Canadian Wind Energy Association
Association canadienne de l'énergie éolienne

Canadian Wind Energy Association Position on Setbacks for Large-Scale Wind Turbines in Rural Areas (MOE Class 3) in Ontario

September 28, 2007

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1. Executive Summary

The Canadian wind industry has witnessed rapid growth in recent years, with Ontario emerging as a leader in both current and projected installed capacity. However, future growth of wind in the province will depend largely on the existence of effective regulatory processes at the municipal level. Without appropriate municipal permitting processes, approvals processes and zoning bylaws, further wind development will be greatly impeded. A key issue at hand involves *setbacks* – or the distance between turbines and dwellings, property lines, roads and other human developments. CanWEA has developed this document to assist Ontario municipal authorities in developing appropriate regulations with respect to these setbacks.

Comprehensive setback guidelines for large-scale wind turbines should address a series of objectives including ensuring public safety, minimizing on and off-site impacts, and promoting good land use planning and practices while balancing the economics and viability of the wind project.

The definition of appropriate setbacks revolves around four main issues: a) ensuring public safety in the event of ice shedding or turbine failure, b) ensuring acceptable sound levels for surrounding receptors, c) ensuring minimum impact on radio, radar and telecommunications and c) ensuring minimal impact on sensitive environments. A review of existing guidelines, regulations and research provides the technical foundation for development of “Best Practices” in all four cases:

- Studies into ice shedding and blade failure conclude that risks to objects or individuals directly drop off significantly with increasing distance from the turbine itself. It is clear then that public safety can be ensured by establishing setbacks between turbines and non-inhabited areas (e.g. property lines and roads) on the basis of a set distance from the area immediately under the turbine. *CanWEA recommends a distance of blade length plus 10 metres from public roads, non-participating property lines and other developments.*
- Studies into sound indicate that propagation is a function of many factors (e.g. turbine model, topography, prevailing wind conditions) and can vary greatly from one site to another. Therefore, setbacks between turbines and dwellings should be set on the basis of sound levels at the receptor rather than on a set distance. *CanWEA recommends a sliding scale for acceptable sound, based on Ontario Ministry of Environment Sound Guidelines, starting at 40 dBa at 4 m/s, rising to 53 dBa at 11 m/s. Note that the setback may be less for participating landowners.*
- Setbacks from radio, telecommunication, radar and seismoacoustic systems should be based on a technical, collaborative review of potential cases of interference and appropriate mitigation measures. *CanWEA recommends following 2007 guidelines developed by the Radio Advisory Board of Canada (RABC) and CanWEA.*
- Environmental impacts are largely site-specific and addressed through the provincial and (if applicable) federal Environmental Assessment processes. *CanWEA recommends that setbacks in this case should be defined through a site-specific study as part of the Provincial or Federal Environmental Screening process and discussion with the local planning authority responsible for the feature in question.*

2. Introduction

The Canadian wind industry has witnessed rapid growth over the past five years and Ontario is no exception; by the end of 2006 the province had the highest installed wind capacity of any Canadian province. This growth has brought with it a series of challenges for municipal governments as they seek to establish the necessary regulatory framework, including a review of permitting processes, approval processes, zoning bylaws and so on. Given the high visibility of modern wind turbines, it is not surprising that a great deal of attention has been paid to the issue of setbacks: How far should turbines be set back from dwellings, property lines, roads etc. in order to ensure public safety and a harmonious integration of wind into the community?[1]

In many jurisdictions the development of mandatory setbacks has taken place independent of other federal and provincial planning processes and without the benefit of experience from other regulating bodies in similar situations. As result, the definition and application of setbacks varies widely between regions, creating difficulties for municipalities, project developers, landowners and other groups.

The purpose of this paper is to outline guidelines for setbacks that can serve as a model for municipalities, communities and other stakeholders in the wind energy industry. The paper, developed by the Canadian Wind Energy Association (CanWEA) through its Ontario Caucus, with broad input from the industry, technical experts and international research, provides an analytical basis and rationale for setbacks that address issues of both safety and community acceptance in the best interests of all stakeholders. The paper primarily offers methods to determine setbacks on a site specific basis using specific turbine characteristics. CanWEA has also tried to harmonize these guidelines with current provincial and federal regulations, in order to minimize the resources required by groups in developing and maintaining parallel processes.

It is hoped that these recommendations will provide consistency in defining setbacks and help to streamline the review and approvals process for wind turbines in rural areas (MOE Class 3) of Ontario.[2]

3. Defining Setbacks

Comprehensive setback guidelines for large-scale wind turbines should address a series of objectives including ensuring public safety, minimizing on and off-site impacts, and promoting good land use planning and practices while balancing the economics and viability of the wind project.

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1 For the purposes of this paper the term setback is defined as: *the shortest horizontal distance measured at grade between a residential building, lot line, public roadway, or other identified feature and the nearest part of the wind turbine structure.*

2 It should be noted that the current document only applies to large wind turbines. Small wind turbines (i.e. those with a rated capacity of 300 kW or less) are a distinct category, and are addressed separately in the CanWEA document "Small Wind Siting Guidelines and Model Municipal Zoning Bylaws" available at www.smallwindenergy.ca.

Most concerns associated with safety, sound and land use can be addressed by placing some level of distance between wind turbines and people, residences, property lines, roads, infrastructure, and natural features. Although no consensus on appropriate distances or types of setbacks can be found in existing policy in Ontario, most local government requirements include setback distances between the wind turbine and residences, property lines, and roads. Some communities have also defined setbacks from railroads, transmission lines and other infrastructure.

In defining setbacks distances there is a need for the setbacks to be reasonable and to allow flexibility in the location of the turbines on the land so as to balance the needs of the community, land owner and wind farm developer. These considerations balance efficient use of agricultural land, maximization of wind power and the need to minimize the impact on surrounding land, roads, buildings and people.

A number of methodologies, guidelines and regulations related to setbacks already exist at a provincial and federal level. Planning processes such as the federal and provincial Environmental Assessment Acts, Ontario Planning Act and Canadian Building Code provide very useful references for local governments. The following section provides an overview of these relevant processes and their application in setback definition.

4. Existing Planning Processes

A wind power facility, whether it consists of a single wind turbine, or a group of wind turbines (referred to as a wind farm), requires a number of permits and approvals for both construction and operation. Some approvals are required for all installations, while others are triggered by the specific natural or social surroundings of the proposed project. Under the Planning Act, Municipal review and/or approval is required for all installations including accessory or private use.

4.1 Federal and Provincial Review and Approvals

Tables 1 and 2 outline the review and approvals processes potentially required by a wind farm being built and operated in Ontario. The third column of each table identifies the specific situation that will trigger the involvement of each review process. It is important to note that not every review on this list will be required for every wind farm.

Table 1 - Federal Reviews and Approvals

Approval Requirement	Departments or Agencies Involved	Trigger for review
Screening in accordance with the requirements of the *Canadian Environmental Assessment Act*	Canadian Environmental Assessment Agency Natural Resources Canada (Responsible Authority (RA)) Fisheries and Oceans Canada as RA to be confirmed Environment Canada Transport Canada	Construction on Federal land Application for federal ecoEnergy Incentive Possible effect on Navigable waterways
Fisheries Act subsection 35(2) authorization	Fisheries and Oceans Canada	Possible effect on fished waters
Blasting Permit near fisheries	Environment Canada	Possible effect on fished waters
Navigable Waters Protection Act permit	Transport Canada	Possible effect on Navigable waterways
Lighting scheme	Transport Canada	Any structure of taller than 90m above ground level (AGL) but below 150 m AGL
Aeronautical safety	NAV Canada	Any structure of taller than 90 m AGL but below 150 m AGL

Table 2 - Provincial Review and Approvals

Approval Requirement	Departments or Agencies Involved	Trigger for review
Environmental screening in accordance with the requirements of Ontario Regulation 116/01 and Guide to Environmental Assessment Requirements for Electricity Projects ** Wind turbine installations $\geq$ 2 MW – Category B – Environmental Screening Process	Ministry of the Environment (MOE)	Wind farm combined capacity of greater than 2 MW
Certificate of Approval for noise evaluation on a per turbine basis per MOE NPC-232	Ministry of the Environment (MOE)	Turbines proposed within 1000 m of a receptor

Approval Requirement	Departments or Agencies Involved	Trigger for review
Phase 1 & 2 archaeological survey	Ministry of Culture	Wind farm capacity of greater than 2MW
Class environmental assessment in accordance with Class Environmental ▪ Assessment for Minor Transmission Facilities ▪ > 50kV transmission line > 2 km	Ministry of the Environment (MOE)	Transmission lines between 115kV & 500kV and longer than 50km Transmission lines greater than 500kV and longer than 2km.
Land Lease Option Agreement with Crown (Crown Land Disposition)	MNR (Ministry of Natural Resources)	Siting on Ontario MNR land
Disposition of Crown lands for wind ▪ Class EA in accordance with the MNR *Class Environmental Assessment for MNR Resource Stewardship and Facility Development Projects for wind resource assessment* ▪ Class EA in accordance with the MNR *Class Environmental Assessment for MNR Resource Stewardship and Facility Development Projects for wind farm construction* ▪ Aboriginal consultation process	Ministry of Natural Resources (MNR)	Siting on Ontario MNR land
Public consultation for disposition of wind rights in Conservation Authority lands	Regional Conservation Authority	Siting within Conservation area
Entrance construction permit	Ministry of Transportation (MTO)	Entrance/egress onto a provincial highway
Section 92 Ontario Energy Board Act "Leave to Construct"	Ontario Energy Board	transmission facility over 50kV and longer than 2 km
Generator's License	OEB (Ontario Energy Board)	All generation facilities
Connection Impact Assessment (CIA) to assess the impact of a connection to a distribution system	Grid Operator	Any generation facility connecting to the existing distribution grid.
Transmission Customer Impact Assessment to determine the impact of new generation connection on existing transmission customers	Grid Operator	Combined capacity of greater than 10MW
Finalized System Impact Assessment & connection agreement	Independent Electricity System Operator (IESO)	Combined capacity of greater than 10 MVA

Approval Requirement	Departments or Agencies Involved	Trigger for review
Connection Cost Recovery Agreement (CCRA) to recover costs to grid operator of changes to allow connection.	Grid Operator	Any generation facility connecting to the existing distribution or transmission grid.
ESA site approval	Electrical Safety Authority	Any generation facility requires site approval for the design of generation (wind turbine) and site installation.

These processes are comprehensive, use the most up-to-date scientific information and have served the province well over time and across all industries. Where appropriate, these processes can provide a useful and quantifiable rationale for defining any required setbacks.

4.2 Municipal Planning and Approvals

All wind energy projects in Ontario are subject to permitting by municipal authorities, who may review project proposals under various planning mechanims, including Official Plans, local zoning by-laws, land use planning approvals, etc. The following section outlines each of these and their role in the planning and approvals process for wind energy projects.

The Official Plan is the long range land use planning document for municipalities. It provides guidance to council, staff and the public, in making land use decisions and often includes general policies about wind turbine setbacks. The policies may also identify the process a local municipality will require to determine suitable setbacks for the particular situation, related to noise and safety.

Municipal zoning by-laws establish regulations including minimum setbacks for buildings and structures, and may include wind turbine setbacks. These setbacks are normally measured from the structure to the nearest property lines. These setbacks are evaluated by the municipality at the time a building permit application is made.

Municipal land use planning approvals may also include site plan applications. A site plan agreement shows the location of the turbine, roads, underground cabling, fencing, drainage and road access. The applications are reviewed, approved and registered on the title of the property showing the details of site development.

Consent applications create permanent (greater than 21 years) access road easements, cabling easements etc. These applications do not address zoning or setbacks and are intended to identify long term use of a small portion of the farm lands.

The following sections provide greater detail on the key drivers of setback definition and outline the processes that govern or inform them.

5. Key Considerations in Defining Setbacks

For the most part, setback distances are based on two key considerations:

a) Ensuring acceptable sound levels for surrounding receptors (e.g. dwellings)[3]
b) Ensuring public safety in the event of ice shedding or turbine failure.

This section provides a discussion of these elements.

5.1 Sound Issues

One of the primary concerns for wind development involves turbine sound levels and their impacts on local residences. Concerns about sound depend on a number of factors including:

- level of intensity, frequency, distribution, and pattern of the sound source,
- background sound levels,
- terrain and topography between the source of the sound and the point of reception, and,
- the characteristics of the reception point (Renewable Energy Laboratory 2002).

Siting and wind farm design can mitigate most, if not all, concerns perceived by human receptors in the vicinity of the wind farm facility. The following discussion provides a background on the sound from turbines, regulations in the province of Ontario and best practices that CanWEA and partners have developed in relation to sound issues.

Sound from Turbines

Wind turbines generate sound from multiple mechanical and aerodynamic sources. Mechanical sounds are produced from the major mechanical components found in the turbine, such as the gearbox, generator and yaw motors. Fans and hydraulic motors can also contribute to the overall sound emissions from the turbine. Aerodynamic sounds are produced as air passes over rotating turbine blades, resulting in a characteristic 'swoosh'.

Although wind turbine manufacturers have done a great deal to reduce these sound emission levels, wind turbines do emit sound that can impact an area around the turbines. When residences are in the vicinity of the turbines, care must be taken to ensure that operation of the wind farm does not cause annoyance or interference with the quality of life of residents. This does not necessarily mean that sound from turbines should be inaudible at all times, but rather that it should be kept to an acceptable level (note: the Ontario Ministry of Environment (MOE) defines the term "noise" as simply as "unwanted sound"). Inaudibility is an unrealistic expectation and is not required or expected from other sound emitting sources such as agriculture, industrial/commercial activities, transportation or the natural landscape.

3 A receptor is typically defined as a residence, but could also include institutional structures such as hospitals, schools or places of worship, or First Nations sacred sites. (HGC Engineering . 2007. Wind Turbines and Sound: Review and Best Practices". Available online at http://www.canwea.ca/Environmental_Issues.cfm.)

The determination of acceptable sound levels is complex, due to the subjective nature of the issue: sensitivity to sound can vary considerably between individuals, typically decreasing with age and past exposure to noise.[4] In Canada, a number of assessment guidelines, methodologies and criteria are currently in use. The Ontario Ministry of Environment has developed a set of noise assessment guidelines specifically intended for wind turbines.

Ontario Ministry of Environment Certificate of Approval

The Ontario Ministry of Environment (MOE) has established sound level limits for different land uses in Ontario. In Ontario, prior to construction, a wind farm proponent is required to obtain a Certificate of Approval (Air) (C of A) from the MOE to ensure that the proposed development will not adversely affect the environment. In order to obtain a C of A a proponent must address the site specific considerations relevant to the proposal, provide enforceable requirements that ensure protection of human health and the natural environment, comply with legislation and policy guidelines, and acknowledge issues that fall within the mandate of the Ministry (MOE 2007). Sound impacts of proposed wind turbines are considered in assessing applications for a C of A.

To assist proponents in applying for a C of A, the MOE has published a series of technical guideline documents for assessing industrial noise. The document most relevant to Ontario wind farms is the *NPC-232 Sound Level Limits for Stationary Sources in Class 3 Areas (Rural)* publication (NPC-232). NPC-232 provides general assessment guidelines governing industrial noise impacting a sensitive land use such as a residence or a residential area (MOE 1995). Due to the growth of wind energy development in Ontario the MOE developed the technical document *Interpretation for Applying MOE NPC-232 Technical Publications to Wind Turbine Generators* to provide additional guidance for the specific assessment of wind farms and for the development of a Noise Report that will be submitted in support of the Certificate of Approval (MOE 2004).

Ontario Sound Regulations and Setbacks

Sound is most often measured as sound pressure levels, commonly expressed in decibels (dB). NPC-232 indicates that the applicable sound pressure level limit from a source, such as a wind farm, should be the background sound level of the area. In rural areas, where the normal background level is low, NPC-232 sets maximum acceptable sound limits for the wind farm. For quiet nighttime periods (19:00-07:00 hours) in rural areas a maximum sound pressure limit of 40 dB is required and 45 dB is required for quiet daytime periods (07:00-19:00 hours).

A proponent must ensure that the design of their wind farm and placement of the turbines does not cause sound levels to exceed these limits. Through the environmental impact assessment process the proponent must develop computer modeling scenarios that estimate how the sound from each turbine travels across the landscape. The appropriate setback distance will vary depending on the type of turbine used, the

4 For a more in-depth discussion of sound issues related to wind turbines, see: HGC Engineering . 2007. Wind Turbines and Sound: Review and Best Practices". Available online at http://www.canwea.ca/Environmental_Issues.cfm.

number of turbines installed, the topography and terrain of the area, and the location of the receptor.

In practice, with current turbine technology, acceptable separation distances for sound under NPC-232 are generally greater than 250 metres.

Once the C of A has been issued and the wind farm is in operation, the set levels are required to be maintained for the life of the wind farm, based on the actual sound levels produced.

CanWEA Best Practices

To provide further clarity and support for decision makers, CanWEA has developed a study that establishes a recommended methodology and acceptable sound levels for wind installations (HGC Engineering 2007). The CanWEA Best Practices are largely consistent with the MOE guidelines in NPC-232. Like the MOE guidelines, the study recommends that setbacks be established on the basis of sound pressure levels at receptor points, as opposed to setbacks based on a set or prescribed distance. This is to reflect the ongoing efforts of turbine manufacturers to reduce the sound output from their wind turbines and to reflect the fact that a single wind turbine or a wind farm may need different setbacks from the same receptor.

5.2 Safety Issues

Similar to sound, safety issues are a common consideration in setback development. In the case of wind turbines, safety issues generally refer to the risks associated with ice shedding, turbine structural failure and blade failure.

The basis of any safety determination of wind turbines is a value judgment defining the acceptability of risk, which is in itself a relative concept. Everyday society as a whole accepts, voluntarily or involuntarily, a certain level of risk from the presence of large structures such as communication towers, power lines, silos, buildings or even trees relative to the location of roads and buildings.

The following sections discuss the specific issues of ice shedding, turbine structural failure and blade failure.

Icing Issues

Under appropriate temperature and humidity conditions, ice can build up on the rotor blades, nacelle and tower of a wind turbine as it would on any structure exposed to the elements. Two types of risk may occur if ice accumulates on a turbine, either ice fragments dislodge and are shed from the rotor of the operating turbine due to aerodynamic and centrifugal forces or they dislodge from the structure and fall to the ground when it is shut down or idling without power production. The risk of each situation depends on the regional weather and wind conditions, instrumentation of the turbine's control system, and the operational and mitigation procedures in place.

A number of conditions must be in place for ice shed from the turbine to cause a risk and these need to be put into context in a discussion of icing. These include; the joint probability that a) icing occurs, b) that the ice dislodges from a blade, c) that the ice fragment is of substantial size and travels an appreciable distance, d) that ice fragments remains intact through the air, e) that the fragment is thrown in a particular direction and lands in a particular square metre of ground, and f) that someone or something is in that space at the time the ice lands.

Occurrence of Icing

The first issue that must be addressed is the likelihood that icing occurs. Icing events, freezing drizzle or freezing precipitation, that lead to ice accumulation are not extensive across most of Ontario. A national freezing drizzle and freezing precipitation study for the 30-year period 1961 to 1990 estimated an annual average of 10 to 25 hours of freezing rain hours throughout southern and eastern Ontario and eastern and northwestern parts of northern Ontario (Klasen et al 2003). This range could be higher for exposed and elevated sites. Observations also indicate that the Great Lakes influence the occurrence of freezing precipitation at shoreline locations and during some months of the year (Cortinas 2000). The influence of Great Lakes water temperatures results in a lower frequency of freezing precipitation near the lakeshore versus areas further inland. The results of freezing rain trend analysis in this study suggest that the risks of average freezing rain occurrence have remained relatively the same or have been decreasing in north-western Ontario, southern Ontario or central Ontario during the period 1953-2001 (Klasen et al. 2003).

Figure 1 below depicts the Canadian Standards Association (CSA) S37 Standard freezing rain ice accretion design criteria for communication structures in Canada, indicating radial ice amounts (mm) that are likely to occur in regions across Canada. Most of Ontario falls within Class II which is characterized by moderate icing conditions of approximately 25 mm.

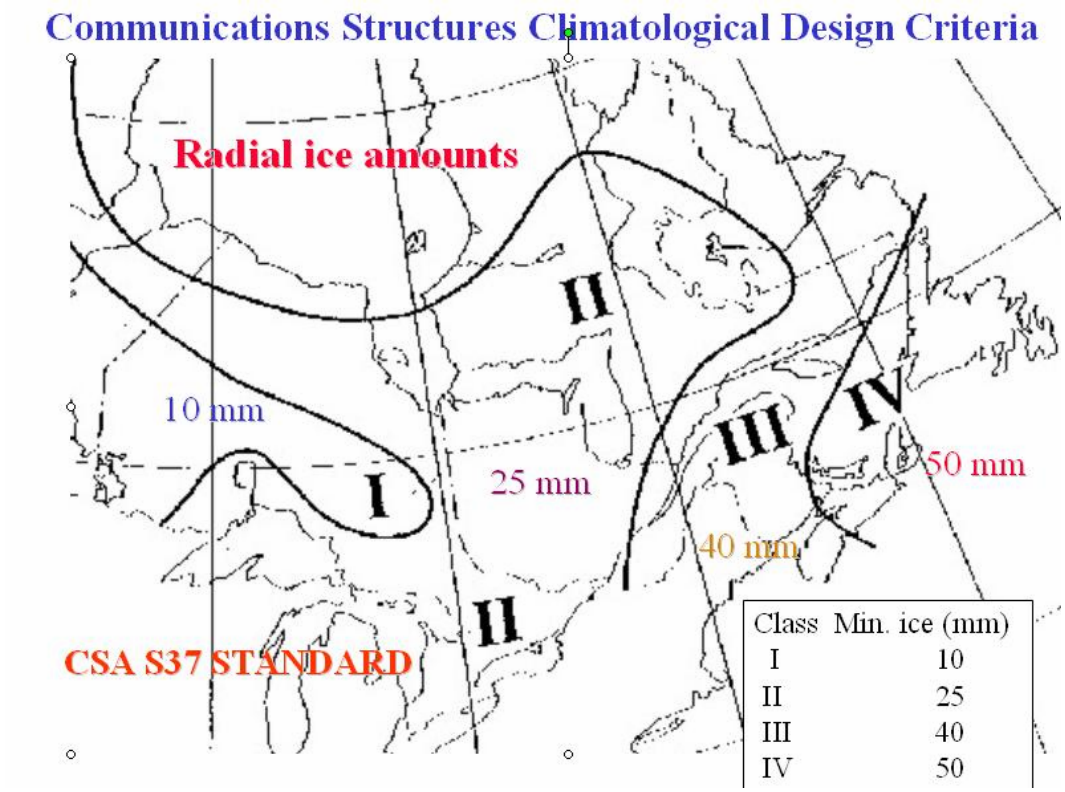

Figure 1 - Canadian Standards Association (CSA) climatological ice amount design criteria for communication structures (CSA 2001).

Based on the data from these studies, it can be reasonably said that the potential for icing in Ontario is light to moderate, i.e. 1 to 5 days.

Ice Shedding

A stationary turbine (i.e. the rotor is not rotating), poses little risk of injury as the ice falls to the ground within a very small distance of the turbine base. Only the area directly under the turbine would be affected by melting ice falling from the turbine, similar to what would be observed from a barn, tree, silo, house, utility pole or other structure.

The risks associated with an operational turbine are somewhat different. Higher rates of icing may occur on the rotor blades of an operational turbine (i.e. that the rotor is rotating) due to the relative velocity of the turbine's rotor (Garrad Hassan Canada 2007). As ice build-up is affected by the flexing of the blades, there is a possibility that ice fragments may be thrown from the turbine. It is the probability of these occurrences, the distance ice travels and the resulting risk this may pose on residences, roads and individuals that need to be understood and addressed.

Ice can accumulate on and regularly drop off the leading edge of a rotor blade due to aerodynamic and centrifugal forces and blade flexing (Siefert 2003). The distance that ice travels will depend on the rotor azimuth, the rotor speed, the local radius and the wind speed. Also the size of the ice fragment and its mass will affect the flight trajectory (Siefert et al. 2003).

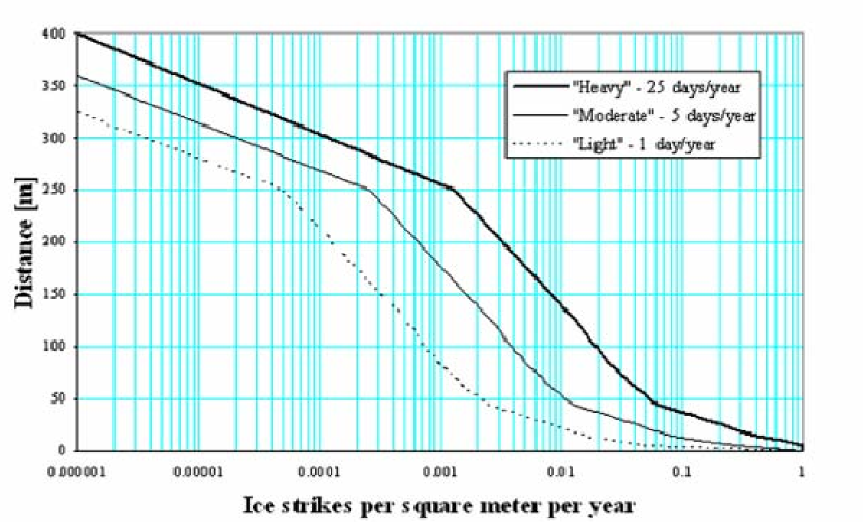

Figure 2 - Probabilities for 3 ice accretion levels per m^2 per year
(Garrad Hassan Canada 2007)

Observations in several studies show that ice fragments do not maintain their size and shape but rather break up into smaller fragments immediately after detaching from the blade (Siefert et al. 2003). Observations from the Wind Energy in Cold Climates study documented shows that the majority of recorded fragments have landed less than 100 m from the turbine (Garrad Hassan Canada 2007). As Figure 2 demonstrates, the probability of ice strikes beyond 200 m is extremely low at between 0.0001 and 0.003 ice strikes per square meter per year. It should be noted that the "kink" in the curves at 250 m are the result of a pragmatic introduction of additional conservatism. Figure 3 shows data collected in the Wind Energy and Cold Climate study.

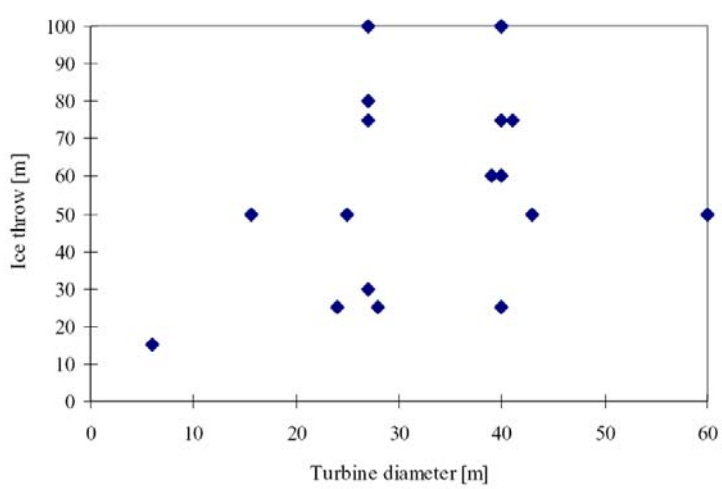

Figure 3 - Recorded Ice Throw data
(Morgan et al. 1997)

Ontario Hydro monitored the operation of its first wind turbine at what is now the Huron Wind farm for the first 6 years of operations, from 1995 to 2001, and approximately

1000 inspections were made and recorded. The observations note some form of ice build-up in only 13 instances. Most of these instances were minor and if fragments did detach from the blades and were identifiable on the ground they were typically found no more than 100 m from the turbine, though most were found much closer to the turbine.

Key Considerations

The importance of the following factors also needs to be considered in any risk assessment of icing hazards:

- Accounting for the presence of individuals in the unpleasant weather conditions necessary for icing;
- Presence of tree coverage or other structures that may provide shelter;
- Frequency of wind direction in relation to the risk area under assessment;
- Terrain slope; and
- Implementation of any mitigation measures or operational procedures undertaken by the turbine operator (Garrad Hassan Canada 2007).

As noted above, operational procedures and mitigation strategies can help to reduce risk to the public and operational staff at time and in areas where there is potential for icing hazards. Mitigation strategies can include:

- Curtailment of turbine operations during periods when there is potential for icing.
- Implementation of features in the turbine which prevent ice build-up or turbine operation during periods of icing, for example automated ice detection systems or blade heating systems.
- Establishment of protocols and procedures for operational staff to follow and act upon to reduce the risk of ice falling or being thrown from the turbine when climatic conditions are likely to lead to icing on the turbine
- Use of warning signs or restricted access in areas of risk.

Modern wind turbines have a number of mechanisms to detect ice build up and trigger operational procedures that help to ensure that any icing does not result in dangerous ice throws. The first mechanism is an imbalance sensor. If ice does build up on the blades the turbine will sense an imbalance and will automatically curtail operations as this imbalance can cause damage to the machine. Turbine power output calculations will also warn operators of any potential ice build-up on blades. The turbine routinely monitors power output and expected efficiencies at specific wind speeds. If output falls below expected ranges a warning triggers operators to inspect or shutdown the turbine. If a freezing event causes the wind speed or direction sensors to freeze the turbine will stop operating. These mechanisms prevent operation of a turbine in icing conditions and help to prevent risk associated with ice shedding.

The referenced studies demonstrate that through risk assessment, scenario modeling and mitigation measures, the risk associated with ice shedding can be effectively assessed and the risks are very low relative to generally accepted natural hazards, particularly outside of the area immediately under the turbine (defined as a circle centred at the turbine base with a radius equal to the length of one blade).

Turbine Structural Failure

Structural failure is assumed to be major component failure under conditions which components should be designed to withstand. This mainly concerns storm damage to turbines and tower collapse. Poor quality control and component failure can also be responsible. However, with the application of established design, manufacture and construction standards and site specific assessment for projects the risk of tower failure is negligible (DEWI 2007).

The International Electrotechnical Commission (IEC) has developed standards, specifically, "WT 01 System for conformity testing and certification of wind turbines", for the purpose of improving the safety of operations of turbines. Through the process of certification of a wind turbine, an accredited certification body reviews the design assumptions, test results, manufacturing process, site specific conditions and tower and foundation designs. All modern wind turbines are subject to certification standards.

The Canadian Standards Association is currently developing wind turbine specific standards for Canada in cooperation with the IEC. In Ontario the Electrical Safety Authority also has to approve the design and installation of the turbines to ensure that they meet the Ontario Electrical code. The turbine design also has to meet Ontario Building Code Standards.

Based on the application of the above standards turbine structural failure is extremely rare. A properly certified turbine imposes negligible risk of the tower to collapse.

Turbine Blade Failure

To better understand the potential risk of turbine failure, CanWEA commissioned a review of publicly-available literature pertaining to turbine rotor failures where that failure resulted in full or partial blade throws (Garrad Hassan Canada 2007). It should be noted that recent international studies of such events suggest that blade failure events are very rare, and therefore data describing the occurrences are quite scarce.

The review found that the main causes of blade failure are related to three events: a) human interference with a control system leading to an overspeed situation, b) lightning strike, and; c) manufacturing defect in the blade.

- **Overspeed:** Through the implementation of stringent standards, blade failures resulting from over speed situation due to control system interference are rare. Rigorous design standards and exhaustive analysis in the certification process of these control systems ensure that systems always operate in a safe and reliable manner. Industry certification also ensures that turbines have a safety system completely independent of the control system. There are redundancies built into these safety systems that ensure that in the event of a failure of one system, the other system can be relied upon to control rotor speed.

- **Lightning:** Blade failure resulting from a lightning strike is also extremely rare due to development of lightning protection systems and best practice standards over the past decade. This has led to a significant reduction in events where lightning causes structural damage. It should be noted that failure from lightning strikes cause does not often lead to detachment of blade fragments

- **Manufacturing defect:** Structural manufacturing defects have been steadily reduced through improved experience and quality control in the industry. Standards developed by the International Electrotechnical Commission (IEC) are applied to all current large wind turbines, and certification to these standards requires full scale strength testing of every turbine blade design (Garrad Hassan 2007)

Similar to the issue of ice shedding, the review demonstrates that the probability of blade failure is very low, and that the probability of blade loss is even lower. This indicates that the safety risks are very low, particularly outside of the area immediately under the turbine.

5.3 Environmental Issues

Additional concerns expressed in the development of setbacks are related to issues of wind turbine impacts on the natural environment. Concerns related to migratory birds, bats, flora, fauna, etc. are frequently cited in setback discussions. As stated earlier, these are legitimate concerns and there are processes in place through the Environmental Assessment process to address any potential impacts and to inform the development of setbacks. Many setbacks associated with these features are site-specific. Generally, provincial parks, environmental sensitive areas (ESAs), Areas of Natural and Scientific Interest (ANSIs), Provincially Significant Wetlands (PSWs), raptor nests, heronries, and other protected areas should be carefully studied to identify site-specific buffers, which could arise after discussions with the local planning authority relevant to the site in question. These discussions would identify what restrictions may be in place related to these natural areas, and the expectations or planning requirements for building a project within a certain distance of the natural areas after review of the study results.

5.4 Conclusions

Studies into ice shedding and blade failure conclude that there are very low risks of either event resulting in harm to objects or individuals in the vicinity of the turbine. Outside of the area immediately under the turbine (i.e. a circle centred at the base with a radius equal to the length of one blade) the risks are extremely low and drop off even further at increasing distance from the turbine itself.

From a safety perspective, it is clear that the setbacks related to non-inhabited areas such as property lines and roads can be based on a set distance from the area immediately under the turbine.

From a human comfort perspective, the setbacks related to inhabited dwellings, i.e. residences, can be set according to sound criteria. Given that this distance exceeds the safety-related setbacks above, it can be concluded that the regulations governing sound and noise from wind turbines and residences provide a sufficient separation distance to ensure public safety.

6. CanWEA Proposed Setbacks

This section draws on the preceding analysis to present CanWEA's recommendations with respect to setbacks for large wind turbines in rural areas (MOE Class 3) in Ontario

6.1 Residential Setbacks

Each wind turbine shall be set back from identified receptors a distance calculated through the Ontario Ministry of Environment's NPC-232 regulations governing appropriate sound level limits in Class 3 Areas (Rural)

Rationale:
As stated above, in Section 4.1, setbacks related to sound emissions should be established using the provincial regulations established by the Ministry of Environment. These regulations were established to address these issues and should be relied upon to provide comprehensive and appropriate setbacks to protect residents from unwanted noise.

Setback thresholds based on sound emissions will provide an appropriate public safety setback from a residence as well. As discussed in Section 4.1, with current turbine technology, acceptable separation distances for sound under NPC-232 are generally greater than 250 metres. This is beyond the critical distance for ice shedding from the rotor blades or any blade fragments that detach from the rotor in the event of failure.

6.2 Town, Village or Hamlet Setbacks

Each wind turbine shall be set back from the identified boundaries of the Town, Village or Hamlet a distance calculated through the Ontario Ministry of Environment's NPC-232 regulations governing appropriate sound level limits in Class 3 Areas (Rural).

Rationale:
As stated above, setbacks related to noise emissions should be established using the provincial regulations established by the Ministry of Environment. These regulations were established to address these issues and should be relied upon to provide comprehensive and appropriate setbacks to protect residents, be it an individual residence or a built up area such as a hamlet or village, from unwanted noise pollution.

Again, setback thresholds based on sound emissions will provide an appropriate public safety setback from a town, village or hamlet as well.

6.3 Public Road Setbacks

Each wind turbine shall be set back a minimum distance equal to one blade length plus 10 metres (10 m) from the nearest public road, determined at the nearest boundary of the underlying right-of-way for the public road. Wind turbine towers proposed within 50 m to 200 m from the public road must demonstrate through risk assessment and mitigation measures that individual risk is minimized.

Rationale:
Based on Ontario's current and proposed installations, with turbine blades averaging 40 metres in length, the proposed minimum setback distance would be in the range of 50 metres from the public road. As noted above, in Section 4.2, individual risk of injury from ice shedding along a public road is based on a number of factors, including separation distance between the turbine and the road, wind direction, wind speed, turbine type, typography, etc. Beyond 200 m the risk is essentially removed. For proposed turbine towers within 50 m and 200 m of the public road risk profiles need to be understood. Risks are very site specific and need to be contextualized based on the characteristics of the site, the proposed turbine location within the site and its orientation to the road. The risks also have to be weighted against the mitigation measures and operational protocol that the developer is proposing to implement at the site.

6.4 Property Line Setbacks

Each wind turbine shall be set back a distance equal to one turbine blade length plus ten metres (10 m) from all property lines, unless appropriate Agreements or Easements are in place with adjacent property owners.

Rationale:
As a non-participating property, i.e. a property not under a contractual agreement with the wind farm development, Ontario's sound regulations would class any residence on the property as a receptor and the sound regulations would provide an appropriate setback for sound and safety at the residence. The issue that remains is to be addressed is safety in the fields or property abutting the wind farm.

The rationale for property line setbacks is similar to that applied to public road setbacks. The proposed distance of turbine blade length plus 10 metres from the property line of a non-participating landowner provides a safe distance that removes any reasonable risk of injury or damage resulting from ice or blade fragments falling from the stationary blades. Based on Ontario's current installations, with turbine blades ranging from 38 to 42 metres in length, these setbacks would place the wind turbine tower in the range of 48 to 52 metres from the property line.

The property line setbacks from participating landowners could be as close as possible or even on the property line, provided both landowners are in agreement. In this case, the rationale for a zero setback is that the impact to existing land uses, typically agriculture, can be minimized.

6.5 Radio, Telecommunication, Radar and Seismoacoustic System Setbacks

Setbacks from radio, telecommunication, radar and seismoacoustic systems shall be determined based on a review of the guidelines developed by the Radio Advisory Board of Canada (RABC) and CanWEA, as referenced in the report entitled 'Technical information on the Assessment of the Potential Impact of Wind Turbines on Radio Communication, Radar and Seismoacoustsic Systems'.

Rationale:
A comprehensive set of best practice guidelines was developed by the Radio Advisory Board of Canada (RABC) and CanWEA in 2007. These guidelines provide a series of analytical methodologies and thresholds that help to indicate where a potential interference may occur between wind turbines and radio, telecommunications, radar or seismoacoustic systems in the area. These guidelines should be used as the starting point for defining any necessary setbacks and/or mitigation measures for nearby radio, telecommunication, radar and seismoacoustic systems.

6.6 Environmentally Sensitive Areas and Natural Feature Setbacks

Setbacks from provincial parks, environmental sensitive areas (ESAs), Areas of Natural & Scientific Interest (ANSIs), Provincially Significant Wetlands (PSW), raptor nests, heronries, and other protected areas are very site-specific and shall be defined through a site-specific study as part of the Provincial or Federal Environmental Screening process and discussion with the local planning authority responsible for the feature in question.

Rationale:
Many setbacks associated with these features are site-specific. Generally, provincial parks, ESAs, ANSIs, Provincially Significant Wetlands, raptor nests, heronries, and other protected areas should be carefully studied to identify site-specific setbacks, which could arise after discussions with the relevant local planning authority. These discussions would identify what restrictions may be in place related to these natural areas, and the expectations or planning requirements for building a project within a certain distance of the natural areas. Provincial and Federal Environmental Screening processes require these reviews. Assessment and calculation of setbacks from these features should be undertaken by persons with qualifications of a recognized professional organization, using current accepted methodology and practices in undertaking the work.

7. References

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Appendix A

The Following best practice and guidance documents are all available online at http://www.canwea.ca/Environmental_Issues.cfm:

Wind Turbines and Sound: Review and Best Practice Guidelines - Howe Gastmeier Chapnik Limited (HGC Engineering), 2007

Wind Turbines and Infrasound - Howe Gastmeier Chapnik Limited (HGC Engineering), 2006

Recommendations for Risk Assessment of Ice Throw and Blade Failure in Ontario – Garrad Hassan Canada, 2007

Recommended Protocols for Monitoring Impacts of Wind Turbines on Birds – Environment Canada / Canadian Wildlife Service, 2006

Technical Information and Guidelines on the Assessment of the Potential Impact of Wind Turbines on Radiocommunication, Radar and Seismoacoustic Systems – Radio Advisory Board of Canada / Canadian Wind Energy Association, 2007