between wind turbine noise exposure and any health effects, other than some acceptable level of community annoyance at higher noise levels.

I believe that the Seneca Wind Power Project, which conforms to the OPSB standard sound and shadow flicker requirements, is unlikely to cause the health concerns raised by the Intervenors.

Q-37. Does this conclude your testimony?

A-38. Yes, it does, except that I reserve the right to update this testimony to respond to any further testimony in this case.

CERTIFICATE OF SERVICE

I hereby certify that the foregoing Direct Testimony of Dr. Christopher Ollson was served upon the following parties of record via regular or electronic mail this 6th day of August 2019.

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Attachment CAO-1

Curriculum Vitae

OLLSON
Environmental Health Management

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Dr. Ollson is Owner and Senior Environmental Health Scientist at Ollson Environmental Health Management (OEHM). He has 20 years of international consulting experience in environmental health sciences and toxicology. Dr. Ollson has worked across the United States and is well versed in Federal and State environmental legislation. His Canadian experience spans from coast-to-coast-to-coast, having worked in all Provinces and Territories. Throughout his career, Chris has led some of North America's most high profile and controversial multi-disciplinary environmental health assessments.

Dr. Ollson is considered an expert in environmental health issues related to the energy sector. He has led risk assessments and provided risk communication support for wind turbine, solar, hydroelectric, energy-from-waste / waste-to-energy facilities, wind turbine projects, natural gas fired stations, oil sands environmental assessments, refineries, pipelines, and coal power plants. Dr. Ollson has conducted extensive research in potential health and environmental issues surrounding wind turbine facilities and has published numerous peer-reviewed articles and government white papers on the topic.

Chris has spent countless hours in community and stakeholder consultation on behalf of clients. Through proper risk communication they became part of the decision-making process on issues surrounding atmospheric, soil and water contaminant issues. Specific to the wind and solar sector Dr. Ollson has spent 1000s of hours in public consultation, stakeholder engagement, meetings with public health staff and local councils.

Dr. Ollson has testified at more than a dozen environmental review tribunals, commissions, hearings and court proceedings with respect to potential health concerns in living in proximity to wind turbines. With six peer-reviewed scientific journal articles, numerous invited conference presentations and invited university lectures he is considered one of the foremost experts in North America on renewable energy health issues. In recognition of these accomplishments he was the co-recipient of the 2015 Canadian Wind Energy Association R.J. Templin Award. The R.J. Templin Award recognizes an individual or organization that has undertaken scientific, technical, engineering or policy research and development work that has produced results that have served to significantly advance the wind energy industry in Canada.

In addition to his consulting practice, Dr. Ollson maintains an active research program through his Adjunct Assistant Professor appointment at the University of Toronto Scarborough. He teaches graduate level courses in Environmental Risk Assessment and has co-supervised a number of graduate students and Post-Doctoral Fellows. Dr. Ollson's primary research interests are in potential health issues related to the renewable energy sector, waste-to-energy sector and the emerging field of Health Impact Assessment of major projects.

EDUCATION

2003	Ph.D., Environmental Science (Specialization in Risk Assessment), Royal Military College of Canada
2000	M.Sc., Environmental Science, Royal Military College of Canada
1995	B.Sc., (Honours), Biology, Queen's University.
QP_{RA}	Qualified Person for Risk Assessment as defined by the Environmental Protection Act of Ontario (Brownfields Legislation)

AREAS OF SCIENTIFIC EXPERTISE

- Health Impact Assessment
- Environmental Health
- Air Quality Assessment
- Human Health Risk Assessment
- Major Infrastructure Health Assessment
- Energy Sector

EMPLOYMENT HISTORY

2015 – Present **Ollson Environmental Health Management**
Senior Environmental Health Scientist

2011-2015 Intrinsik Environmental Sciences Inc.
Mississauga, Ontario
Vice President, Strategic Development
Senior Environmental Health Scientist

2002 – 2011 Stantec Consulting Ltd (formerly Jacques Whitford Limited)
Practice Leader, Environmental Health Sciences

1997 - 2002 Royal Military College of Canada,
Environmental Sciences Group (ESG)
Senior Environmental Scientist / Risk Assessor

1990 – 2002 Naval Reserves, Department of National Defence
Maritime Surface (MARS) Officer, Lt(N) Ret'd

PROFESSIONAL AFFILIATIONS

- Full Member of the International Association for Impact Assessment (IAIA)
- Full Member of the Society of Practitioners of Health Impact Assessment (SOPHIA)

ACADEMIC EXPERIENCE

2013 – PRESENT **University of Toronto Scarborough, Department of Physical and Environmental Sciences**
Adjunct Professor

2011 – PRESENT
University of Toronto, School of the Environment
Graduate Course Lecturer

2013 - 2016
University of Toronto Scarborough, Member Campus Governing Council, Vice-Chair of the Academic Affairs Committee

2009-2011 **University of Toronto, Scarborough**
Adjunct Lecturer, Physical & Environmental Sciences,

2004 - PRESENT **Royal Military College of Canada**
Adjunct Assistant Professor

AWARDS

Co-recipient of the 2015 Canadian Wind Energy Association R.J. Templin Award. *First awarded in 1985, the R.J. Templin Award recognizes an individual or organization that has undertaken scientific, technical, engineering or policy research and development work that has produced results that have served to significantly advance the wind energy industry in Canada.*

Wind Turbine Peer Reviewed Scientific Publications

Primary Research

Berger, R.G., Ashtiani, P., **Ollson, C.A.**, Whitfield Aslund, M. McCallum, L.C., Leventhall, G. and Knopper, L.D. 2015 Health-based audible noise guidelines account for infrasound and low-frequency noise produced by wind turbines. Front. Public Health 3:31. Citations: 8

McCallum, L., Whitfield Aslund, M., Knopper, L.D., Ferguson, G.M. and **Ollson, C.A.** 2014. An investigation of wind energy and health: quantifying electromagnetic fields around wind turbines in Canada. *Environmental Health* 2014, **13**:9. Citations: 7

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. Citations: 4

Systematic Literature Reviews

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, 19 June 2014. Citations: 22

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. Citations: 86

Published Critique

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. Citations: 5

Hearings, Tribunals and Court Proceedings on Wind Turbines and Associated Transmission Lines

In the following proceedings I testified and was formally qualified as an expert in wind turbines and human health

South Dakota Public Utilities Commission. Crowned Ridge Wind Project. Case EL19-003 (2019)

Diana's Great Idea, LLC, et. al. v. Crazy Mounty Wind, LLC et. al. Cause No. Dv 18-161 Montana Sixth Judicial District Court Park County (2019)

Rivard & Bourque v. Éoliennes de l'Érable S.E.C. Superior Court of Québec. Case No. 415-06-000002-128. (2019)

North Dakota Public Services Commission 2015

Brady Wind Energy Center	NextEra
Brady II Wind Energy Center	NextEra
Oliver III Wind Energy Center	NextEra

Alberta Utilities Commission (AUC)

Proceeding No. 22563, Halkirk 2 Wind Project (2017)
Proceeding No. 3329, Grizzly Bear Creek Wind Project (2016)
Proceeding No. 1955, Bull Creek Wind Project (2013)

Ontario Environmental Review Tribunal

Erickson v. MOE 2011	Suncor
Monture v. MOE 2012	Samsung
Moseley v. MOE 2014	Capstone
Lambton County v. MOE 2015	Suncor
EOCA v MOE 2015	ProWind

Clinton County Planning and Zoning Commission, MO, County Ordinance Changes (2016)

Chowan County and Perquimins County Board of Commissioners hearings for the Timbermill Wind Project (2016)

Queen's Bench of Saskatchewan in McKinnon v. Martin in Red Lily Wind (2010)

Court Proceedings Unrelated to Wind Turbine Projects

John Chart vs. Town of Parma. W.D.N.Y Civil Action No. 6:10-CV-06179, Deposed 2013.

Lockridge and Plain v. Ministry of the Environment and Suncor Energy Products Ltd., 528/10, Ontario Superior Court of Justice, Deposed 2012

Appearances before Government Bodies

North Dakota State Senate and Representative Natural Resources Committee. Study on Wind Energy Conversion Facilities. December 2017.

Indiana State Senate Energy Committee Meeting on Wind Turbine Siting. October 2017.

North Dakota State Senate Energy and Natural Resources Committee. Senate Bill 2313. Exclusion Areas for Wind Energy Conversion Facilities. February 2017.

Vermont Public Services Board. Proposed Rule on Sound from Wind Generation Facilities. December 2016.

Example Appearances before US County Planning & Zoning Commissions and County Boards

Redfield Town Board, New York, Mad River Wind Farm, 2017

Parshville Town Board, New York, North Ridge Wind Farm, 2017

Grant and Dickinson County Planning and Zoning Commissions, Iowa, Upland Prairie Wind Farm, 2017

Codington and Grant County Planning Commissions, Dakota Range Wind, South Dakota, 2017

Deuel County Zoning Board, South Dakota, Crown Ridge Wind Project, 2017

Rush County Board of Zoning Appeals, Indiana, West Forks Wind Project, 2016

Hettinger County Planning and Zoning Commission and County Commission, North Dakota, Brady II Wind Energy Center, 2016

Kingman County Planning and Zoning Commission, Kansas, Kingman Wind Energy Center, 2016

Pratt County Planning and Zoning Commission, Kansas, Ninnescah Wind Energy Center, 2016

Stark County Planning and Zoning Commission and County Commission, North Dakota, Dickinson Wind Energy Center, 2015, 2016

Stark County Planning and Zoning Commission and County Commission, North Dakota, Brady Wind Energy Center, 2015, 2016

Colfax Township Board, Dekalb County, Missouri, Osborn Wind Energy Center, 2016

WashingtonTownship Planning Board, Dekalb County, Missouri, Osborn Wind Energy Center, 2016

Niagara County Board of Health, New York, Lightstation Wind Energy Center, 2015

El Paso Planning Commission and County Commission, Colorado, Golden West Energy Center, 2015

Stony Creek Town Commission, New York, Proposed InvEnergy project, working for the Town Commission, 2011

Wind Project Developers- Worked as Project Health Consultant of Record (Alphabetical)

- APEX, Algonquin Power, Avangrid, BluEarth, Boralex, Capital Power, Capstone, EDF, EDPR, InvEnergy, Longyung Power, NextERA, Niagara Region Wind Corporation, Northland Power, Pattern Energy, Prowind, RES, Samsung, South Canoe Wind, Sprott, Suncor, Veresen, Vermont Public Services Department, WPD

Wind Turbine Conference Proceedings

Whitfield Aslund, M.L., Berger, R.G.; Ashtiani, P.; **Ollson, C.A**.; 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. *Proceedings of the 6th International Conference on Wind Turbine Noise, April 2015, Glasgow, Scotland*.

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', submitted for publication in *Proceedings of the 5th International Conference on Wind Turbine Noise, Denver Colorado 28-30 August 2013*

Knopper, L.D., Whitfield Aslund, M.L., McCallum, L.C., Ollson, C.A. 2013. 'Wind turbine noise: What has the Science Told Us?', submitted for publication in *Proceedings of the 5th International Conference on Wind Turbine Noise, Denver Colorado 28-30 August 2013*

Conference Presentations on Wind Turbines and Health

Ollson, C.A., 2015. Effective Communication Strategies for Addressing Health Concerns. CanWEA annual conference.

Ollson, C.A. 2014. Responding to Health Concerns. CanWEA annual conference.

Ollson, C.A. 2014 Wind Turbines – Do They Cause Health Impacts? CPANs Air & Waste Management Association. Edmonton, Alberta

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Attachment CAO-2

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