

# **Noise Guidelines for Wind Farms**

Interpretation for Applying MOE NPC Publications to  
Wind Power Generation Facilities

Ministry of the Environment



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# NOISE GUIDELINES FOR WIND FARMS

## Interpretation for Applying MOE NPC Publications to Wind Power Generation Facilities

October 2008

*This document establishes the sound level limits for land-based wind power generating facilities and describes the information required for noise assessments and submissions under the Environmental Assessment Act and the Environmental Protection Act. It replaces the document "Interpretation for Applying MOE NPC Technical Publications to Wind Turbine Generators," Version 1.0, July 6, 2004.*

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## 1. SCOPE

Noise impacts of proposed land-based wind power generation facilities, i.e. Wind Farms, are considered in the course of assessing an application for a Certificate of Approval (Air/Noise), in accordance with section 9 of the *Environmental Protection Act*. Wind Farms two megawatts or more are subject to review under the Environmental Screening Process, in accordance with Ontario Regulation 116/01 under the *Environmental Assessment Act*, and noise impacts are also considered during review under the screening process. The purpose of this document is to describe the applicable sound level limits and to specify the information proponents are to submit to the Ministry of the Environment when seeking approval for a proposed land-based Wind Farm. This document has been developed to provide consistency in the submissions and to streamline the review and approval process. Accordingly, the guidance contained herein is intended to provide uniformity in planning of Wind Farms in Ontario.

Proponents of Wind Farms are to prepare and submit to the Ministry of the Environment (MOE) a Noise Assessment Report that includes details of the wind turbine design and operation, location of the wind turbine(s) within the specific site and surrounding area, as well as summary of compliance with the applicable sound level limits. If applicable, the Noise Assessment Report must also include similar details of the Transformer Substation used for transforming the power from the wind turbine units. This document defines a template for the Noise Assessment Report to be submitted to the MOE.

This document also provides guidance on the assessment of the combined noise impact produced by the proposed Wind Farm in combination with the noise impact of approved Wind Farms or Wind Farms that are in the process of being planned.

## 2. REFERENCES

Reference is made to the following publications:

- [1] NPC-104, "Sound Level Adjustments," Ontario Ministry of the Environment
- [2] NPC-205, "Sound Level Limits for Stationary Sources in Class 1 & 2 Areas (Urban)," Ontario Ministry of the Environment
- [3] NPC-206, "Sound Levels due to Road Traffic," Ontario Ministry of the Environment
- [4] NPC-232, "Sound Level Limits for Stationary Sources in Class 3 Areas (Rural)," Ontario Ministry of the Environment
- [5] CAN/CSA-C61400-11-07, "Wind Turbine Generator Systems - Part 11: Acoustic Noise Measurement Techniques"
- [6] ISO 9613-2, "Acoustics-Attenuation of sound during propagation outdoors - Part 2: General method of calculation"
- [7] ANSI/IEEE C57.12.90, "Distribution, Power, and Regulating Transformers"

## 3. DEFINITIONS

For the purpose of this document, the following definitions apply:

"Environmental Screening Process" is a prescribed planning process for electricity projects set out in Part B of the Guide to Environmental Assessment Requirements for Electricity Projects. As set out in Ontario Regulation 116/01 under the *Environmental Assessment Act*, certain electricity projects are subject to review under the Environmental Screening Process.

“Noise Assessment Report” means a report for wind power electricity generation projects, prepared in accordance with the guidance described in this document.

“Participating Receptor” means a property that is associated with the Wind Farm by means of a legal agreement with the property owner for the installation and operation of wind turbines or related equipment located on that property.

“Switching Station” means a collection point for the outputs of the wind turbine generators. Switching Stations are not significant noise sources.

“Transformer Substation” means a central facility comprised of power transformer(s) and associated equipment such as cooling fans for transforming the electrical outputs from the wind turbine generators to a higher voltage for input to the grid transmission system. Transformer Substations are significant noise sources.

“Wind Farm” means an electrical generating facility comprised of an array of wind turbine generators and a common electrical connection point such as a Transformer Substation or a Switching Station.

The following definitions are also included in the current Publications NPC-205 and NPC-232, References [2] and [4]:

“Class 1 Area” means an area with an acoustical environment typical of a major population centre, where the background noise is dominated by the urban hum.

“Class 2 Area” means an area with an acoustical environment that has qualities representative of both Class 1 and Class 3 Areas, and in which a low ambient sound level, normally occurring only between 23:00 and 07:00 hours in Class 1 Areas, will typically be realized as early as 19:00 hours.

Other characteristics which may indicate the presence of a Class 2 Area include:

- i. absence of urban hum between 19:00 and 23:00 hours;
- ii. evening background sound level defined by natural environment and infrequent human activity; and
- iii. no clearly audible sound from stationary sources other than from those under consideration.

“Class 3 Area” means a rural area with an acoustical environment that is dominated by natural sounds having little or no road traffic, such as the following:

- i. a small community with less than 1000 population;
- ii. agricultural area;
- iii. a rural recreational area such as a cottage or a resort area; or
- iv. a wilderness area.

The following definition is also included in the current Publication NPC-232, Reference [4]:

“Point of Reception” means any point on the premises of a person within 30 m of a dwelling or a camping area, where sound or vibration originating from other than those premises is received.

For the purpose of approval of new sources, including verifying compliance with section 9 of the *Environmental Protection Act*, the Point of Reception may be located on any of the following existing or zoned for future use premises: permanent or seasonal residences,

hotels/motels, nursing/retirement homes, rental residences, hospitals, camp grounds, and noise sensitive buildings such as schools and places of worship.

For equipment/facilities proposed on premises such as nursing/retirement homes, rental residences, hospitals, and schools, the Point of Reception may be located on the same premises.

#### **4. DESCRIPTION OF WIND FARM NOISE**

A Wind Farm is a collection of wind turbines, located in the same area, used for the production of electric power. As the individual wind turbines are separated by several hundred metres from each other, a large wind farm covers an area of tens of square kilometres. Larger Wind Farms may include a Transformer Substation that collects and increases the voltage produced by the turbines to the higher voltage for the grid transmission system.

A typical wind turbine consists of a tall tower with a hub (nacelle or housing) containing the drive-train and generator mounted on top of the tower. Three rotating blades (typically) are connected to a horizontal hub. In general, the significant noise sources associated with the operation of a Wind Farm are the wind turbines and the Transformer Substation. Noise from wind turbines consists of the aerodynamic noise caused by blades passing through the air, and mechanical noise created by the operation of mechanical elements of the drive-train. Close to the turbine, the noise typically exhibits a swishing sound as the blades rotate; and the whirr of the drive-train and generator. However, as distance from the turbine increases, these effects are reduced. The wind turbine noise perceived at receptors is typically broadband in nature. Any tonal character associated with the wind turbine noise is generally associated with maintenance issues.

The Transformer Substation noise is produced by the vibration of the transformer core and associated components, and by the operation of other equipment such as cooling fans. The noise produced by a Transformer Substation generally exhibits a pronounced hum, associated with the fundamental electrical frequency and its harmonics. Consequently, the Transformer Substation noise perceived at receptors is typically tonal.

The noise produced by wind turbines, as well as the background noise, typically increases with wind speed. The noise produced by a Transformer Substation is unaffected by the wind speed.

#### **5. SOUND LEVEL LIMITS FOR WIND FARMS**

##### **5.1 Limits for Wind Turbine Generators**

The sound level limits for wind turbines are set relative to the existing MOE Noise Guidelines in Publications NPC-205 and NPC-232, References [2] and [4], as well as to a reference wind induced background sound level. Consistent with these guidelines, the sound level limits, expressed in terms of the hourly, "A-weighted," equivalent sound level ( $L_{eq}$ ), apply at Points of Reception.

##### **a) Receptors in Class 1 & 2 Areas (Urban)**

The sound level limits at a Point of Reception in Class 1 & 2 Areas (Urban) are given by the applicable values in Table 1 and Figure 1, or by the sound level limits, established in accordance with requirements in Publication NPC-205.

b) Receptors in Class 3 Areas (Rural)

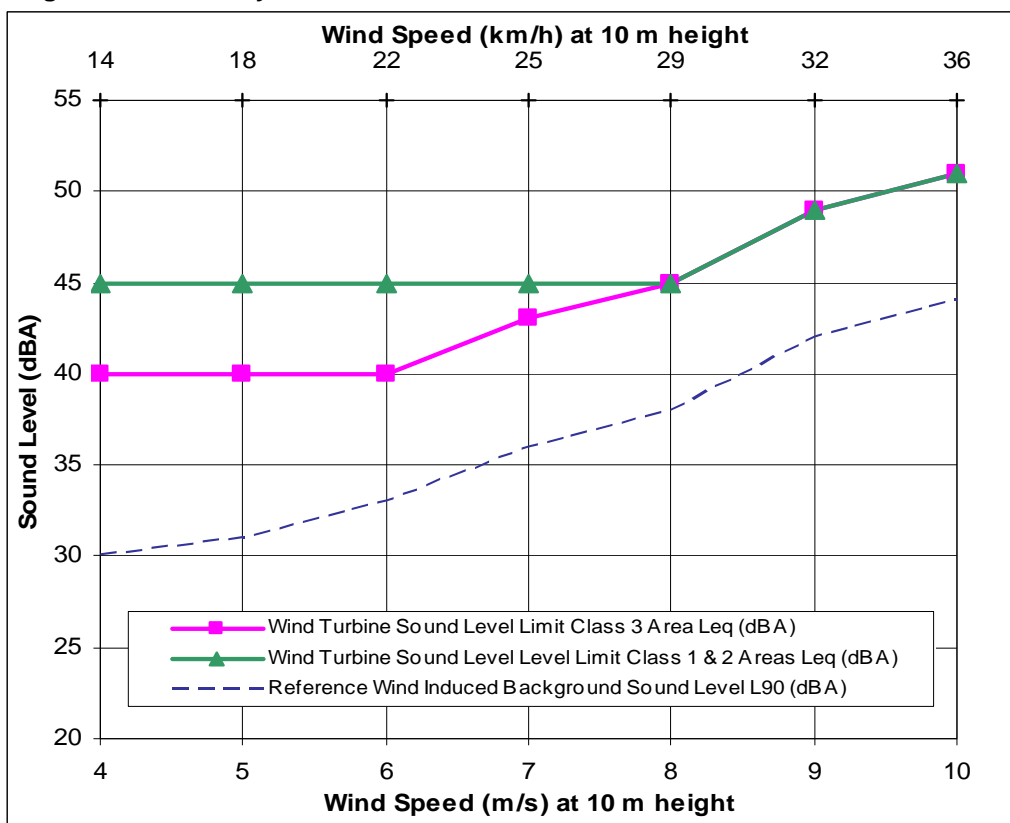
The sound level limits at a Point of Reception in Class 3 Areas (Rural) are given by the applicable values in Table 1 and Figure 1, or by the sound level limits, established in accordance with requirements in Publication NPC-232.

The wind turbine sound level limits are given at integer values of the wind speed and are shown as the solid lines in Figure 1. The dashed line in Figure 1 does not represent a limit and is included only for information purposes<sup>1</sup>. These sound level limits range from the lowest value of 40 dBA for Class 3 Areas and wind speeds at or below 4 m/s to the maximum value of 51 dBA for wind speeds at or above 10 m/s.

**Table 1 Summary of Sound Level Limits for Wind Turbines**

Wind Speed (m/s) at 10 m height	4	5	6	7	8	9	10
Wind Turbine Sound Level Limits Class 3 Area, dBA	40.0	40.0	40.0	43.0	45.0	49.0	51.0
Wind Turbine Sound Level Limits Class 1 & 2 Areas, dBA	45.0	45.0	45.0	45.0	45.0	49.0	51.0

**Figure 1 Summary of Sound Level Limits for Wind Turbines**



<sup>1</sup> The measurement of wind induced background sound level is not required to establish the applicable limit. The wind induced background sound level reference curve, dashed line in Figure 1, was determined by correlating the A-weighted ninetieth percentile sound level ( $L_{90}$ ) with the average wind speed measured at a particularly quiet site. The applicable  $L_{eq}$  sound level limits at higher wind speeds are given by adding 7 dB to the wind induced background  $L_{90}$  sound level reference values, using the principles for establishing sound level limits described in Publication NPC-232, Reference [4].



## 5.2 Limits for Wind Turbine Generators and Transformer Substations

In cases where the noise impact at a Point of Reception is composed of combined contributions due to the Transformer Substation as well as the wind turbine generators, the applicable limits are those shown in Table 1 and Figure 1, as described in Section 5.1.

The combined noise impact must comply with the limits at all the wind speeds from 0 m/s to 10 m/s. It should be noted that the acoustic emissions from a Transformer Substation are independent and unrelated to the wind speed, unlike the acoustic emissions from wind turbine generators which are wind speed dependent.

In determining the combined impact, a 5 dB adjustment must be added to the Transformer Substation noise in accordance with Publication NPC-104, Reference [1].

## 5.3 Limits for Transformer Substations

In unique cases where the noise impact assessment at a Point of Reception is limited to the operation of the Transformer Substation, as in a case described in Section 6.4.1, the sound level limit at a Point of Reception is given in the Publication NPC-205, Reference [2] or Publication NPC-232, Reference [4], whichever is applicable. The limit is independent of wind induced noise.

In order to account for the tonal characteristics of Transformer Substation noise, a 5 dB adjustment must be added to the acoustic emissions in accordance with Publication NPC-104, Reference [1].

## 6. NOISE ASSESSMENT REPORT

A Noise Assessment Report must be prepared for all proposed Wind Farms. The requirements for a detailed noise impact assessment depend on the proximity of the Wind Farm to receptors and are described in Section 6.4. The report must be submitted in a hard copy as well as in an electronic format.

The Noise Assessment Report must demonstrate compliance with the applicable sound level limits and the supporting information must be organized in a clear and concise manner. The report must be prepared by a qualified acoustical consultant and the cover document must be signed by the proponent for the project.

The Noise Assessment Report should be performed early in the planning of the project, as part of the Environmental Screening Process. The expectation of the MOE is that the submitted Noise Assessment Report be complete and accurate. Results of the Noise Assessment Report should be included in the Screening Report or Environmental Review Report prepared under the Environmental Screening Process. Any revisions to the Noise Assessment Report following the completion of the Environmental Screening Process should be very limited and clearly identified. In cases where complete information about the Wind Farm (e.g., information relating the transformer equipment) was not available at the environmental screening stage, such information must be provided to the MOE with the application for the Certificate of Approval under section 9 of the *Environmental Protection Act* for the Wind Farm.

As a minimum, the report must include the following sections in the given sequence:

### 6.1 Project Layout

The overall plan of the Wind Farm must be described in detail for the purpose of supporting the noise impact assessment calculations and for demonstrating compliance with the sound level

limits. General project layout description must be supported with clear maps of the site and surrounding area, complete with scale, northing, and legend information. A suitable minimum drawing scale for the overall plan of the project is 1 cm : 500 m.

The following details must be included:

- a) Geographic location of the project study area;
- b) Locations of wind turbines;
- c) Location of Transformer Substation or Switching Station;
- d) Locations of all receptors including buildings, dwellings, campsites, places of worship, and institutions, up to 2000 m from any wind turbine location; and
- e) Property boundaries of lands associated with the project and location of dwellings therein.

The following additional information must be included, if applicable:

- f) Municipal zoning and land-use plans;
- g) Topographical features including roadways, terrain elevations, and ground cover; and
- h) Available information regarding the location and scope of other approved<sup>2</sup> Wind Farms, and Wind Farms in the process of being planned<sup>3</sup>, located within 5 km of any wind turbine generators of the proposed Wind Farm.

## 6.2 Noise Sources

For the purposes of this document, noise sources mean land-based wind turbine generators and Transformer Substations.

### 6.2.1 Description

The Noise Assessment Report must include the description of the wind turbine generators, including: manufacturer's make and model, maximum electrical output rating, hub height above grade, range of rotational speeds, and mode of operation.

The Noise Assessment Report must also include the description of the Transformer Substation, including all available information at the time of submission on the manufacturer's make and model designations, maximum electrical output rating, primary and secondary voltages, method of cooling, physical dimensions, drawing showing elevation and plan views of the unit, and any noise abatement measures.

Manufacturer's specifications should be included in an Appendix.

### 6.2.2 Wind Turbines

The acoustic emissions of the wind turbine must be specified by the manufacturer for the full range of rated operation and wind speeds. As a minimum, the information must include the sound power levels, frequency spectra in octave bands (63 to 8000 Hz), and tonality at integer

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<sup>2</sup> For the purposes of this document, a Wind Farm is considered to be "approved" if a Certificate of Approval (Noise) under section 9 of the *Environmental Protection Act* has been issued.

<sup>3</sup> For the purposes of this document, a Wind Farm is considered to be "in the process of being planned" if a Notice of Commencement has been issued for the project in accordance with the Environmental Screening Process prescribed under Ontario Regulation 116/01 under the *Environmental Assessment Act*, but for which a Certificate of Approval (Noise) under section 9 of the *Environmental Protection Act* has not yet been issued.

wind speeds from 6 to 10 m/s. The acoustic emission information must be determined and reported in accordance with the international standard CAN/CSA-C61400-11-07, Reference [5].

#### 6.2.3 Adjustment to Wind Turbine Generator Acoustic Emissions for Wind Speed Profile

The wind speed profile on site of the Wind Farm may have an effect on the manufacturer's wind turbine acoustic emission data and, consequently, on the sound levels predicted at a Point of Reception. Therefore, the wind turbine generator acoustic emission levels must be consistent with the wind speed profile of the project area.

To address this issue, the assessment must use manufacturer's acoustic emission data adjusted for the average summer night time wind speed profile, representative of the site.

The adjusted acoustic emissions data must be used in the noise impact assessment at each receptor. The manufacturer's acoustic emissions data and the adjusted acoustic emission data used in the noise impact assessment must be tabulated in Table 3.

#### 6.2.4 Transformer Substation

The acoustic emissions of each transformer unit must be specified by the manufacturer and conform to the standard ANSI/IEEE C57.12.90, Reference [7]. In cases where the specific information is not available in the early stages of planning the proposed Wind Farm, as described in the introduction to Section 6, proponents must submit a maximum rated value of the transformer acoustic emissions.

The requirements do not apply to the small transformer units attached to each wind turbine. These small transformers are insignificant noise sources and, therefore, their contributions do not require assessment.

The acoustic emissions data must be used in the noise impact assessment at each receptor.

#### 6.2.5 Noise Sources and Locations

All wind turbine units and Transformer Substations must be assigned a unique source identification and must be listed along with their Universal Transverse Mercator (UTM) coordinates in a table in the report. The table should be provided in electronic form along with the report. A sample table format is shown in Table 4.

The source identifications should remain consistent throughout the submission and review process. Any changes to source identifications in revised versions of the Noise Assessment Report should be explicitly stated.

### 6.3 **Receptors**

For the purposes of this document, receptors mean Points of Reception and Participating Receptors, including vacant lots described in Section 6.3.3.

The definitions of a Point of Reception and a Participating Receptor are given in Section 3. The distance requirements for detailed noise assessments at receptors are described in Section 6.4.1. To provide clarity and consistency in the detailed noise assessments, the following describes the specific receptor locations for assessment purposes:

### 6.3.1 Wind Farm Does Not Include Transformer Substation

#### a) Single Storey Dwelling

- 4.5 m above grade at the centre of the dwelling; or
- 1.5 m above grade and 30 m horizontally from the façade of the dwelling in the direction of each wind turbine location. If the 30 m radius spans beyond the property line of the dwelling then the receptor location is at the property line.

Either of the two locations is acceptable for assessment<sup>4</sup>.

#### b) Two Storey Dwelling (or Raised Bungalow)

- 4.5 m above grade at the centre of the dwelling.

#### c) Three Storey or Higher Dwelling

- at the centre of the highest storey of the dwelling.

### 6.3.2 Wind Farm Includes Transformer Substation

#### a) Dwellings up to Two Storey High

- 4.5 m above grade at the centre of the dwelling; or
- 1.5 m above grade and 30 m horizontally from the façade of the dwelling in the direction of each wind turbine location. If the 30 m radius spans beyond the property line of the dwelling then the receptor location is at the property line.

The location that results in the higher noise impact must be selected<sup>5</sup>.

#### b) Three Storey or Higher Dwelling

- at the centre of the highest storey of the dwelling; or
- 1.5 m above grade and 30 m horizontally from the façade of the dwelling in the direction of each wind turbine location. If the 30 m radius spans beyond the property line of the dwelling then the receptor location is at the property line.

The location that results in the higher noise impact must be selected<sup>6</sup>.

### 6.3.3 Vacant Lots

Receptors include vacant lots that have been zoned by the local municipality to permit residential or similar noise-sensitive uses, as described in the definition of a Point of Reception in Section 3.

The receptor location, if unknown at the time of the proposal, shall be based on a 1 hectare (10,000 m<sup>2</sup>) building envelope within the vacant lot property that would reasonably be expected to

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<sup>4</sup> Assessment at the centre of the dwelling is simpler. The sound level at 4.5 m above grade at the centre of the dwelling is generally higher.

<sup>5</sup> Assessment at the centre of the dwelling is simpler. The sound level at 4.5 m above grade at the centre of the dwelling is generally higher except where transformer substation noise is a factor.

<sup>6</sup> Assessment at the centre of the dwelling is simpler. The sound level at the highest storey at the centre of the dwelling is generally higher except where transformer substation noise is a factor.

contain the use, and that conforms with the municipal zoning by-laws in effect. The specific receptor location for assessment purposes should be assumed to be 4.5 m above grade and:

- consistent with the typical building pattern in the area, or
- at the centre of the 1 hectare building envelope.

#### 6.3.4 Area Classification of Receptors

Based on the rural nature of the areas surrounding most wind power projects, the Class 3 Area sound level limits shown in Table 1 and Figure 1 apply to all receptors, regardless of their proximity to a roadway, unless it can be shown clearly that less restrictive sound level limits are justified.

Less restrictive sound level limits for receptors within their designated area classification must be justified by analysis of hourly-traffic volumes data or by hourly acoustic monitoring results consistent with Publication NPC-206, Reference [3]. The use of general estimates, such as the Annual Average Daily Traffic data (AADT), is an insufficient method for determining the minimum hourly sound level of the background.

#### 6.3.5 Receptors and Locations

All receptors must be assigned a unique receptor identification and must be tabulated along with their precise coordinates in the report. The table should be provided in electronic form along with the report. A sample table format is shown in Table 5 and Table 6.

The receptor identifications should remain consistent throughout the review process. Any changes to receptor identifications in revised versions of the Noise Assessment Report must be explicitly stated.

### 6.4 **Detailed Noise Impact Assessment**

Assessment of the sound levels produced by a Wind Farm, i.e. detailed noise impact assessment, must be made at each Point of Reception and Participating Receptor, within the distance requirements described in Section 6.4.1. In the event that all Points of Reception and Participating Receptors are outside the distance requirements described in Section 6.4.1, a detailed noise impact assessment is not required and the provisions contained in Sections 6.4.2 through to 6.4.10 are not applicable. Note that all proposals for Wind Farm projects must address the requirements described in Sections 6.1, 6.2 and 6.3, and Table 4, Table 5 and Table 6, even if a detailed noise assessment is not required.

The noise assessment must represent the maximum rated output of the Wind Farm, and reflect the principle of "predictable worst case" noise impact, Publications NPC-205 and NPC-232, References [2] and [4].

#### 6.4.1 Distance Requirement

##### a) Wind Farm Does Not Include Transformer Substation

- A detailed noise impact assessment of the Wind Farm is required if one or more Points of Reception or Participating Receptors are located within 1500 m of a wind turbine generator.

b) Wind Farm Includes Transformer Substation

- A detailed noise impact assessment of the Wind Farm including a Transformer Substation is required if one or more Points of Reception or Participating Receptors are located within 1500 m of a wind turbine generator.
- A detailed noise impact assessment limited to the Transformer Substation is required if no Points of Reception or Participating Receptors are located within 1500 m of a wind turbine generator but a Point of Reception or a Participating Receptor is located within 1000 m of a Transformer Substation.

6.4.2 Whole Wind Farm Assessment

In the event that a detailed noise impact assessment is required, the assessment must not be limited to a 1500 m radius from a receptor, but must consider the impact of the whole Wind Farm subject to the limitations relating to very large distances described in Section 6.4.9.

6.4.3 Transformer Substation Assessment

In general, Transformer Substation noise impact must be assessed in combination with the noise impact from the wind turbine generators. In the unique case where the noise impact is caused only by the Transformer Substation, as described in Section 6.4.1 b), the detailed noise impact assessment is only required to consider the sound levels from the Transformer Substation.

6.4.4 Impact of Adjacent Approved Wind Farms

If a Point of Reception or a Participating Receptor is or can be affected by adjacent, approved<sup>7</sup> Wind Farms, the detailed noise impact assessment must address the combined impact of the proposed and the adjacent Wind Farms. The distance requirements described in Sections 6.4.1 and 6.4.9 apply.

Note that in accordance with Section 6.4.2, where a detailed noise impact assessment is required, it must consider all the wind turbine generators and Transformer Substations in the proposed as well as in the adjacent approved Wind Farms, subject to the limitations relating to very large distances described in Section 6.4.9.

6.4.5 Impact of Adjacent Wind Farms in the Process of Being Planned

If a Point of Reception or a Participating Receptor is or can be affected by adjacent Wind Farms in the process of being planned<sup>8</sup>, the detailed noise impact assessment must address, subject to available information<sup>9</sup>, the combined impact of the proposed and the adjacent Wind Farms. The distance requirements described in Sections 6.4.1 and 6.4.9 apply.

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<sup>7</sup> For the purposes of this document, a Wind Farm is considered to be "approved" if a Certificate of Approval (Noise) under section 9 of the *Environmental Protection Act* has been issued.

<sup>8</sup> For the purposes of this document, a Wind Farm is considered to be "in the process of being planned" if a Notice of Commencement has been issued for the project in accordance with the Environmental Screening Process prescribed under Ontario Regulation 116/01 under the *Environmental Assessment Act*, but for which a Certificate of Approval (Noise) under section 9 of the *Environmental Protection Act* has not yet been issued.

<sup>9</sup> The combined impact would be expected to be assessed if, for example, the information on turbine locations and models at an adjacent proposed Wind Farm is publicly available (e.g., through a Screening Report or Environmental Review Report under the Environmental Screening Process).

Note that in accordance with Section 6.4.2, where a detailed noise impact assessment is required, it must consider all the wind turbine generators and Transformer Substations in the proposed Wind Farm as well as in the adjacent Wind Farm in the process of being planned, subject to the limitations relating to very large distances described in Section 6.4.9.

#### 6.4.6 Assessment of Participating Receptors

A receptor is a Participating Receptor and not considered as a Point of Reception if the property of the receptor is associated with the Wind Farm, see definition in Section 3. The sound level limits stated in Section 5 do not apply to Participating Receptors.

Despite this exemption, it is prudent to design Wind Farms so as to minimize the noise impact on all receptors, including Participating Receptors.

In some cases, a detailed noise assessment may be required of a receptor that was considered a Participating Receptor for an adjacent approved Wind Farm, or is being considered as a Participating Receptor for an adjacent Wind Farm in the process of being planned. Unless the property owner has also entered into an agreement with the proponent of the proposed Wind Farm, the receptor shall be considered a Point of Reception for the purposes of the detailed noise impact assessment for the proposed Wind Farm.

#### 6.4.7 Prediction Method

Predictions of the total sound level at a Point of Reception or a Participating Receptor must be carried out according to the method described in the standard ISO 9613-2, Reference [6]. The calculations are subject to the specific parameters indicated in Section 6.4.10.

#### 6.4.8 Adjustment for Special Quality of Sound

Should the manufacturer's data indicate that the wind turbine acoustic emissions are tonal, the acoustic emissions must be adjusted by 5 dB for tonality, in accordance with Publication NPC-104, Reference [1]. Otherwise, the prediction should assume that the wind turbine noise requires no adjustments for special quality of sound described in Publication NPC-104, Reference [1].

No special adjustments are necessary to address the variation in wind turbine sound level (swishing sound) due to the blade rotation, see Section 4. This temporal characteristic is not dissimilar to other sounds to which no adjustments are applied. It should be noted that the adjustments for special quality of sound described in Publication NPC-104, Reference [1], were not designed to apply to sounds exhibiting such temporal characteristic.

The calculations of the transformer noise must be consistent with the provisions of Section 6.2.4. Furthermore, since transformer acoustic emissions are tonal, an adjustment of 5 dB must be added to the specified acoustic emissions in accordance with Publication NPC-104, Reference [1].

#### 6.4.9 Sound Level Contributions from Distant Wind Turbine Generators

The standard on which the noise impact prediction method is based, namely standard ISO 9613-2, Reference [6], is designed for source/receiver distances up to about 1000 m. Although the use of the standard may be extended to larger distances, other factors affecting sound level contributions from the distant sources may need to be considered. In practice, sound level contributions from sources such as wind turbines located at very large distances from receptors are affected by additional attenuation effects.

To address the above in a prediction method, contributions from sources located at very large distances from receptors, larger than approximately 5 km, do not need to be included in the calculation.

#### 6.4.10 Specific Parameters

The assessment must use the following parameters that have been designed to provide clarity and consistency as well as reflect the principle of the “predictable worst case” noise impact.

- a) All calculations must be performed in terms of octave band sound levels (63 to 8000 Hz) and for each integer wind speed from 6 to 10 m/s.
- b) The attenuation due to atmospheric absorption must be based on the atmospheric attenuation coefficients for 10°C temperature and 70% relative humidity, specifically:

**Table 2 Atmospheric Absorption Coefficients**

Centre Octave Band Frequency (Hz)	63	125	250	500	1000	2000	4000	8000
Atmospheric Absorption Coefficient (dB/km)	0.1	0.4	1.0	1.9	3.7	9.7	32.8	117.0

- c) The term for Ground Attenuation must be calculated using the “General” method in the standard ISO 9613-2, Reference [6]. For Class 2 and 3 Areas, the assessment must use ground factor values not exceeding the following:

$$G_s = 1.0$$

$$G_m = 0.8$$

$$G_r = 0.5$$

Where  $G_s$  is ground factor for the source region,  
 $G_m$  is ground factor for the middle region, and  
 $G_r$  is ground factor for the receiver region.

Alternatively, a global value ground factor not exceeding 0.7 may be used.

Ground factor values for assessments in Class 1 Areas are not specified in this document. The choice of the ground factor values for assessments in Class 1 Areas is site-specific.

## 6.5 Results and Compliance

### 6.5.1 Presentation of Results

Results of the noise impact assessment calculations must be presented in accordance with the Noise Impact Assessment Summary Tables, Table 7 and Table 8. In addition, the results should be plotted on drawings of the site plan, showing property boundaries, noise sources and receptor locations with their identifications. A suitable scale for these drawings is 1 cm : 250 m.

A separate drawing must be presented for each of the following wind speeds: 6, 8 and 10 m/s. The sound level scale should be the same on all drawings. If practical, each drawing should show the sound level contours for the 40 dBA level as well as the contour for the applicable sound level limit. The drawings should be included as an Appendix.



6.5.2 Assessment of Compliance

Compliance must be based on the comparison of the combined sound levels from all sources, described in Section 6, at each Point of Reception with the sound level limits stated in Section 5. All calculations and the determination of compliance with the sound level limits must be presented to a precision of one decimal place.

6.6 **Summary Tables**

6.6.1 Wind Turbine Acoustic Emissions Summary Table

The wind turbine acoustic emissions data used in the calculations must be presented as shown in Table 3. Separate tables should be used if the project involves different models of equipment.

**Table 3 Wind Turbine Acoustic Emissions Summary**

<b>Make and Model:</b> <b>Electrical Rating:</b> <b>Hub Height (m):</b> <b>Wind shear coefficient, as per Section 6.2.3<sup>10</sup>:</b>										
	<b>Octave Band Sound Power Level (dB)</b>									
	<b>Manufacturer's Emission Levels</b>					<b>Adjusted Emission Levels</b>				
<b>Wind Speed<sup>11</sup> (m/s)</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>
<b>Frequency<sup>12</sup> (Hz)</b>										
<b>63</b>										
<b>125</b>										
<b>250</b>										
<b>500</b>										
<b>1000</b>										
<b>2000</b>										
<b>4000</b>										
<b>8000</b>										
<b>A-weighted</b>										

<sup>10</sup> Adjustment based on the differences in wind shear factors reflecting manufacturer's data and on-site data.

<sup>11</sup> At 10 m reference height.

<sup>12</sup> Centre Octave Band Frequency.

6.6.2 Locations of Wind Turbine Generators, Transformer Substations and Receptors

Location coordinates of all wind turbine generators, Transformer Substations, Points of Reception and Participating Receptors must be given in accordance with Table 4, Table 5 and Table 6.

**Table 4 Wind Turbine Locations**

<b>Project Name:</b>				
Identifier	Equipment Make & Model	UTM Coordinates		Remarks
		X	Y	

Changes in ID or location in revised submissions must be clearly identified under the "Remarks" column.

**Table 5 Point of Reception Locations**

<b>Project Name:</b>			
Point of Reception ID	Description	UTM Coordinates	
		X	Y

**Table 6 Participating Receptor Locations**

<b>Project Name:</b>			
Receptor ID	Description	UTM Coordinates	
		X	Y

6.6.3 Noise Impact Assessment Summary Tables

**Table 7 Combined Noise Impact Summary – Points of Reception**

Point of Reception ID	Description	Height (m)	Distance to Nearest Turbine (m)	Nearest Turbine ID	Calculated Sound Level at Selected Wind Speeds (dBA)					Sound Level Limit (dBA)									
					6	7	8	9	10	6	7	8	9	10					

Values in the table that exceed the applicable limit should be **Underlined and Bolded**.

**Table 8 Combined Noise Impact Summary – Participating Receptors**

Participating Receptor ID	Description	Height (m)	Distance to Nearest Turbine (m)	Nearest Turbine ID	Calculated Sound Level at Selected Wind Speeds (dBA)					
					6	7	8	9	10	

**Table 9 Wind Turbine Noise Impact Summary – Points of Reception**

Point of Reception ID	Description	Height (m)	Distance to Nearest Turbine (m)	Nearest Turbine ID	Calculated Sound Level at Selected Wind Speeds (dBA)					Sound Level Limit (dBA)									
					6	7	8	9	10	6	7	8	9	10					

Values in the table that exceed the applicable limit should be **Underlined and Bolded**.

**Table 10 Wind Turbine Noise Impact Summary – Participating Receptors**

Participating Receptor ID	Description	Height (m)	Distance to Nearest Turbine (m)	Nearest Turbine ID	Calculated Sound Level at Selected Wind Speeds (dBA)				
					6	7	8	9	10

**6.7 Appendices**

All information necessary to support the conclusions of the report, but not specifically described as required in Section 6, should be referenced and attached as Appendices to the report. Supporting information includes but is not limited to specifications, drawings, letters/agreements, photos, measurements and miscellaneous technical information.

In addition, sample calculation should be included in the Appendices. The sample calculation must include at least one detailed calculation for a source to receiver “pair,” preferably addressing the closest wind turbine unit. The sample calculation must represent all other “pairs.” If applicable, a sample calculation for the Transformer Substation is also required.

In cases where a Transformer Substation is part of the Wind Farm, Table 11 and Table 12 must be included in the Appendices:

**Table 11 Transformer Substation Noise Impact Summary – Points of Reception**

Point of Reception ID	Description	Distance to Transformer Substation (m)	Calculated Sound Level (dBA)	Sound Level Limit (dBA)

Values in the table that exceed the applicable limit should be **Underlined and Bolded**.

**Table 12 Transformer Substation Noise Impact Summary – Participating Receptors**

Point of Reception ID	Description	Distance to Transformer Substation (m)	Calculated Sound Level (dBA)