Chatham-Kent 2008

The Health Impact of Wind Turbines: A Review of the Current White, Grey, and Published Literature

Chatham-Kent Public Health Unit

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Introduction

On May 5, 2008, during the regular meeting of the Chatham-Kent Municipal Council, the following notice of motion was moved by Councillor Parsons and seconded by Councillor Sulman:

"That Council request a report from the Board of Health identifying any health impacts and recommended mitigation measures for placement of wind turbines in proximity to residences, public facilities that house individuals, and school properties."

The following report addresses the health and safety issues of wind turbines identified within current Canadian, American, European and Australian literature, and correspondence with key health officials from Ontario, Nova Scotia, and Prince Edward Island. The report presents findings and recommendations from impact assessments, research studies, and opinions of individuals and organizations for and against wind power. New information, research studies, and further impact assessments will continue to be generated; despite the utilization of extensive search techniques, documents will have inadvertently been missed. This report will enable the Chatham-Kent Board of Health to make an evidence-based decision regarding the known health impacts of wind turbines from the current literature and will assist the Board of Health with their recommendations to Chatham-Kent Council.

Using key words, two North American accredited university electronic library search engines provided dissertation papers and published research on wind turbines. An internet search revealed numerous white and grey literature. A posting on the Association of Local Public Health Agencies (alPHa) list serve resulted in documents prepared for two of the thirty-six health units in Ontario that received similar requests for health information surrounding wind turbines. Searching continued until saturation was

achieved. Wherever possible, peer reviewed journals were utilized as the first information source in efforts to reduce potential bias.

Wind Power and Health

Wind power has been identified by the United Nations and the World Health Organization as a clean renewable energy source that has no impact on global warming, and no known emissions, waste products, or harmful pollutants.[1,2] One modern wind turbine will save over 4,000 tonnes of carbon dioxide emissions annually.[3] Climate change and global warming are discussed in the news daily and are often cited as the leading cause for major droughts, flooding, and disease crises, that affect the health of populations the world over. Renewable sources of energy are required to ensure the health and safety of future generations. On the opening of the First Session of the Thirty-Ninth Parliament of the Province of Ontario, the Honourable David C. Onley, Lieutenant Governor of Ontario, ensured all Ontarians that the current government was committed to seeing a greener Ontario within its mandate with a goal of reducing emissions that contribute to climate change 6% by 2014 and 50% by 2050.[4]

The Chatham-Kent Official Plan articulates clearly the position of wind farms within the Municipality. Section 2.5.1.1 states,

"It shall be the objective of Chatham-Kent to: encourage the development of wind energy systems for electricity production, as a source of renewable energy for the economic and environmental benefit of Chatham-Kent and the Province of Ontario".[5]

However, any new technology brings questions and concerns regarding health and safety implications that must be assessed, and the impact of such, publicly acknowledged.

Human Health Impacts versus Human Safety

The Public Health Agency of Canada (PHAC) defines health impact as an immediate effect of a program, policy, or process on health. It further defines health outcome as a distant or ultimate effect on health of a program, policy, or process.[6] A health impact assessment seeks to determine if a policy or program positively or negatively affects the health of a population. William Lowrence defines human safety as "a judgement of the acceptability of risk, and risk, in turn, as a measure of the probability and severity of harm to humans" he continues, "a thing is safe if its risks are judged to be acceptable".[7] Driving a car is an example of an acceptable risk that most individuals experience on a daily basis.

The Workplace Safety and Insurance Board of Ontario define a health hazard as something that results in an injury, illness, or disease. The agency specifies five types of health hazards: chemical agents in the forms of solids, liquids, or gases; physical agents that are forms of energy or force; biological agents including microorganisms in plant, animal, or human tissue; ergonomic hazards; and stress hazards.[8] Health outcomes result from exposure over time; safety concerns usually result from a specific incident. This review attempts to identify the impact of wind turbines on both human health and human safety. Despite extensive searching of the current literature, limited information is available on health concerns relating to wind turbines. It is premature to assume that the limited research available is indicative of the recent influx of wind power to North America; for decades, wind turbines have existed throughout the world with stringent procedures ensuring adherence to established safety regulations. Potential health and safety issues identified and recommended for scrutiny within the impact assessments reviewed include:

- Turbine blade and structural failure
- Icing issues in northern climates
- Sound emissions and noise concerns
- Shadow flicker
- Construction injuries

Aesthetic issues, wildlife concerns, flora and fauna impact, and communication and aviation navigation issues are well documented but beyond the scope and purpose of this review.

Turbine Blade and Structural Failure

It is estimated that 68,000 wind turbines have been installed worldwide over the last 25 years. Cape Wind, Prince Edward Island, opened in 2001 doubling the number of wind turbines by 2004 and now supplies 6% of the province's power.[9] Nova Scotia's first wind farm opened in 2005 at Pubnico Point.[10] To date, there is no recorded evidence of injury to the public caused by a wind turbine.[11] Modern wind turbines must meet strict international engineering standards, and documented injuries to construction crews occurring only when construction and operating instructions were not adhered to.[12,13] In Ontario, four documented turbine failure issues were found within the literature, all due to lightening strikes requiring the turbine to be shut down for repairs.[14] In 1945, the first commercial wind turbine threw an 8-ton blade 225 meters.[15] Today, wind turbine safety standards meet wind strengths equivalent to hurricane forces.[16] The current Canadian Wind Energy Association's minimum setback requirement for wind turbines is one turbine

blade length plus 10 metres.[17] The research supports lightning strikes as posing the greatest potential for blade or turbine breakage. To date, no injuries or fatalities have occurred in North America due to blade or turbine breakage and/or collapse, or with fragments and pieces found between 100-200 meters from the turbines.[18] The American Wind Energy Association identifies the leading causes of blade failure as vandalism, improper assembly, or exceeding design limits.[19]

The current Chatham-Kent minimum wind turbine setback requirement of 600 metres from any residential or institutional zone, which would include schools, provides ample setback in the unlikely event of a turbine failure. In May 2007, Garrad Hassan Canada released an independent report on *Recommendations for Risk Assessments of Ice Throw and Blade Failure in Ontario*. Ontario wind turbines now receive certification through Statements of Compliance and a Type Certification including a Statement of Compliance for Design Assessment. Turbine failure has decreased dramatically with the introduction of International Electrotechnical Commission standards and continue to be caused mainly by human interference, lightening strikes, or manufacturing defects.[20] The 74 known European turbine failures since 2000, have thrown whole blades up to 150 meters and blade pieces up to 500 meters; as indicated previously, no injuries have been documented in Ontario because of a wind turbine failure.[21]

Icing Issues in Northern Climates

Compared to the rest of Canada, Chatham-Kent enjoys a relatively mild climate. However, weather history demonstrates that from October through to April there are days when the average daily temperature can drop below freezing.[22] Potential injuries resulting from ice build up on wind turbines occurs two different ways, ice throw during turbine operation or ice shed when the turbine is off or idling. [23,24,25] For human injuries to result from wind turbine ice throw, several conditions must exist

simultaneously:

- a sustained weather condition conducive to icing,
- the ice dislodges from the turbine or turbine blade,
- ice pieces are large enough to remain intact through the air,
- the ice travels in a particular direction past setback guidelines, and
- someone is in the path of the ice as it lands.[26]

Ontario Hydro monitored its first wind turbine (Huron County Wind Farm) during the first six years of operation. Ice throw occurred thirteen times, with the furthest ice fragment found less than 100 m from the turbine.[27] Tammelin and Seifert investigated the introduction of wind turbines in the Northern Austrian Alps to determine power losses resulting from ice build-up on the rotor blades. While not investigating safety impacts, they recommend a setback distance of turbine height plus rotor diameter wherever the potential of ice throw occurs and the wind turbine is in proximity to buildings, resorts, roads, or ship routes.[28]

Computer modelling was used to estimate the number of potential residential, vehicle, and person ice strikes within a typical wind farm environment in Southern Ontario. With a setback distance of 300 meters for buildings, 200 for vehicles, and 300 for individuals on the ground, the potential number of ice strikes to buildings is 1/500,000 years, vehicles 1/260,000 years, and 1/137,500,000 years for individuals on the ground.[29] The minimum setback regulation in Chatham–Kent is 250 meters from an on-site residential dwelling and 600 meters from residential or institutional zones. This distance is within the generally accepted safety zones and concurs with safe levels of incident probability.

AMEC Earth & Environmental released an environmental assessment in April 2008. The Public Health Department of Prince Edward Island provided the assessment to

Chatham-Kent Public Health despite its pending national public availability.[30] The assessment concurs with data and impact assessments released previously, stipulating that while ice throw is a normal operating process and likely to occur, setbacks of greater than 400 meters provide ample distance in the event of an icing incident in PEI's climate. The impact of turbine icing is greatest for construction workers when the turbine is at rest and not rotating. AMEC approaches the concerns generated from wind turbine icing by recommending mandatory icing training of all construction workers, maintenance and enforcement of setback by-laws, and signage of the potential for icing.[31] Illinois Institute Department for Rural Affairs' Wind Energy Handbook recommends placing tourist information kiosks far enough away from the turbine to prevent a potential hazard from falling ice and encourages adherence to local set back by-laws.[32] Impact assessments concur that ice shedding is of greatest impact during construction and subsequently to the operators of the wind turbines in the event individuals are in the way of falling ice.

Sound and Noise Concerns

Wind turbines produce noise from two distinct sources; the sound of rotor blades as they rotate (aerodynamic effect) in the wind and the motor noise from within the turbine unit itself (mechanical operations). The sound wind turbines emit is described as audible or as infrasound, that which is inaudible to the human ear. The health impact of the noise created by wind turbines has been studied and debated for decades with no definitive evidence supporting harm to the human ear. [33,34,35,36.37.38] It is unrealistic to expect any type of machinery to be noiseless; the community does not demand this from other administrative, industrial, commercial or farming operations. Although noise tolerance is very subjective, care

should be taken to ensure a reasonable noise level exists in relation to normally occurring sounds within the environment.

The Ontario Ministry of the Environment defines noise simply as “unwanted sound”.[39] Noise is measured in decibels (dB), however, environmental noise is adjusted to include the sensitivity of the human ear and is measured in dB(A). The audible sound created by a wind turbine, measured at 350 meters, is approximately 35-45 dB(A). In comparison, rural night-time background noise is 20-40 dB(A), a jet airplane at 250 meters is 105 dB(A), and an urban residential environment is 58-62 dB(A). Wind on its own, as it interacts with the environment, produces levels up to 35 dB(A).[40] The Ministry of the Environment has published technical guidelines for the protection of the environment; prior to construction, wind turbines must receive a Certificate of Approval (Air) that includes sound impacts and their effect on the environment.[41] Again, these fall well within Chatham-Kent setback limits.

Modern wind turbine construction has drastically decreased the noise complaints that resulted from the thumping sound created by a downwind rotor placement.[42,43,44,45] The Canadian Wind Association and the Ministry of the Environment indicate that current turbine technology requires a setback placement of at least 250 meters to meet separation distances for noise.[47,48] While noise and sound can be annoying, the audible noise created by a wind turbine, constructed at the approved setback distance does not pose a health impact concern. A wind turbine setback at 750 meters emits noise comparable to a kitchen refrigerator.[49,50,51] Greenpeace, in the September 2006 report *Global Wind Energy Outlook*, advise that wind turbine noise is comparatively lower than road traffic, trains, construction activities, and industrial noise.[52]

Howe Gastmeier Chapnik Limited (2007) recommends several best practice guidelines with respect to wind turbine sound by, identifying the potential receptors of turbine noise, acknowledging the noise generated (wind turbines are not silent), following

established setbacks, acknowledging the impact of ambient sound, and dispelling the rumours regarding infrasound which have not been supported by research.[53]

Inaudible noise, also known as infrasound is described as noise generated that humans cannot hear.[54,55,56] Early wind turbines, those installed in the 1980s, were *downwind* models meaning the wind had to pass by the tower before reaching the blades, subsequently creating a low frequency repetitive or constant thumping that created concerns and complaints from individuals located in close proximity to early wind farms.[57] In 2006, Howe Gastmeier Chapnik engineering completed an independent study on infrasound associated with Canadian wind farms. [58] This study determined that wind farms do generate infrasound however, it is not at a level perceptible to the human ear. Studies around the world have also indicated that infrasound generated by wind turbines is not known to be harmful to human health. [59,60,61,62,63]

Huron County Health Unit completed an assessment of human health impacts from wind turbines in 2006. Noise was the only issue identified as requiring complete assessment and modeling prior to wind farm development.[64] The Kingston, Frontenac, Lennox & Addington Health Unit provided a summary of the information presented to the local Board of Health, municipal government, and community stakeholders, concluding that current evidence failed to demonstrate a health concern associated with wind turbines and would be taking no further action at this time.[65] Even noise that falls within known safety limits is subjective to the recipient and will be received and subsequently perceived positively or negatively. However, noise is one of the few health issues surrounding wind turbines that can be measured and has guidelines that must be adhered to.

Shadow Flicker

Shadow flicker occurs when the sun is located behind a wind turbine casting a shadow that appears to flick on and off as the wind turbine blades rotate.[66] Modern wind turbines rotate at a frequency between 1 and 1.75 hertz. Atlantic Canadian turbines rotation frequencies range from .45 to 1.61Hz. Shadow flicker from all causes, has been demonstrated to negatively affect about 5% of individuals who suffer from epilepsy however, the frequency known to affect individuals with epilepsy is above 2.5 to 3 hertz.[67,68] The frequency of wind turbines is well below the current known documented threshold for triggering epilepsy symptoms.

Jones Consulting Group, (2007) in the planning study completed for Essex County recommended a limit of 30 hours per calendar year of shadow flicker exposure in any one location.[69] Pheonix Engineering released a shadow flicker assessment on the Enbridge Ontario Wind Farm (Bruce County) housing 110 turbines with 336 residences affected by shadow flicker. Only one third of houses were affected by shadow flicker, 5% experienced more than 10 hours per year with the maximum exposure of 21.5 hours per year.[70] Government standards do not exist for shadow flicker caused by wind turbines however, best practices from the available research, and usage history in Europe and the United States, have determined shadow flicker not to be a health concern when setbacks are enforced.[71,72,73] Chatham-Kent setback limits are consistent with current best practice recommendations.

Construction Injuries

A wind farm development is a large construction site that must comply with Canadian occupational health and safety guidelines.[74] Few documents were found addressing construction hazards or

injuries occurring during building and/or maintenance of wind turbines. Strict adherence to construction guidelines and occupational health and safety laws will decrease the potential impacts to health and safety of construction crews. The few construction injuries identified during this search were caused by human error, failure to adhere to required safety measures, and lack or misuse of protection equipment.[75,76,77] A recent settlement awarded against an employer following the death of a worker was determined to be caused by the company's failure to adhere to known safety regulations.[78] This is consistent with all other construction project guidelines.

Concerns Presented by Those Opposed to Wind Power

In February 2008, Chatham-Kent Municipal Council received a package of documents titled *Wind Energy and Human Health Research Brief Volume 1, 2, and 3.*[79,80,81] The volumes consist of numerous entries from curriculum vitas to newspaper articles. Nina Pierpont, writes several of the articles. The literature search utilized by Chatham-Kent Public Health for the Chatham-Kent report, revealed no articles or research papers by Nina Pierpont published in scientific or peer reviewed journals. Several of the studies Dr. Pierpont has conducted are case studies, meaning they are a documentation of an individual's account of a situation or experience. One cannot discount the information, yet it is prudent that generalizations from such limited data are avoided. Several of the articles, all of Volume 3, have nothing to do with wind power or the health effects of wind farms and the intent of these articles remains unclear.

The main opposition concerns presented in the documentation appear to be noise and shadow flicker's potential impact on epilepsy. The evidence on shadow flicker does not support a concern. As noted previously, wind turbines in Canada do not rotate at a speed high enough to trigger epileptic seizures.[82] Noise remains a subjective issue; when setback guidelines are adhered to, the resulting noise impact is minimal. A survey conducted on public attitudes toward wind farms concluded that the majority of

individuals are supportive of wind power as long as the turbines were not in their neighbourhood. [83]

Recommendations

The following table lists the discussed health and safety issues and suggested mitigation activities. It provides recommendations one would expect from any construction project of this magnitude.

Health & Safety Issue	Suggested Mitigation Activities
Structural Failure • blade failure • turbine failure	Ensure design and construction activities are completed by a known, reputable manufacturer and builder Ensure and enforce adherence to Chatham-Kent municipal setbacks – including visitor information centres Turbine design must be equipped with lightening protection systems Turbine design adheres to navigational regulations Shut-down occurs during high wind episodes Quality assurance protocols are within the projects safety plan Fencing at turbine base prevents access and potential vandalism
Icing Issues • ice drop • ice throw	Ensure and enforce adherence to Chatham-Kent municipal setbacks – including visitor information centres Education of construction crew and maintenance staff regarding icing potential, policies and procedures (shut-down and system reactivation) Signage/warning flag or other potentially proven system available in areas where icing potential exists Ensure automatic shut-off in times of icing is a design

	feature of turbine Obtain a management plan for icing emergency
Noise Concerns • Construction noise • Blasting, grading, materials delivery • Operational noise	Ensure and enforce adherence to Chatham-Kent municipal setbacks Construction occurs during times of least disruption to neighbouring lands – day time Landscape screening is preserved or designed after installation of wind turbines to decrease sound impact to neighbouring land Complaint resolution procedures are in place, documented, addressed, and resolved Sound assessment by an acoustical consultant is obtained on a need basis
Shadow Flicker • Low angle sunlight	Landscape screening is preserved or designed after installation of wind turbine to decrease flicker impact to neighbouring land Window treatments as required for neighbouring lands
Construction • Workplace injuries • Heavy Equipment • Local infrastructure to support turbine (roads, site)	No public on site during construction phase Fencing and security access during construction Minimize impacts on other land uses Roads not originally designed to handle weight during construction assessed prior to construction Safety plans are posted and accessible during construction

Conclusion

Wind power has been in use around the world for decades with very little human impact. Research occurs when issues create enough interest or concern to compel researchers

and scientists into study. Governments fund research but often on a need to know basis. Stakeholders from community groups to turbine manufacturers, rely on expert opinions both for and against wind power, potentially allowing bias to enter the equation.

This document presents the current available white, grey, and published literature on the health effects of wind turbines. Despite copious literature from experts in government, manufacturers of wind turbines, and support groups both for and against wind power, very little scientific evidence exists on the health effects of wind turbines.

This paper concludes and concurs with the original quote from Chatham-Kent's Acting Medical Officer of Health, Dr. David Colby,

> *"In summary, as long as the Ministry of Environment Guidelines for location criteria of wind farms are followed, it is my opinion that there will be negligible adverse health impacts on Chatham-Kent citizens. Although opposition to wind farms on aesthetic grounds is a legitimate point of view, opposition to wind farms on the basis of potential adverse health consequences is not justified by the evidence."*

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