

The Real Truth About Wind Energy



A Literature Review on Wind Turbines in Ontario

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List of Abbreviations

AECL.....	Atomic Energy of Canada Limited
CMA.....	Canadian Medical Association
DOE.....	Department of Energy
dB.....	Decibel
dBA.....	A-weighted decibels
EIA.....	U.S Energy Information Administration
EMF.....	Electro Magnetic Field
EREC.....	Energy Efficiency and Renewable Energy Clearinghouse
EWEA.....	European Wind Energy Association
GWEC.....	Global Wind Energy Council
Hz.....	Hertz
IESO.....	Independent Electricity Systems Operator
KW.....	Kilowatt
MOE.....	Ministry of the Environment
MW.....	Megawatt
MWh.....	Megawatt Hours
POST	Parliamentary Office of Science and Technology
RSPB.....	The Royal Society for Protection of Birds

Foreword

Sierra Club Canada has, for many years, championed the cause of renewable energy with the goals of protecting Canadians from the dangerous health effects of hydrocarbons; protecting our environment from climate changing greenhouse gas emissions; and creating a sustainable economy. Toward these goals, Sierra Club Canada has supported the Ontario Green Energy Act and the resulting investment in the wind industry in Ontario and Canada. The Green Energy Act provides a springboard for the development of renewable energy through investment in small and large-scale projects, helping Ontario to move away from dangerous fossil fuels such as coal and oil.

Recently in Ontario, there has been backlash and opposition to wind power. As a leading Canadian environmental organization, Sierra Club Canada sees this reaction as an indication of the need to further evaluate the safety and value of wind turbines, wind farms and the wind industry in general. **After a thorough review of the science we are confident in saying there is no evidence of significant health effects** that should prevent the further development and implementation of wind turbines, wind farms and wind energy. In fact, the further development of wind energy as a growing portion of our energy supply will reduce direct carbon emissions, improve the quality of the air we breathe, and generally improve the health and well-being of Canadians, our families and the environment in which we live.

With a full review of available data, including that referenced by wind opposition groups, Sierra Club Canada adds its voice to the overwhelming majority of governmental, non-governmental, scientific, and environmental groups in saying that **a link between well-sited wind turbines and health concerns is unfounded.** After a review of the pertinent information we hope that Ontario, indeed all Canadian municipalities and citizens, can embrace wind power and the role it will play in a clean, safe, sustainable future.

A Literature Review on Wind Turbines in Ontario

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Introduction

In addressing wind power as a source of renewable energy a great many questions have been raised and worries have surfaced. In the hopes of clarifying misconceptions and addressing the many questions posed, this document reviews available literature addressing wind turbines, the sound produced and any health effects associated with them. Publications, journal articles and various studies have been reviewed and summarized to give an impression of wind as a part of the renewable energy sector in comparison with traditional electricity production.

This literature review approaches questions of the wind industry on a large scale analyzing available studies which look at all aspects of the industry. This review cannot and does not address specific wind turbines, wind farms or wind installations, nor does it address individual complaints. Instead it is a review of the available scientific knowledge discussing the viability, safety and environmental impact of wind power. As scientific study is ongoing and constantly advancing, so too will this document. As new information is found and brought to our attention it will be added to this document in the hopes of maintaining an up to date view of the wind industry.

Wind Power

While it is not exactly known when wind first began to be used as a source of power, it is likely that some form of windmill was used in Japan and China 3000 years ago (Wizelius, 2007, p.7). The first wind mill to be well documented had a vertical axis, and was located in Persia, dating to 947 AD (Wizelius, 2007, p.7). Horizontal axis wind mills were built in Europe by the later part of the 12th century (Wizelius, 2007, p.7). Windmills were one of the dominant forms of power in Europe until the finish of the 19th century, with the number of windmills peaking in the mid-19th century with wind mills numbering 9000 in the Netherlands, 18,000 in Germany, 8000 in England, 3000 in Denmark and 20,000 in France (Wizelius, 2007, p.9). Early mills provided significant mechanical energy which was used in a variety of industries from flourmills and water pumps to lumber mills and the processing of various foodstuffs, spices and grains.

Wind power has since developed in its efficiency and its ability to produce electricity, the form of energy we most commonly associate with wind turbines today. Windmills of all sorts use the energy of wind and the principles of aerodynamics to produce energy in many forms. Modern turbines add the use of a generator to produce electricity. In 1892 the first wind turbine used to produce electric power was build in Denmark by Paul la Cour (Wizelius, 2007, p.15). Modern wind turbines can be designed and installed in multiple ways. Horizontal or vertical axis, facing into or away from the wind, the number and type of blades, and the construction materials, all aspects are variable (France Énergie Éolienne). In Ontario for the sake of efficiency, and life cycle, as well as human and environmental impacts, most wind turbines are three bladed horizontal turbines placed atop a tower of 80-120m, facing into the wind.

The familiar windmill has evolved, and in our age of growing energy consumption, is becoming an increasingly common feature, appearing on hilltops, across plains, and on the coasts, shores and banks of oceans, lakes and rivers. New technologies are allowing the installation of wind turbines at increasingly greater distances off shore.

For a detailed description on the functioning of a modern wind turbine, or to get a step-by-step guide to the processes behind the installation of wind turbines and the building of wind farms, please read the Ontario Land Owners Guide released by the Ontario Sustainable Energy Association. For any landowners who are interested in leasing land for wind energy, this document is highly recommended (Gipe et al., 2005).

Energy Consumption and Emissions in Canada

Anthropogenic climate change is now a well documented phenomenon. As stated in The Stern Review “an overwhelming body of scientific evidence indicates that the Earth’s climate is rapidly changing, predominantly as a result of increases in greenhouse gases caused by human activities” (Stern, 2006, p. 4). This view has been substantiated in multiple documents, and is supported by many organizations. The effects of climate change will be disproportionate in countries at Northern latitudes such as Canada, with Arctic regions being most impacted. It has already been documented that average annual temperatures for Canada as a whole have increased 1.4°C between 1948 and 2007, with some Arctic regions experiencing a 2.1°C increase in annual temperature during this time (Statistics Canada, 2009). 70% of greenhouse gas emissions are the result of energy generation in North America and Europe since 1850 (Stern, 2006, pp.193).

In 2000, per capita greenhouse gas emissions in Canada were 22.1 tons CO₂ equivalent (Baumert et al., 2005, p.21). To put this in perspective 1 kg of CO₂ occupies a volume of 0.53 cubic meters (FieldCleggBradleyStudios et al., [No date]). Driving a medium sized car 5,000 km results in 1 tonne of CO₂ emissions (Statistics Canada, 2009). This ranks Canada as the seventh worst greenhouse gas emitter in the Organization for Economic Co-operation and Development following Qatar, United Arab Emirates, Kuwait, Australia, Bahrain and the United States (Baumert et al., 2005, p.21). Although home to only 0.5% of the world’s population, Canada is responsible for 2% of world wide greenhouse gas emissions (Statistics Canada, 2009). Correspondingly, Canada has one of the highest rates of per capita energy consumption in the world, sitting at 17,030.83kWh in 2008 (The World Bank Group, 2011).

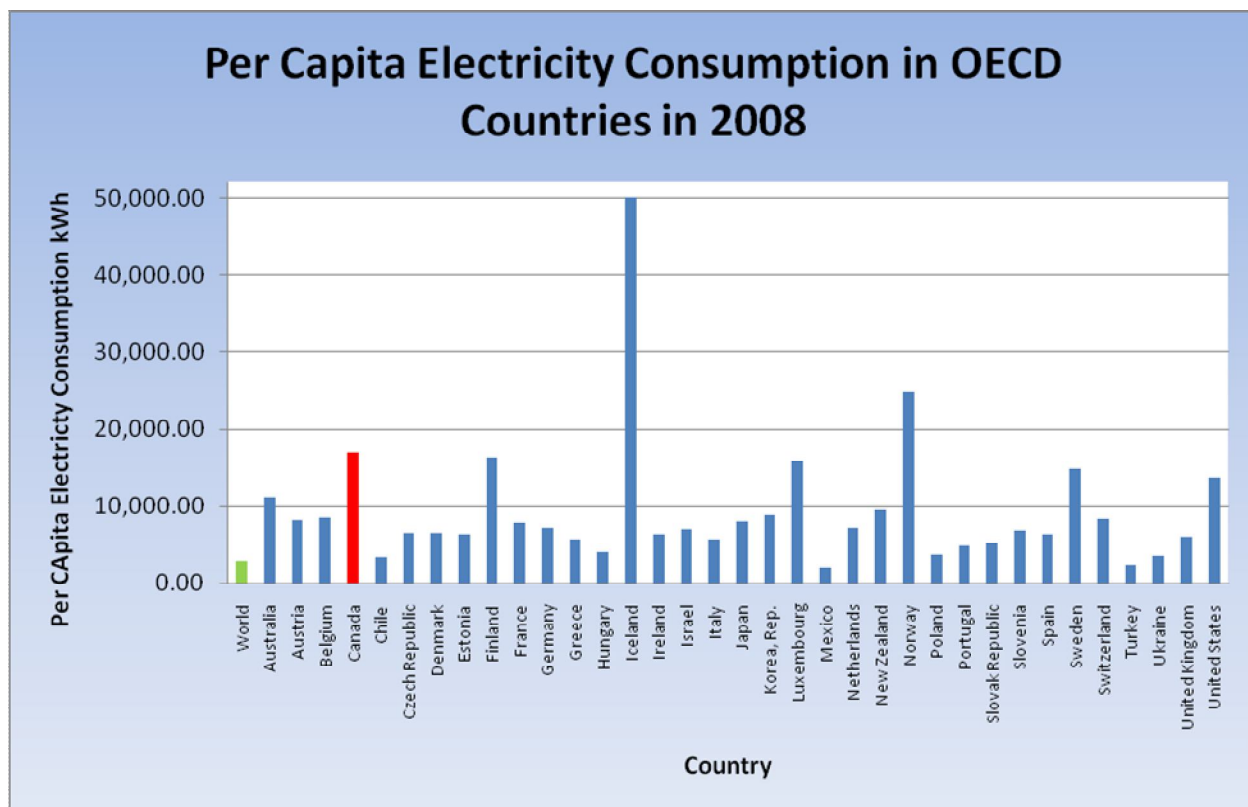


Figure 1: Per Capita Electricity Consumption in OECD Countries 2008 Information from (The World Bank Group, 2011)

In 2010, the majority of electricity produced in Ontario came from nuclear, followed by hydro, gas, and coal, with wind and other generation types making up the balance (IESO, 2011).

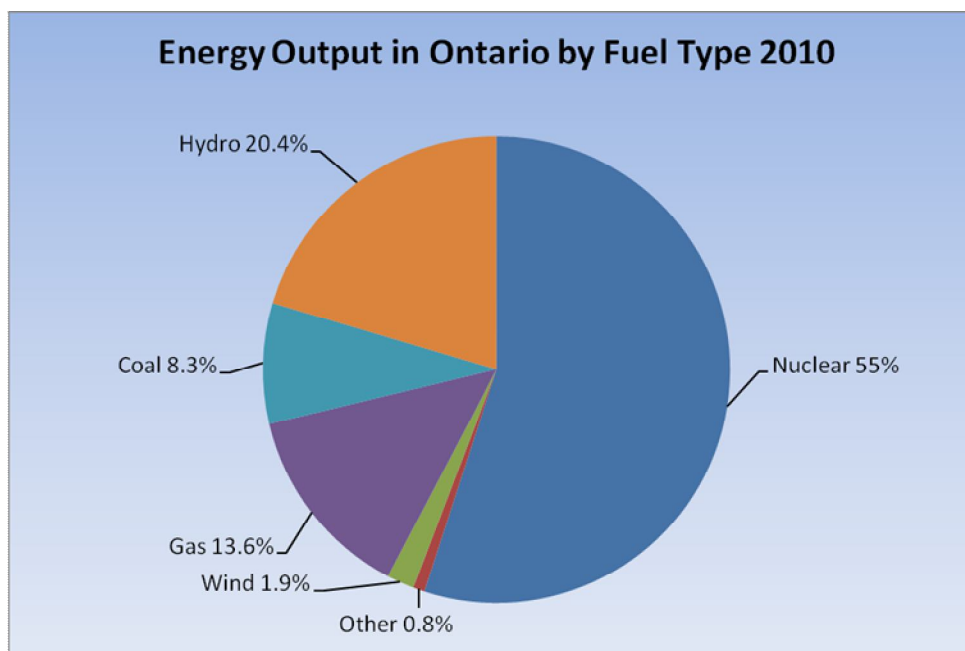


Figure 2: Energy Output in Ontario by Fuel Type Information from (IESO, 2011)

Renewable energy is one solution to a dependence on fossil fuels, and a corresponding reduction in greenhouse gas emissions. Renewable energy is typically defined as electricity generated from wind, biomass, solar, hydro, geothermal and marine power. Wind power is an example of a renewable generation technique with tremendous potential. There are no direct greenhouse gas emissions from the generation of electricity from wind turbines, and every 1 MWh of electricity generated by a wind turbine equates to a reduction of 0.8-0.9 t in greenhouse gas emissions when compared to a power plant producing electricity from either coal or diesel (Statistics Canada, 2009).

When evaluating the total emissions from electricity generation technology, it can be seen that the emissions from wind turbines are extremely low when compared to other methods of generation (Jacobsen, 2009, p.154). The comparison shown in Table 1 takes a holistic approach to the emissions associated with different forms of electricity generation. This analysis takes into account direct life cycle emissions, mining emissions, emissions associated with accidents, war and terror, as well as “opportunity-cost emissions” (Jacobsen, 2009, p.154). This more complete accounting analyses even the planning, approval, construction retrofit, and upgrades of different energy technologies and all associated delays (Jacobsen, 2009,p.153-160).

Table 1: Total eqCO₂ Emissions from Various Electricity Generation Technologies (Jacobsen, 2009, p.154)

<u>Technology</u>	<u>Total Emissions in g CO₂e/kWh¹</u>
Solar PV	15-59
CSP	8.5-11.3
Wind	2.8-7.4
Geothermal	16.1-61
Hydroelectric	48-71
Wave	41.7-62.7
Tidal	34-55
Nuclear	68-180.1
Coal-CCS	307.8-571

It is typically expected that the life span of a wind turbine will be between twenty and thirty years (Crawford, 2009, p.2655). The major structural components, for example the base and the tower, can potentially last for many years beyond this range, while moving parts may require more frequent replacement (Crawford, 2009, p.2655). A study on wind turbines by Crawford has shown that “The life cycle energy requirements were shown to be offset by the energy produced within the first 12 months of operation” (Crawford, 2009, p.2653).

Current Regulations

In order to understand the debate behind wind turbines today we must first evaluate the standards presently in place. This evaluation will focus on Ontario, as a great deal of investment is being put into wind in this province. **The strictest standards in North America are already in place in Ontario for the protection of citizens from any potential harm due to wind turbines (MOE, 2011).** Most of these regulations are in the form of specific setbacks (the distance a wind turbine must be from homes, roads etc) and noise thresholds. These standards apply to any turbine over 50 kW (industrial scale wind turbines) and are as follows:

- A 550 metre setback from any building used by people (Ontario, Environmental Protection Act, 359/09).
- A setback distance equal to the height of the tower from any properties not involved in the project (unless there are no land use concerns, in which case it can be reduced to the length of the blades of the windmill) (Ontario, Environmental Protection Act, 359/09).
- A setback of 10 metres plus the length of the blades of the wind turbine must be allowed from the right of way of roads and railways (Ontario, Environmental Protection Act, 59/09).

These regulations were put in place with the intention of eliminating any disturbing noise from wind turbines by keeping sound levels below 40dBA in all nearby residences. They are also designed to provide adequate distance to avoid any damage or injury due to malfunction, regular maintenance or blade icing (Copes et al.).

Feed-in-Tariff

Much has been said of the Feed-in-Tariff program in Ontario. This is a program modeled on international feed-in-tariffs used to encourage the growth of the renewable energy sector. In understanding the debate surrounding the wind industry one must understand the FIT program as well. This report does not evaluate the FIT program but simply outlines its function. The FIT program is actually broken down into two programs: the FIT program and the microFIT program.

The FIT program is applied to commercial sized installations (greater than 10kW) while the microFIT program is applied to individual or community owned installations (less than 10kW). Essentially both programs provide the same function: guaranteeing a set price for electricity produced using renewable methods. Both programs have set prices depending on the type of renewable energy, though the prices

differ between the two programs. Table 2 outlines pricing for both the FIT and micro FIT programs (Ontario Power Authority):

Table 2: Feed in Tariff Prices (OPA)

Feed-In Tariff Prices for Renewable Energy Projects in Ontario		
Technology	Size tranches	¢/kWh
Biomass*	≤ 10 MW	13.8
	> 10 MW	13.0
Biogas*		
On-farm	≤ 100 kW	19.5
On-farm	> 100 kW ≤ 250 kW	18.5
Biogas	≤ 500 kW	16.0
Biogas	> 500 kW ≤ 10 MW	14.7
Biogas	> 10 MW	10.4
Waterpower*	≤ 10 MW	13.1
	> 10 MW ≤ 50 MW	12.2
Landfill gas*	≤ 10 MW	11.1
	> 10 MW	10.3
Solar PV		
Any type**	≤ 10 kW	80.2
Rooftop	> 10 ≤ 250 kW	71.3
Rooftop	> 250 ≤ 500 kW	63.5
Rooftop	> 500 kW	53.9
Ground Mounted	≤ 10 MW	44.3
Wind		
Onshore	Any size	13.5
Offshore	Any size	19.0

* on/off-peak pricing applies here. Peak pricing is 35 per cent higher from 11 a.m. until 7 p.m. on business days and 10 per cent lower during off-peak hours.

**A new price category of 58.8¢/kWh has been proposed for ground-mounted projects.

Table 2 shows the guaranteed price of electricity produced by onshore wind turbines is 13.5¢ regardless of the scale of the installation. This price is far below the 80.2¢ for Solar PV installations less than 10kW often evoked when discussing the FIT program. This program gives specific prices for renewable energy toward the goal of the growth of the industry. These prices are based on the scale of installation and the state of the technology being used. As the various technologies further mature and drop in cost the FIT program will adapt and progress with them (OPA).

Sound and Noise

We are constantly surrounded by various types and levels of sound, whether we live in rural areas with agricultural sound scapes or urban areas filled with the fluctuating sounds of city life. With recent increases in the installation of wind turbines in both rural and urban environments it is important to understand the potential impacts of their sound. In order for research on the sound levels of wind farms and wind turbines to be comprehensible it is necessary to understand how the volumes and types of sound we experience every day are measured, studied, and understood.

Sound levels are generally measured in decibels (dB), and for the purpose of studies on windmills expressed in A-weighted decibels (dBA), a measurement specific to human hearing. This chart shows typical sound levels in various situations.

TYPICAL SOUND PRESSURE LEVELS MEASURED IN THE ENVIRONMENT AND INDUSTRY		
Noise Source At a Given Distance	A-Weighted Sound Level in Decibels	Qualitative Description
Carrier deck jet operation	140	
	130	Pain threshold
Jet takeoff (200 feet)	120	
Auto horn (3 feet)	110	Maximum vocal effort
Jet takeoff (1000 feet)	100	
Shout (0.5 feet)		
N.Y. subway station	90	Very annoying
Heavy truck (50 feet)		Hearing damage (8-hour, continuous exposure)
Pneumatic drill (50 feet)	80	Annoying
Freight train (50 feet)	70 to 80	
Freeway traffic (50 feet)	70	Intrusive (Telephone use difficult)
Air conditioning unit (20 feet)	60	
Light auto traffic (50 feet)	50	Quiet
Living room	40	
Bedroom		
Library	30	Very quiet
Soft whisper (5 feet)		
Broadcasting/Recording studio	20	
	10	Just audible

Figure 3: Typical Sound Pressure Levels (Colby et al, 2009, p.12)

As seen in Figure 3, most sound in our lives ranging from approximately 10 to 140 decibels. We need to strain to hear anything below this decibel level, for example the sound of leaves or snowflakes falling. Anything above 130 decibels can become painful and cause permanent hearing damage. On this scale wind turbines fall at approximately 45 decibels, somewhere between the quiet of a bedroom and a

calm house. Decibels are used to measure volume, though sound is much more complex, having a large range of pitch.

Sound is produced as a wave. The pitch of a sound is measured by the frequency of the wave, measured in Hertz (Hz). The higher the frequency of the sound, the higher the pitch perceived. Human hearing is generally sensitive to sound between 20Hz and 20000Hz, depending on many variables including age, locale, nature of work and sound exposure. The limits of human hearing and the effects of sound on the human body depend on a combination of both decibel level and wavelength. Although we are sensitive to low frequency sound, any sound at these levels must be at a significantly higher volume to be heard. **It is understood that sound below the threshold of hearing has little if any effect on people** (Howe. 2006, p.5).

Figure 4 shows the decibel levels perceptible by human hearing according to frequency and it shows several curves of perceived sound levels in phons. It is clear that with lower frequency sound human hearing becomes progressively less sensitive.

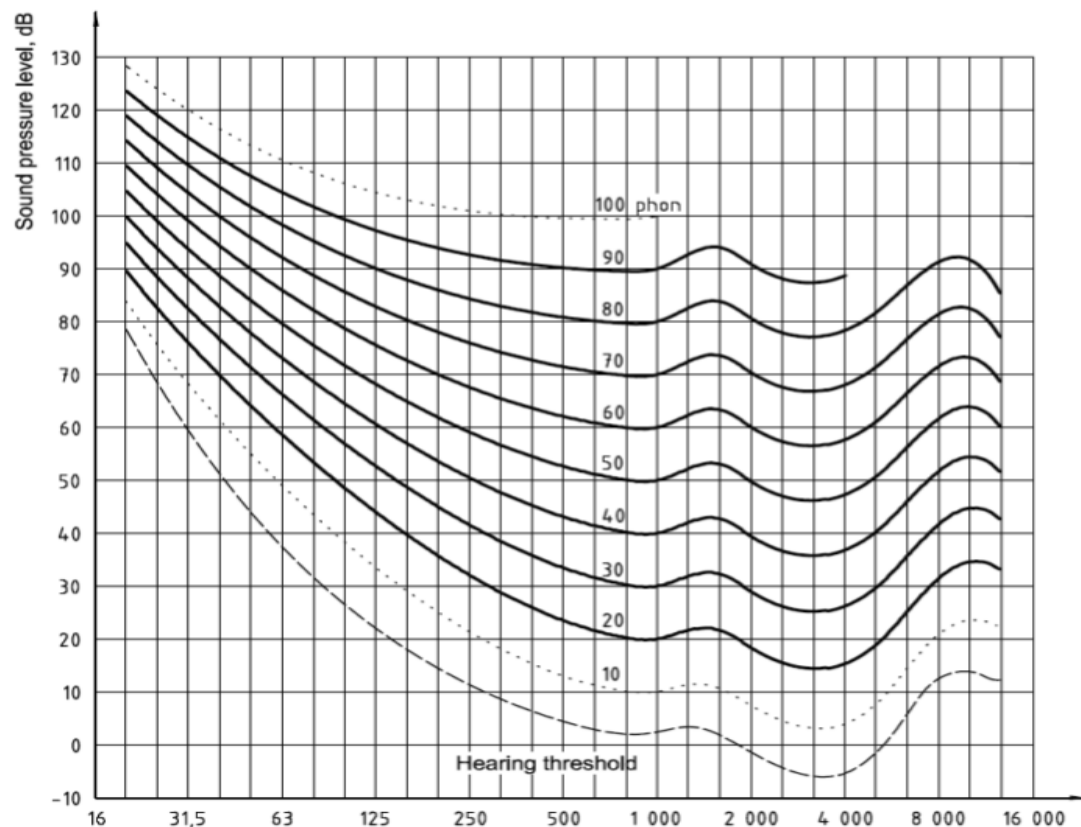


Figure 4: Hearing Threshold Graph (Agence Française de sécurité sanitaire de l'environnement, May 2010)

Wind Turbines and Noise

A great deal of study has been done on the effects of noise on the human body, though there is always need for further research. The Agence Française de Sécurité Sanitaire de l'Environnement is one of many organizations confident in the existing science to address the questions of sound produced by wind turbines.

“Perceptible noise at the foot of a wind turbine is of either mechanical or aerodynamic origin; mechanical noise which was audible with early wind turbines has more or less disappeared. Aerodynamic noise, initiated by the passage of wind over the blades in front of the tower, has equally been reduced by the optimization of blade design and the materials used in their production.”

(Agence Française de Sécurité Sanitaire de l'Environnement et du Travail, 2010)

A large number of studies and literature reviews have all concluded that noise (audible, low frequency and infrasound) from windmills is minimal and has no significant effect on the health of nearby residents. To better address this question, sound produced by windmills must be discussed in two categories: audible sound and low frequency/infrasound.

Audible Sound

As with any moving thing wind turbines do produce audible sound. For the most part, as discussed above, this sound comes from the interaction of wind and the turbine's blades. The sound profile for wind turbines has been well studied and is quite complex; for the sake of clarity, generalization will suffice.

At the base of a wind turbine the noise level can vary depending on wind speed, the size of the wind turbine, and the angle at which the blades are set, amongst a host of other variables. **This sound level is generally in the audible range (1000 to 20 000 Hz) and diminishes with distance: no more than 50dBA at 350 metres, and not exceeding 40dBA at 500 metres (Rideout, 2009).** These levels of sound elicit various reactions depending on the present background sound of the particular environment.

In many cases, especially urban installations, background sound already exceeds the sound produced by any wind turbine. In this case, the sound from the wind turbine blends into the background sound, simply becoming part of the present soundscape without the notice of residence. **It is generally accepted that in order for a noise to be audible and noticeable it must exceed the background noise of a given environment by approximately 5dBA (Rogers, 2006).**

In rural environments, where most wind farms are located, the sound profile tends to have much lower levels of background noise, varying from 20-30 decibels. In this situation, in buildings located at the minimum mandated set back distance, most people would be able to hear the wind turbines, but annoyance would be minimal (Rogers, 2006).

Studies done in Sweden have found interesting results in the relationship between proximity to wind turbines, perceived sound and accompanying annoyance. These studies were done on wind farms where houses were found within visual distance of wind turbines. This included homes both closer to wind turbines than Ontario regulation allow, as well as homes placed well beyond these regulations. This research used decibel levels and questionnaires to determine general reactions. Decibel levels were separated into five groups: less than 32.5 dBA; 32.5-35 dBA; 35-37.5 dBA; 37.5 - 40 dBA; and, above 40 dBA (Pederson, 2008; Pederson, 2007). For our purposes we will look at the groups around the limits in Ontario.

In this self-reported study, for levels between 37.5-40 dBA, 73% of respondents noticed the noise of wind turbines while approximately 6% were annoyed. At 40 dBA and above 90% of people noticed the sound while 15% were annoyed. By maintaining the limit of 40 dBA most people will hear the sound of a wind turbine, but very few if any will be annoyed and there are no negative health effects (Pederson, 2008).

The same study found an interesting correlation between those who benefited financially from windmills and reduced perception/annoyance levels even with closer proximity and higher sound levels. It also found that those who did not like windmills to begin with, or who found them to be unattractive were more likely to notice and be annoyed by the sound of the wind turbines (Pedersen, 2008).

These results are not unique. Several studies have similar findings, showing perception and annoyance occurring around the 40dBA threshold, the limit set by the Ontario government. For the studies themselves, and more detailed analysis, please consult the works cited and the accompanying quotes and documents (Pederson, 2010).

Low Frequency and Infrasonic

As discussed earlier, not all sound can be heard by the human ear, though it is everywhere in our environment. Both low frequency sound and infrasound, though different types of sound, will be dealt with here in one section as most research applies to both. Low frequency sound is generally defined as sound at a frequency of less than 200Hz. This sound, though still audible, is very much at the limits of human perception. Infrasound is considered to be the sound frequencies often below our audible range, below 20hz, because of this it is discussed in dB instead of A-weighted decibels (dBA) (Copes, no date)(Howe, 2006 p.5).

Low frequency sound is produced all around us and is a constant part of our lives, but at such low frequencies, and with such a low volume, that much of it is unheard by the human ear. Infrasound, usually

inaudible, is only heard at extremely high decibel levels. Both of these kinds of sound are produced naturally and by man made sources such as waves, wind, waterfalls, industrial processes, vehicles, and indeed wind farms. In the case of wind farms however, several peer-reviewed articles conclude that infrasound is inaudible and thus has no noticeable effect on people (Colby, 2009)(Howe, 2006).

“Specific International studies, which have measured the levels of infrasound in the vicinity of operational wind farms, indicate that levels are significantly below recognized perception thresholds and are therefore not detectable to humans.”(Sonus Pty Ltd. 2010)

In this report infrasound from two Australian wind farms is shown with the internationally recognized Audibility Threshold and measurements taken from a beach.

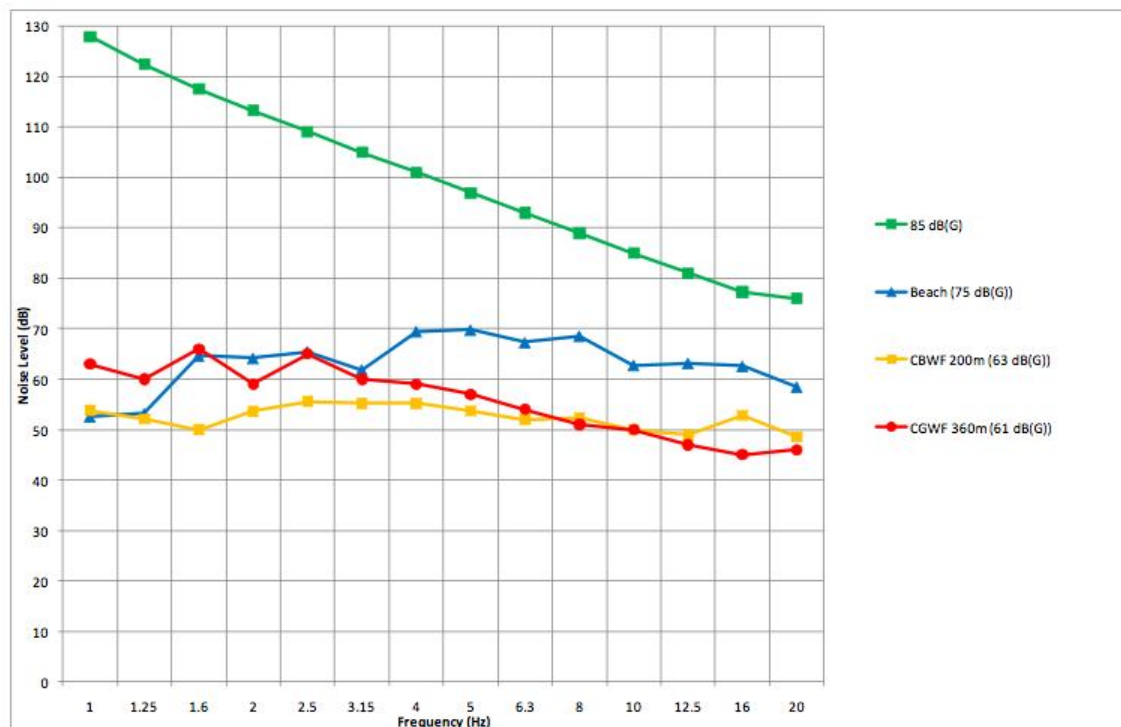


Figure 5: Audibility Threshold (Sonus Pty Ltd. 2010, p.4)

The threshold for human hearing of low frequency sound, shown in Figure 5 in green, is well above both that of the wind farms and the beach itself. This is not to say that sound from these sources is unheard; simply, low frequency sound and infrasound from these sources are not heard. The similarity in wind farm infrasound levels to that of a natural source of infrasound such as a beach is seen very clearly in this study.

In examining the evidence in regard to infrasound most researchers and organization involved in wind power come to the conclusion that infrasound below the level of hearing poses no threat.

Studies completed near Canadian wind farms, as well as international experience, suggest that the levels of infrasound near modern wind turbines, with rated powers common in large scale wind farms are in general not perceptible to humans, either through auditory or non-auditory mechanisms. **Additionally, there is no evidence of adverse health effects due to infrasound from wind turbines.** (Howe, 2006, p.11)

The Effects of Windmill Sound

The studies examining wind turbine sound repeatedly come to the same conclusion: the effects on health, if any, are minimal and affect only a very small portion of the population. For levels of sound under 40dBA wind turbines may be audible to the general population, and at the very worst may be perceived as annoying. **This annoyance may cause sporadic waking throughout the night, though no effects beyond this are seen to be the results of wind turbine noise (Copes, no date). Several publications have linked the negative perspective toward wind turbines with adverse reactions to sound: those who don't like wind farms, or the look of wind turbines tend to notice and be annoyed by the sound of windmills significantly more than anyone else (King, 2010).**

It is generally agreed among several levels and branches of Canadian and international government, research institutions and environmental groups that sound from wind turbines pose no adverse health effects to the general population. This consensus is based upon thorough review and interpretation of scientific data with the health and well being of the population in mind. The reassurance of the Chief Medical Officer of Ontario comes amidst a crowd of voices supporting wind energy:

"The sound level from wind turbines at common residential setbacks is not sufficient to cause hearing impairment or other direct health effects..."
(King, 2010 p.2)

Ice and Blade Icing

Due to a combination of freezing temperatures and fog there is the potential for wind turbine blades to freeze and develop ice layers. Studies have shown that when the blades are stationary, ice will fall within 50 metres of the windmills and, while turning, ice could be thrown up to 250 metres. **Though both of these distances are well below Ontario's setback regulations** Ontario's public health agency recommends the shut

down of wind turbines when ice forms on the blades. This can be done either manually or automatically (Copes, no date).

On the whole, blade icing of wind turbine is seen as a very preventable, minor problem. There have been no documented injuries due to ice falling or being thrown from wind turbines. As long as regulations are followed this reputation for safety will be maintained.

Shadow Flicker

The light effect caused when the sun is positioned behind a rotating wind turbine has been described as shadow flicker. This effect generally lasts no more than 30 minutes and only appears in very specific situations. The geographic situation: lay of the land, the placement of the wind turbine and the position of the sun all have to line up perfectly (Rideout et al., 2010). If this situation occurs, the probability of shadow flicker being noticed in a building depends upon a variety of conditions including: the angle between the turbine and the building; the distance between the building and the turbine; the length of the blades and the height of the hub; the time of the year; the wind direction; the number of daylight hours the turbine is in operation, and the number of days with clear and cloudless skies (Office of the Deputy Prime Minister, 2004, p.176). In locations north of the equator there will be a zone to the south of the wind turbines where shadow flicker will not happen (Stankovik et al., 2009, p. 96). The area where shadow flicker can occur is limited by the size of the turbine. It has been stated that "Flicker effects have been proven to occur only within ten rotor diameters of a turbine" (Office of the Deputy Prime Minister, 2004, p.178). The greater the distance between the turbines and the observer the less noticeable the shadow flicker will be (Office of the Deputy Prime Minister, 2004, p.177).

1.3% of Canadians are affected by epilepsy and there is some concern over a potential link between epilepsy and shadow flicker. 5% of those with epilepsy are light sensitive though this sensitivity is restricted to frequencies around 16-26Hz, occurring occasionally as low as 10Hz (Epilepsy Canada). A wind turbine producing shadow flicker would do so between 0.5 - 1Hz, well below the sensitivity level of the few people affected. There have been no documented cases of epileptic seizures brought on by shadow flicker.

Shadow flicker is a real effect of wind turbines. **With the sun in the background, large moving shadows can be produced which some people may find distasteful.** Table 3 shows the approximate sensitivity to shadow flicker at different RPM for three blade turbines, according to Stankovik et al.

Table 3: Sensitivity to Shadow Flicker at Different Rates (Stankovik et al., 2009,p.96)

Flicker Rate (Hertz)	Human Perception	Equivalent RPM Rate for a 3-Bladed Turbine
< 2.5	Negligible Effect	<50
2.5 - 3	May Affect 0.25% of the Population	50-60
3 - 10	Effect is Perceptible	<200
10 - 25	Greatest Sensitivity	200-500
>50	Continuous Light Source	1000

Larger turbines generally operate between 18 and 45 RPM, while smaller turbines generally operate below 150 RPM (Stankovik et al., 2009,p.96). This effect can however be prevented with proper placement of wind turbines to avoid the particular setup necessary to create this effect.

Electro Magnetic Fields (EMFs)

Electro Magnetic Fields surround us in modern society. All electronic devices, power lines, and generating stations produce EMFs. They are ubiquitous. As wind turbines are producing electricity they too create an EMF and when power is then transferred from a wind farm via hydro lines EMFs are once again present. The danger of EMFs is constantly under analysis as they are something that each and every one of us encounters on a regular basis. This constant research will help us to continue to evaluate EMFs and learn more about any safety issues.

Though wind power produces EMFs like any other source of power and power transmission there are two major benefits to wind power in respect to safety. First, as wind turbines are 80 to 100 metres above the ground the EMF created by the production of energy is generally well above any people who may be in the area. Second, most power from wind farms is transmitted to the grid by underground cables which, being below ground, effectively produce no EMF (Rideout, 2010).

There is constant research into EMFs, and safety issues are constantly being re-evaluated. For the time being safety issues are considered minimal. Certainly in the case of wind turbines EMFs are of little concern, producing as much or less of an EMF than other forms of energy production and transmission.

The Real Health Hazards

A report by the Canadian Medical Association (CMA) outlines the grave impact that air pollution has on human health, as well as the large financial costs associated with air pollution related illnesses. This report states that in 2008, air pollution was responsible for 21,000 deaths in Canada (CMA, 2008, p.iii). 90,000 people will have died from acute effects and 710,000 will have died from long-term exposure to air pollution by 2031, with the highest number of deaths from acute exposure in Quebec and Ontario (CMA, 2008, p.iii). In 2008 air pollution was responsible for 620,000 visits to doctors offices, and 92,000

emergency room visits, while these numbers are expected to rise to 940,000 and 152,000 respectively in 2031 (CMA, 2008, p.iii). In 2008 the cost of air pollution was \$8 billion, and by 2031, the cumulative cost of air pollution will be \$250 billion (CMA, 2008, p.iii). There are no emissions directly associated with energy produced from wind turbines (Andersen, 2008, p.11).

Wind Power

The variability of wind is sometimes cited as a barrier to the proliferation of wind power, but no energy source produces at 100% capacity all of the time. Capacity factor is commonly discussed when referring to electricity generation techniques. It is the actual output of a generating facility over the theoretical output if generation was at the maximum level all the time. For example, a power plant working at 100% capacity 50% of the time would have a capacity factor of 50% the same as a power plant working at 50% capacity 100% of the time. The capacity factor for renewable energy falls within the range of conventional generation techniques and indeed has a higher capacity factor than hydroelectric generation (EIA, [No date]).

Table 4: Average Capacity Factors by Energy Source in 2007 (EIA, [No date])

Energy Source	Average Capacity Factors %
Coal	73.6
Petroleum	13.4
Natural Gas CC	42
Natural Gas Other	11.4
Nuclear	91.8
Conventional Hydroelectric	36.3
Renewable (Solar, Wind, Biomass)	40
Average	48.7

While wind speed can vary, it “can be quite accurately forecast in the appropriate timeframes for balancing electrical supply” (Sustainable Development Commission, 2005, p.22).

Wind Power Internationally

All around the world countries are moving aggressively to increase their wind generation capacity. This increase in installed generating capacity is documented in the Global Wind Report Annual Market Update, with Europe and Asia leading (GWEC, 2010, p.14).

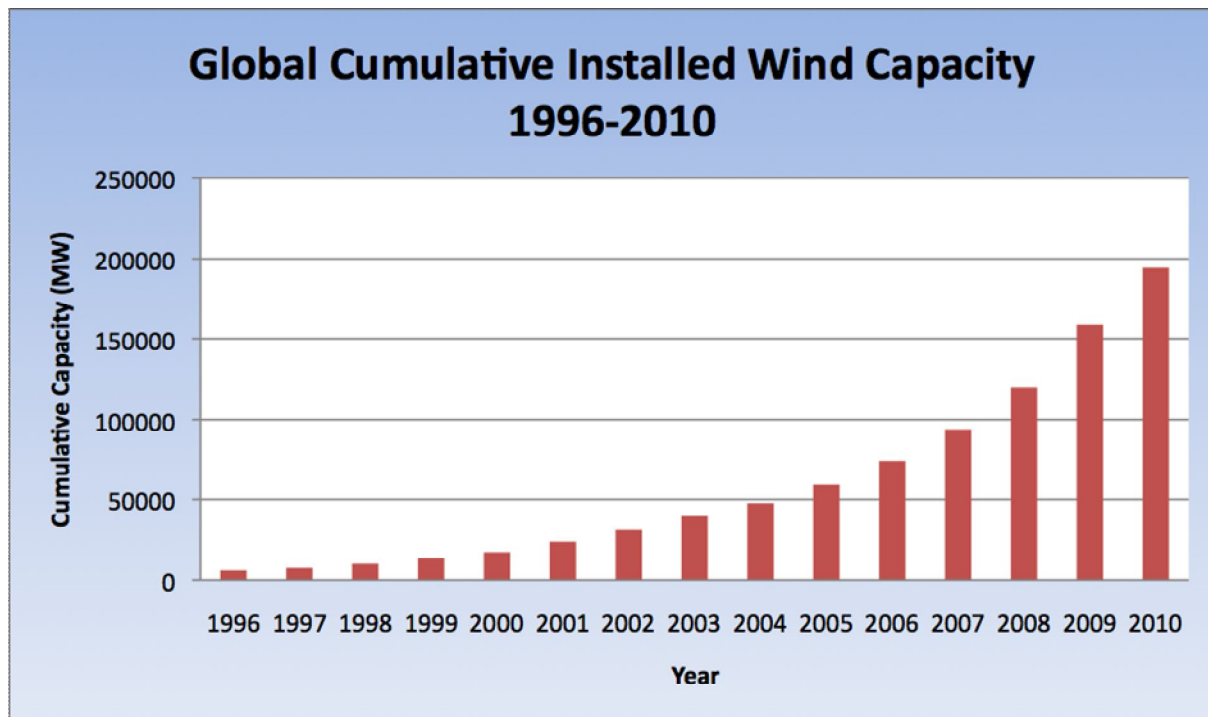


Figure 6: Global Cumulative Installed Wind Capacity 1996-2010 Information from (GWEC, 2010, p.14)

Over the course of 2010 many countries, most notably China, have dramatically increased their number of wind installations (GWEC, 2010, p.11).

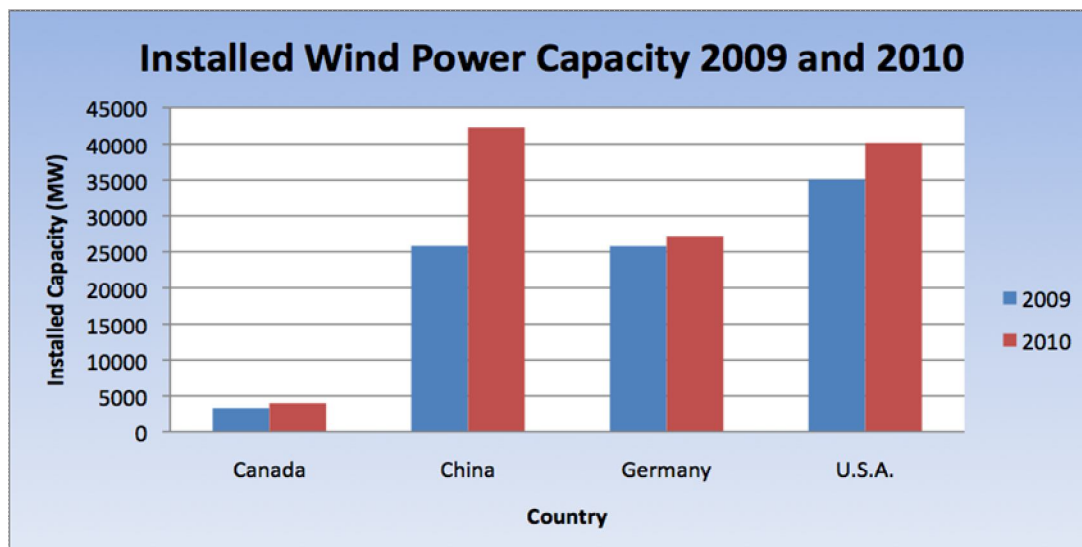


Figure 7: Installed Wind Power Capacity in 2009 and 2010 Information from (GWEC, 2010, p.11)

Canada and Wind Energy

Canada remains behind the rest of the world in installed wind generation capacity, despite the fact that there are tremendous benefits to be gained from renewable electricity generation. If Canada continues

to delay involvement in the renewable energy industry, it will become increasingly difficult to be competitive, as other countries will have substantially more knowledge, skills and development.

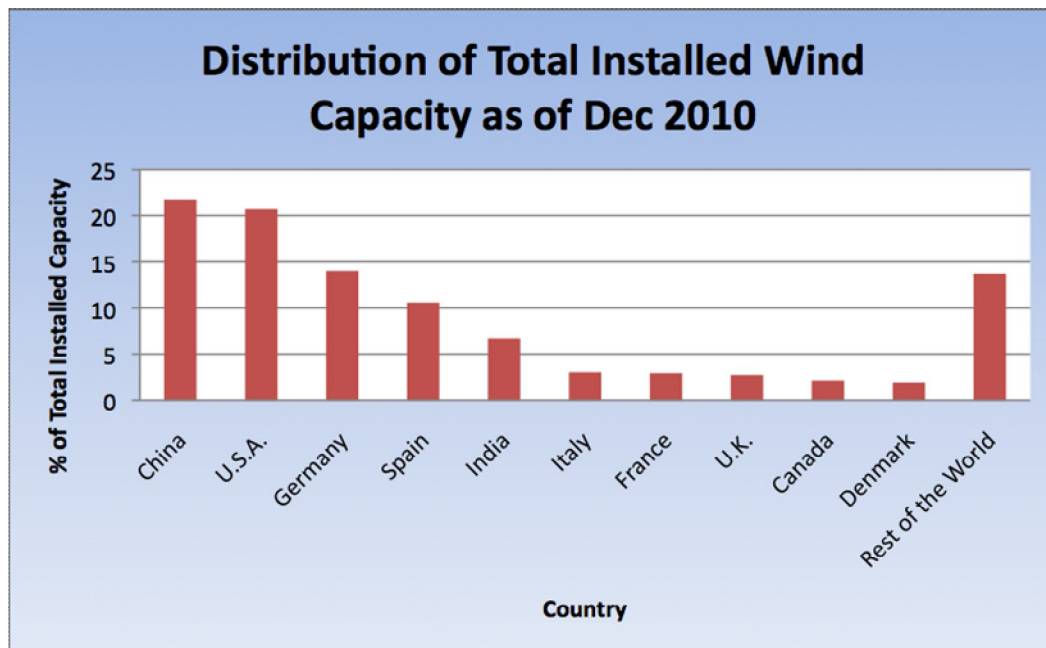


Figure 8: Distribution of Total Installed Wind Capacity as of Dec 2010 Information from (GWEC, 2010, p.12)

It has been shown that wind generation will be beneficial to Canada in a number of areas. According to Bloomberg New Energy Finance, in 2010, worldwide investment in wind power increased 31% to an all time high of 96 billion USD (GWEC, 2010, p.18). It would seem prudent to capitalize on the influx of capital and interest in this sector. Investment in wind energy would create jobs in many sectors, including communications, business, marketing, meteorology, many streams of engineering, mechanical and electrical technology, research and the construction trades (EREC, 2001, p.2).

Since 2009 the United States has made substantial investment in clean energy. If Canada were to match these investments on a per capita basis, an additional \$11 billion would need to be set aside for renewable energy development (Campbell et al., 2010, p.2). It is anticipated that this would lead to the creation of 66,000 jobs in the clean energy sector, with the potential of additional job creation in the energy efficiency and transport industries (Campbell et al., 2010, p.2).

Wind Energy and Jobs

The Conference Board of Canada has estimated, based on a 2000 MW generating capacity, that the development and operation of offshore wind farms in Ontario has the potential to create 3 900- 4 000 jobs during the construction phase, from 2013-2026 (Conference Board of Canada, 2010). This

development would contribute between \$4.8 and \$5.5 billion to Ontario's economy for this period (Conference Board of Canada, 2010).

The development of wind energy in Europe has created many new jobs. In 2007 in the European Union the wind energy sector directly employed 108 600 people, and indirectly employed over 150 000 (EWEA, 2008, p.13). It is expected that by 2030 the number of people employed by the wind energy sector will have risen to 375 000 (EWEA, 2008, p.11).

The Cost of Wind

In Europe, as wind turbines have become increasingly common, the cost of producing energy from wind has decreased by over 50% over the last 15 years (EWEA, [No date], p.5). Manufacturers estimate the cost of generating electricity from wind turbines will fall 3-5 % for each new generation of turbines developed (EWEA, [No date], p.5).

It has been estimated that if the environmental externalities associated with generating electricity from fossil fuels was included in their cost, the price of electricity generated from coal and oil would double, and the cost of electricity generated from gas would rise 30% (EWEA, [No date], p.6).

If subsidies to the fossil fuel and nuclear sector were removed the renewable energy sector would not require any subsidies to be competitive (EWEA, [No date], p.6). It has been estimated that in Canada, annual government subsidies for the oil sector in Newfoundland and Labrador, Alberta, and Saskatchewan were \$1.38 billion in 2009 (Enviro Economic Inc., et al, 2010, p. 40). A report from Atomic Energy Canada Limited states that they received \$321 million in parliamentary appropriation, a form of taxpayer subsidy, during the 2009-2010 period (AECL, 2010, p. 24).

In 1999 Ontario hydro was separated into five companies, and its \$20.9 billion debt was transferred to the Ontario Electricity Financial Corporation (Gibbons, [No date], p.14-15). This debt was effectively transferred from the power company to the taxpayers and electricity consumer of Ontario (Gibbons, [No date], p.14-15). In 2007 the average electricity consumer in Ontario paid \$377 to the Ontario Electricity Financial Corporation, to pay off this debt (Gibbons, [No date], p. 14-15). These payments are unlikely to be discontinued in the near future, as of December 31st 2007, the debt was at \$18.3 billion (Gibbons, [No date], p. 14-15).

Although subsidies may initially be required to establish a new industry it has been shown that wind power can be self-sustaining. In Denmark, a country with a large number of wind turbines, subsidies of 30%

of the total cost were provided in 1979 (Andersen, 2008, p.10). These subsidies were gradually reduced until they were no longer required by 1989 (Andersen, 2008, p.10).

Land and Wind

Wind power has the advantage of not being land intensive. Wind farms generally require 0.08-0.13km²/MW of generation capacity (Andersen, 2008, p.12). The land surrounding the wind turbines can remain as natural habitat or agricultural land (Andersen, 2008, p.12). Many of the materials wind turbines are made of can be recycled, and no decommissioning issues are associated with wind turbines (Andersen, 2008, p.11).

Impacts on Wildlife

Wildlife can be impacted by all forms of electricity generation. In 2008 the New York State Energy Research and Development Authority commissioned a report to look at the comparative impacts of different types of electricity generation on wildlife, including mammals, birds, reptiles, amphibians and fish (Newman and Zillioux, 2009, p.1-1). This report looked at the levels of death and injury, degradation and destruction of habitat and the disturbance of typical behaviours (Newman and Zillioux, 2009, p.2-2) The types of electricity generation studied were coal, oil, natural gas, hydro and wind (Newman and Zillioux, 2009, p. 1-1). While acknowledging that all forms of electricity generation will have some impact on wildlife, it can be seen when comparing generating types that wind generation is far less damaging to wildlife populations throughout the entire generation cycle (Newman and Zillioux, 2009, p.3-1).

Table 6: Comparative Wildlife Risks Levels for Various Electricity Generation Methods Information from (Newman and Zillioux, 2009, p.3-1)

Source	Resource Extraction	Fuel Transportation	Construction	Power Generation	Transmission and Delivery	Decommissioning
Coal	Highest	Lower	Lower	Highest	Moderate	Lower
Oil	Higher	Highest	Lower	Higher	Moderate	Lower
Natural Gas	Higher	Moderate	Lowest	Moderate	Moderate	Lowest
Nuclear	Highest	Lowest	Lowest	Moderate	Moderate	Lowest
Hydro	None	None	Highest	Moderate	Moderate	Higher
Wind	None	None	Lowest	Moderate	Moderate	Lowest

Birds

It has been stated that wind turbines can have a negative impact on bird populations, but wind turbines actually have a comparatively low impact on the number of birds that die every year from human causes (Erickson et al., 2005. P 1029). It has been estimated that, in the U.S. 500 million to over 1 billion

birds are killed every year due to human intervention in the environment with wind turbines contributing an estimated 28.5 thousand deaths a year to this total (Erickson et al., 2005. P 1029).

Table 5: Avian Mortality by Source

<u>Mortality Source</u>	<u>Annual Mortality Estimate</u>	<u>Percent Composition</u>
Buildings	550 million	58.2%
Power Lines	130 million	13.7%
Cats	100 million	10.6%
Automobiles	80 million	8.5%
Pesticides	67 million	7.1%
Communication Towers	4.5 million	0.5%
Wind Turbines	28.5 thousand	<0.01%
Airplanes	25 thousand	<0.01%
Other Sources	Not calculated	Not calculated

(Erickson et al., 2005. P 1039)

In a 2006 work, Drewitt and Langston found that annually there were 0.01-23 incidents of bird collisions per wind turbine (Baldock et al., 2009, p.9). A 2008 work by the same authors found that annually power lines were responsible for 2.95 to 489 collisions per km of line (Baldock et al., 2009, p.9).

The National Audubon Society in the United States has voiced its approval of electricity generated by wind, stating: "Audubon strongly supports properly-sited wind power as a clean alternative energy source that reduces the threat of global warming" adding that "Scientists have found that climate change has already affected half of the world's wild species' breeding, distribution, abundance and survival rates." (National Audubon Society, 2011). Ruth Davis, the head of Climate Change Policy at The Royal Society for Protection of Birds has also shown support for renewable energy projects, including properly situated wind generation, stating,

The need for renewable energy could not be more urgent. Left unchecked, climate change threatens many species with extinction. Yet, that sense of urgency is not translating into action on the ground to harness the abundant wind energy around us.

(RSPB, 2011)

Bats

The impacts of wind turbines on bats is a fairly recent discovery, which came about by accident while studying impacts on birds. It was found that at certain sites there was a higher than expected numbers of bat fatalities. Though the research on bat deaths is still preliminary estimates say that approximately 15.3 – 41.1 bats/ MW of installed capacity are killed each year (Kunz, 2009). This number varies greatly, however, from site to site. Most of these deaths (approximately 75%) are tree bats and a large portion of research has been restricted to this group of bats (Kunz, 2009). What is curious is that bat fatalities tend to be lower than that of

birds at tall structures; it seems that bats do not have a tendency to fly into tall buildings and structures as birds do. This has led to questions regarding the causes of bat fatalities and has further inspired further research in this area (Arnett, 2008). That being said, “No study reported a species of bat listed as threatened or endangered under the endangered species act killed at wind facilities.” (Arnett, p. 64)

Most studies undertaken to determine possible reasons why a higher number of bat deaths are occurring at wind farms have come to a few conclusions. First, after the recording of bat deaths, the collection and dissection of bat carcasses, there are two major causes of bat deaths. One, collision with wind turbines or wind turbine blades though these numbers are extremely low when the wind turbines are not in operation. The other is barotrauma: injury to the abdominal and thoracic cavities as well as the lungs due to the pressure difference caused by the sweeping of a wind turbine's blades (Cryan 2009).

With an understanding of how bats are being injured by wind turbines, research has also focused on why bats are colliding with turbines; the questions of attraction and avoidance are being asked. It has been theorized that some bat fatalities are due purely to chance. Bats can however, be attracted to windmills leading to injury and loss of life. It has been posited that bats may be attracted for a variety of reasons including: an attraction to the high wind areas that are also prime locations for wind turbine development, attraction to the large number of insects in the area which are in turn attracted to the white colour of wind turbines, attraction to the lights or sound produced by wind turbines, as well as a host of other hypotheses.(Cryan 2009, Long 2010) The study on bat fatalities seems to indicate that the problems with the interaction between bats and wind turbines are restricted to certain sites. Where some sites are seeing surprising numbers of fatalities others are seeing minimal deaths similar to that of other tall structures; this indicates that proper monitoring needs to be done at individual sites in order to implement the most appropriate mitigation techniques.

As study continues the understanding of bat behaviour and their interaction with wind turbines will increase. For the moment current research and understanding is leading to a variety of methods for the mitigation of bat death. **These improvements in understanding are already improving bat fatality rates and will continue to improve.**

Prevention and Mitigation

The impacts of wind turbines on bird and bat species is a priority for those in the environmental and renewable energy fields. Mitigation techniques are now at the point where improvement is being seen and fatality numbers are dropping. This section will discuss mitigation techniques being proposed, tested or put in place now on a large scale, as well as, techniques specific to individual sites.

In Ontario, the Ministry of Natural Resources, as part of the Green Energy Act, **requires certain procedures to be followed during the pre-construction, construction and post construction phases of wind**

turbines and wind farms in order to mitigate bird and bat deaths. Most of these regulations apply to both, while others are specific to either birds or bats themselves. These regulations can be found in the MNR documents: “Bird and Bird Habitats Guidelines for Wind Power Projects” and, “Bat and Bat Habitats, Guidelines for Wind Power Projects”.

For both birds and bats pre-construction studies must be done to determine species in the area, activities undertaken in the area and any critical habitat components.

“The PPS specifically identifies wildlife habitat as: areas where plants, animals, and other organisms live, and find adequate amounts of food, water, shelter, and space needed to sustain their populations. Specific wildlife habitats of concern may include areas where species concentrate at a vulnerable point in their annual or life cycle; and areas which are important to migratory or non-migratory species.

Wildlife habitat is considered significant where it is: ecologically important in terms of features, functions, representation or amount, and contributing to the quality and diversity of an identifiable geographic area or Natural Heritage System. Criteria for determining significance may be recommended by the Province, but municipal approaches that achieve the same objective may also be used.” (MNR March 2010)

This definition is further explained and laid out in detail in the “Significant Wildlife Habitat Technical Guide” produced by the Ministry of Natural Resources. With this in mind the wind industry is required to allow a buffer of 120m from any SWH. This is seen in Figure 10 below.

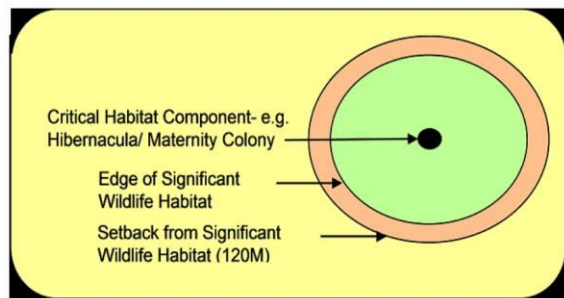


Figure 10: Significant Wildlife Habitat Setbacks

These two documents require monitoring of the wind farms for a period of 3 years of the completion of the projects. During this 3 year monitoring period the following fatality thresholds are laid out.

For birds:

18 birds/ turbine/year at individual turbines or turbine groups;

0.2 raptors/turbine/year (all raptors) across a wind power project;

0.1 raptors/turbine/year (raptors of provincial conservation concern) across a wind power project; or

2 raptors/wind power project (<10 turbines) (MNR March 2010)

For Bats:

10 bats/turbine/year (MNR March 2010)

If these thresholds are then surpassed further monitoring and mitigation techniques may need to be put into place. (MNR March 2010)

With the understanding that the government of Ontario requires mitigation techniques if the mortality thresholds above are exceeded, effective techniques must be put into place. New studies in the last few years have highlighted the potential to decrease fatality rates of bats and birds. **The best technique to avoid wildlife fatality and loss of habitat is good siting and placement of wind turbines.** This is an imperative step in the development of a wind turbine project. By following ministry guidelines wind farms should give space to “significant wildlife habitat” allowing for the development of the project with minimal impact upon wildlife. If, however, during the 3 year monitoring period significant mortality rates are found, mitigation techniques and monitoring must be undertaken.(MNR March 2010) Some well understood techniques are already in place while new techniques are being developed and tested to further improve mitigation practices.

When discussing bird mortality and wind turbines it is necessary to approach the topic of the Altamont Pass wind farm in California. This installation now almost 30 years old has had many problems in regard to bird deaths and has motivated research into wind turbine effects on wildlife. It has been concluded that this installation was poorly sited to begin with, being put in a bird migratory route, with many small turbines placed closely together.(USGAO 2005) Toward mitigating the effects of this poorly sited installation, many of the older turbines are now being replaced with fewer larger new wind turbines. This replacement strategy is part of a larger strategy to reduce environmental impact: the Altamont Pass Wind Resources Area (APWRA) Conservation Plan. **This new plan should increase bird monitoring as well as decrease bird fatalities in the area.** (APWRA, 2011)

The Altamont Pass wind farm is often cited both as an example of the negative impacts wind farms can have on wildlife as well as an example of improvements from poorly sited installations. For the prevention of environmental impact good siting prevents impact and the need for mitigation. Where mitigation is necessary the most common technique is intermittent shutdown of wind turbines depending on the life cycle of birds being affected in the area. Using bird migratory and behaviour data, turbines can be shut down at certain points to allow for the protection of certain species. This type of mitigation does, however, lead to questions of loss of profit.

As to bats, new research is coming out and many strategies are being put into place to reduce bat deaths. It has been well documented that bat deaths tend to occur under low wind conditions and that as winds increase bat activity decreases (Baerwald et al. 2009). Due to this aspect of bat activity, an increase of the cut in wind speed (the speed at which wind turbines begin to produce electricity) from 4 m/s to 5.5 m/s has seen decreases of bat deaths by 57.5%-60%. This change in cut in wind speed was put in place as part of research in south western in Alberta where large numbers of bats were seen being killed (Baerwald et al. 2009). "It is estimated that over the 1-month experiment, total revenue lost from the 15 turbines with increased rotor start-up speed was between \$3000 and \$4000" (Baerwald. p. 3) this cost could have been further lowered if the start up speed was only changed at night and weather variables and high risk times could be taken into account (Baerwald et al. 2009). Though this technique is quite effective, new techniques and theories are arising too. It has been proposed that the colour of the wind turbines attracts more insects and thus more bats. A simple change of the colour of wind turbines could decrease bat attraction to wind farms and thus the number of bat deaths.

In all, most studies conclude that the most important aspect of wildlife protection is good siting practices in during the pre-construction of wind farms. This focus on siting should then be followed up with consistent, high quality monitoring ensuring the protection of the wildlife and surrounding environment.

Conclusion

It would seem that the disconnect between resources and their end point of consumption becomes greater and greater as time progresses. Advances in technology and transportation allow the consumption of resources from places never personally experience, shielding the consumers from the impact of their choices; "a commercial pattern has emerged that has increasingly separated, or distanced, consumers from the consequences of their behavior" (Luna, 2008, p.1278). This would seem to hold true for most forms of consumption, including electricity use. Pasqualetti states that

"One of the most important spatial consequences of the dispersed processing that characterizes most generation of electricity is the resulting visual and absolute dilution of the aggregate impacts that result. It is the reward of such dilution that no single place must absorb or suffer cumulative environmental-including aesthetic insults. Unfortunately, this "out of sight, out of mind" pattern misleads the public by suggesting that the environmental costs of electricity are less than they actually are." (Pasqualetti, 2000, p.384).

This separation has perhaps played some role in the rise in per capita electricity consumption that has been seen in Canada since the mid twentieth century.

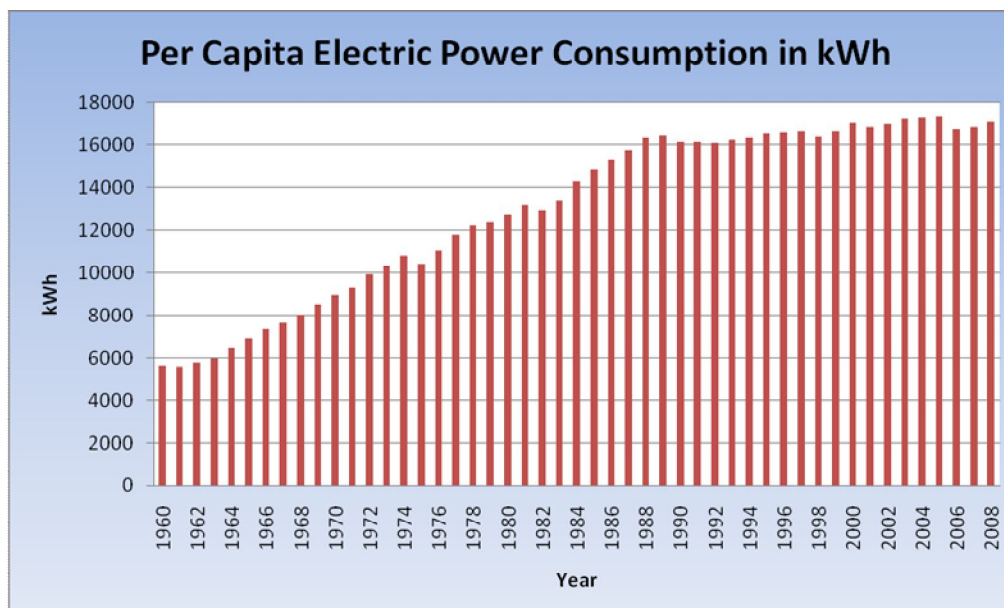


Figure 9: Per Capita Electric Power Consumption in kWh (The World Bank Group, 2011)

This separation between source and consumption has perhaps allowed a lack of awareness, either innocent or purposeful, to permeate understanding of the true impact of consumption on both people and the environment. People and places, no less valuable than those personally known, have been allowed to bear the burden of others needs and wants simply because of geographical separation.

“As distance between consumption and production increases, we can expect a breakdown in the flow of information, creating misperceptions of scarcity and damage, resulting in unrestrained or excessive consumption. No less important, the pursuit of distancing as a method of cost externalization, either by producers or consumers, leads to displacement of environmental problems. Worse, this displacement often appears as a solution to environmental problems when ecological feedback is severed and price is the only information available to consumers.” (Luna, 2008, p.1278).

Renewable electricity generation can potentially be seen to be reversing this trend. No longer will electricity generation be entirely concentrated and remote, it may very well be present and visible. It must be acknowledged that all forms of electricity generation will have an impact in some location, and the comparative close proximity of renewable generation should not be seen as a deterrent to its acceptance. Wind electricity generation does have visibility in the landscape. Work by Bishop suggests that in some circumstances it can be reasonable to do visibility modeling of wind turbines to a distance of twenty to thirty kilometers, but that in “normal” circumstances wind turbines located ten kilometers from the viewer will only be recognized by one out of five viewers. (Bishop, 2002, p.718). This work also concludes that “Visual impact remains ‘in the eye of the beholder’ but may well become minimal beyond 5 km - 7 km, even in clear air” (Bishop, 2002, p.718).

It has been shown that properly sited wind turbines are a low impact source of electricity, and have the potential to minimize the use of environmentally detrimental electricity sources.

A number of municipalities have passed motions calling for a moratorium on the installation of wind turbines until the time when appropriate proof of their safety has been set forward. We present this document, along with all accompanying reports, as reassurance not only of the safety, but of the many advantages of wind power. The same strength of opinion comes from the following individuals, groups and organisations.

The Chief Medical Officer of Health (CMOH) of Ontario Dr. Arlene King:

“The sound level from wind turbines at common residential setbacks is not sufficient to cause hearing impairment or other direct adverse health effects. However, some people might find it annoying ... Low frequency sound and infrasound from current generation upwind model turbines are well below the pressure sound levels at which known health effects occur. Further, there is no scientific evidence to date that vibration from

low frequency wind turbine noise causes adverse health effects."
(King, Dr., 2010, p.9)

Ontario's Public Health Agency:

"Based on best available evidence, any identified risks can be addressed through siting (setbacks) and operating practices." (Copes)

The Ontario Ministry of the Environment:

"A panel of three judges has ruled that Ontario's approach to wind turbines protects human health and the environment. The province's 550 metre setback for wind turbines is the strictest in North America and based on peer-reviewed science.

The Ministry of the Environment consulted 122 scientific journals in developing noise guidelines and protocols for wind turbines. This includes 15 peer-reviewed journals, eight conference presentations and 34 policy papers." (Ministry of the Environment, 2011)

Natural Resources Canada/Canmet Energy

"Harnessing the natural and renewable energies of the sun, wind, moving water, earth and biomass improves the sustainability of our energy production and delivers benefits to the environment and to human health." (CanMet Energy, 2009)

CanWEA

"Wind energy is a benign technology with no associated emissions, harmful pollutants or waste products. In over 25 years and with more than 68,000 turbines installed around the world, no member of the public has ever been harmed by wind turbines." (CanWEA, 2008)

The National Medical Academy of France:

“It is understood that the worries and fears have largely been spread because they serve as supplementary arguments for Associations which oppose the installation of these turbines for ecological, aesthetic or economic motives, put forward, generally, politically and not with the competence of the Academy. Presently in the scientific literature, there is little proof of the potential dangers of windmills on man.” (Auquier, Louis. Et al., 2006)

“On comprend que ces doléances et ces craintes aient été alors largement diffusées, parce qu'elles servaient d'arguments supplémentaires aux Associations qui s'opposent à l'installation de ces engins pour des motifs écologiques, esthétiques ou économiques, qui, eux, relèvent de la politique générale, et non des compétences de l'Académie. Actuellement, dans la littérature scientifique, on retrouve très peu de données sur les dangers potentiels des éoliennes pour l'homme.” (Auquier, Louis. Et al., 2006)

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Appendices

Appendix 1: Quotations by Subject

	Source	Quotation
<u>General</u>	(King, 2010)	« ...the scientific evidence available to date does not demonstrate a direct causal link between wind turbine noise and adverse health effects. The sound level from wind turbines at common residential setbacks is not sufficient to cause hearing impairment or other direct health effects, although some people may find it annoying. »
<u>Sound and Noise</u>	(King, 2010)	« The sound was annoying only to a small percentage of the exposed people; approximately 4 to 10 per cent were very annoyed at sound levels between 35 and 45dBA. Annoyance was strongly correlated with individual perceptions of wind turbines. Negative attitudes, such as an aversion to the visual impact of wind turbines on the landscape, were associated with increased annoyance, while positive attitudes, such as direct economic benefit from wind turbines, were associated with decreased annoyance. »
	(Rideout & Bos, 2009)	« No published data that confirm the claims of adverse health effects for low-frequency sounds of low pressure (i.e. below 20 Hz and 110 dB) »
	(Colby, 2009)	« There is no evidence that the audible or sub-audible sounds emitted by wind turbines have any direct adverse physiological effects. » « The sounds emitted by wind turbines are not unique. There is no reason to believe, based on the levels and frequencies of the sounds and the panel's experience with sound exposures in occupational settings, that the sounds from wind turbines could plausibly have direct adverse health consequences. »

	(Colby, 2009)	<p>« As the annoyance of a given sound increases as loudness increases, there is also a more rapid growth of annoyance at low frequencies. However, there is no evidence for direct physiological effects from either infrasound or low frequency sound at the levels generated from wind turbines, indoors or outside. Effects may result from the sounds being audible, but these are similar to the effects from other audible sounds. »</p> <p>« It is important to note that although annoyance may be a frustrating experience for people, it is not considered an adverse health effect or disease of any kind. Certain everyday sounds, such as a dripping faucet—barely audible—can be annoying. Annoyance cannot be predicted easily with a sound level meter. Noise from airports, road traffic, and other sources (including wind turbines) may annoy some people, and, as described in Section 4.1, the louder the noise, the more people may become annoyed. »</p>
	(Pedersen et al., 2008)	<p>« There is no indication that the sound from wind turbines had an effect on respondents' health, except for the interruption of sleep. At high levels of wind turbine sound (more than 45 dBA) interruption of sleep was more likely than at low levels. Higher levels of background sound from road traffic also increased the odds for interrupted sleep. Annoyance from wind turbine sound was related to difficulties with falling asleep and to higher stress scores. From this study it cannot be concluded whether these health effects are caused by annoyance or <i>vice versa</i> or whether both are related to another factor. »</p>
	(Health Canada, 2005)	<p>« In a typical community, noise starts to make people highly annoyed when the sound level outside their home is around 55dbA. In comparison , the sound level on the shoulder of the major highway is between 80 and 90 dbA »</p>
	(Leventhall, 2006)	<p>«The fluctuations of wind turbine noise (swish – swish) are a very low frequency modulation of the aerodynamic noise, which is typically in the region of 500 - 1000Hz. The modulation occurs from a change in radiation characteristics as the blade passes the tower, but the modulating frequencies do not have an independent and separate existence. » (p.33)</p> <p>«Fear of a source is not the same as fear of the noise itself, but it is understandable that those who fear the effects of a noise upon their health will be less tolerant of the noise than those who do not fear it. » (p.33)</p>

<u>Infrasound</u>	(Sonus Pty Ltd, 2010)	« Specific International studies, which have measured the levels of infrasound in the vicinity of operational wind farms, indicate the levels are significantly below recognised perception thresholds and are therefore not detectable to humans. »
	(Howe, 2006)	« Studies completed near Canadian wind farms, as well as international experience, suggest that the levels of infrasound near modern wind turbines, with rated powers common in large scale wind farms are in general not perceptible to humans, either through auditory or non-auditory mechanisms. Additionally, there is no evidence of adverse health effects due to infrasound from wind turbines. »
	(King, 2010)	« There is no evidence of adverse health effects from infrasound below the sound pressure level of 90dB »
	(Leventhall, 2006 p.34)	«It has been shown above that there is insignificant infrasound from wind turbines and that there is normally little low frequency noise. Turbulent air inflow conditions cause enhanced levels of low frequency noise, which may be disturbing, but the overriding noise from wind turbines is the fluctuating audible swish, mistakenly referred to as –infrasound □ or –low frequency noise □. Objectors uninformed and mistaken use of these terms (as in Fig 3), which have acquired a number of anxiety-producing connotations, has led to unnecessary fears and to unnecessary costs, such as for re-measuring what was already known, in order to assuage complaints. »
	(Syndicat des énergies renouvelables, 2010)	<p>« Windmills, just like the wind in the trees or the circulation of traffic emit infrasound, that's to say low frequency sound below the audible limit of the human ear, but the impact of infrasound on human health has only been observed in very rare situations and never in the case of a wind farm. »</p> <p>« Les éoliennes, tout comme le vent dans les arbres ou la circulation automobile, émettent des infrasons, c'est-à-dire des sons de basse fréquence, au dessous du seuil audible par l'oreille humaine. Mais l'impact des infrasons sur la santé humaine n'a été observé que dans très rares situations et jamais dans le cas de parcs éoliens.»</p> <p>–The production of infrasound by wind mills is at close proximity well analysed and very moderate: it is without danger for people. □</p> <p>« ...la production d'infrasons par les éoliennes est, à leur voisinage immédiat, bien analysée et très modérée : elle est sans danger pour l'homme ; »</p>

<u>Vibration</u>	(Colby, 2009)	« Vibration of the body by sound at one of its resonant frequencies occurs only at very high sound levels and is not a factor in the perception of wind turbine noise. »
	(Colby, 2009)	« The ground-borne vibrations from wind turbines are too weak to be detected by, or to affect, humans. »
<u>EMFs</u>	(King, 2010)	« Wind turbines are not considered a significant source of EMF exposure since emissions levels around wind farms are low. »
	(Rideout & Bos,2009)	« Lower exposure than other electricity generation / Underground cables bury electrical field »
<u>Shadow Flicker</u>	(King, 2010)	« About 3 per cent of people with epilepsy are photosensitive, generally to flicker frequencies between 5-30Hz. Most industrial turbines rotate at a speed below these flicker frequencies »
	(Rideout & Bos,2009)	« • Most pronounced at distances from wind turbines less than 300 m (1,000 feet) • No evidence of health effects • Aesthetic or nuisance effect »
	(Académie nationale de médecine, 2006)	« The fear of an epileptic effect from windmills has often been brought up. However, if in other circumstances the epileptic reaction to a repetitive light stimulation has been demonstrated, we have not found any observation incriminating windmills in this pathology; this fear is not supported by any reviewed case. » « La crainte d'un effet épileptogène des éoliennes a été souvent évoquée. Cependant, si dans d'autres circonstances le rôle épileptogène d'une stimulation lumineuse répétitive est bien démontré, nous n'avons retrouvé dans la littérature aucune observation incriminant les éoliennes dans cette pathologie: cette crainte n'est étayée par aucun cas probant. » « There is not a risk of the stroboscopic visual stimulation from the rotation of windmill blades. » « qu'il n'y a pas de risques avérés de stimulation visuelle stroboscopique par la rotation des pales des éoliennes »
<u>Ice Throw and Ice Shed</u>	(King, 2010)	« Depending on weather conditions, ice may form on wind turbines and may be thrown or break loose and fall to the ground. Ice throw launched far from the turbine may pose a significant hazard. Ice that sheds from stationary components presents a potential risk to service personnel near the wind farm. Sizable ice fragments have been reported to be found within 100 metres of the wind turbine. Turbines can be stopped during icy conditions to minimize the risk. »

<u>Structural hazards</u>	(King, 2010)	« The maximum reported throw distance in documented turbine blade failure is 150 metres for an entire blade, and 500 metres for a blade fragment. Risks of turbine blade failure reported in a Dutch handbook range from one in 2,400 to one in 20,000 turbines per year (Braam et al 2005). Injuries and fatalities associated with wind turbines have been reported, mostly during construction and maintenance related activities. »
	(Académie nationale de médecine, Groupe de Travail, 2006)	« ... the risks associated with the installation, functioning and disassembly of these turbines are anticipated and taken into account by the vigorous regulations for industrial sites, which apply to this phase of installation and to the demolition of obsolete wind.» « ...les risques traumatiques liés à l'installation, au fonctionnement et au démontage de ces engins sont prévus et prévenus par la réglementation en vigueur pour les sites industriels, qui s'applique à cette phase de l'installation et de la démolition des sites éoliens devenus obsolètes. »
<u>Setbacks</u>	(King, 2010)	« The minimum setback for a wind turbine is 550 metres from a receptor. The setbacks rise with the number of turbines and the sound level rating of the selected turbines. For example, a wind project with five turbines, each with a sound power level of 107dB, must have its turbines setback at a minimum 950 metres from the nearest receptor. These setbacks are based on modelling of sound produced by wind turbines and are intended to limit sound at the nearest residence to no more than 40 dB. »
	(Syndicat des énergies renouvelables, 2010)	«The volume of a windmill functioning at a distance of 500 metres rises to 35db, the equivalent of a whispered conversation. So, to eliminate all sound for those living nearby, the developers of wind projects should respect a certain distance from the nearest residence. » «Le volume d'une éolienne en fonctionnement à 500 mètres de distance s'élève à 35 décibels, soit l'équivalent d'une conversation chuchotée. Afin d'éliminer tout de gêne sonore pour les riverains, les développeurs de projets éoliens respectent un éloignement et les premières habitations. »

	(Académie nationale de médecine, Groupe de Travail, Mars, 2006)	<p>«It is understood that the worries and fears have largely been spread because they serve as supplementary arguments for Associations which oppose the installation of these turbines for ecological, esthetic or economic motives, put forward, generally, politically and not with the competence of the Academy. Presently in the scientific literature, there is little proof of the potential dangers of windmills on man. »</p> <p>«On comprend que ces doléances et ces craintes aient été alors largement diffusées, parce qu'elles servaient d'arguments supplémentaires aux Associations qui s'opposent à l'installation de ces engins pour des motifs écologiques, esthétiques ou économiques, qui, eux, relèvent de la politique générale, et non des compétences de l'Académie. Actuellement, dans la littérature scientifique, on retrouve très peu de données sur les dangers potentiels des éoliennes pour l'homme. »</p>
<u>Impacts on Wildlife</u>	(Newman and Zillioux, 2009)	<p>«Acidic deposition, climate change and mercury bioaccumulation are identified as the three most significant and widespread stressors to wildlife from electricity generation from fossil fuel combustion in the NY/NE region. Risks to wildlife vary substantially by life cycle stage. Higher risks are associated with the resource extraction and power generation stages, as compared to other life cycle stages. Overall, non-renewable electricity generation sources, such as coal and oil, pose higher risks to wildlife than renewable electricity sources such as hydro and wind. Based on the comparative amounts of SO₂, NO_x, CO₂ and mercury emissions generated from coal, oil, natural gas, and hydro and the associated effects of acidic deposition, climate change and bioaccumulation, coal as an electricity generation source is by far the largest contributor to risks to wildlife in the NY/NE region. »</p> <p>(Newman and Zillioux, 2009, p.iii)</p>
	(The Royal Society for Protection of Birds, 2011)	<p>Ruth Davis, the head of Climate Change Policy at The Royal Society for Protection of Birds has said:</p> <p>«The need for renewable energy could not be more urgent. Left unchecked, climate change threatens many species with extinction. Yet, that sense of urgency is not translating into action on the ground to harness the abundant wind energy around us. »</p> <p>«The solutions are largely common sense. We need a clear lead from government on where wind farms should be built and clear guidance for local councils on how to deal with applications. We must reduce the many needless delays that beset wind farm developments. »</p>

Appendix 2: List of Works Consulted

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