UNIVERSITY OF TORONTO

Final Assignment

Wind Farm Development:

New Glasgow Ontario, Canada.

Site Analysis, Design, Environmental Assessment, Permitting, Grid Integration, Operation and Maintenance

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CRE 402 Wind Energy

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New Gloscow Wind Farm Project

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Executive Summary

This report undertakes the site and turbine selection for the development a minimum of 10 MW onshore wind farm (Project) in Ontario. It further explores the environmental permitting and grid connection requirements and entails the operation and maintenance plan.

Site analysis concludes that despite of its site constraints, the New Glosgow site located in the Municipality of Elgin in Ontario is selected due to its relatively high wind speed as careful turbine selection and siting can overcome the site obstacles. The analysis also calculates that Weibull shape parameter is 1.93, considering the annual average wind speed of 8.02 m/s and a mean energy in the wind of 512 W/m^2 at the site.

For the turbine model, the Vestas V 117-3.3 MW turbine is selected for this Project considering the power output as well as its flexibility and adoptability. Therefore, the Project is composed of seven Vestas 117 turbines each 3.3 MW at a total of 23. 3 MW name plate capacity with two additional back-up turbines. Each turbine is expected to produce 1.78 MW of power and have an efficient of 18.8%. MW. The mean annual power and energy expected from the seven turbines is 11.2 MW, 98,440 MWh/yr respectively considering array efficiency of 90%.

Under O.Reg 359/09, the REA process requires the proponent to obtain the MOECC’s approval for the commencement of the Project. Although proposed site may contain the candidate water bodies, the woodland or the potential archaeological sites, no setback is considered for the development of the Project, as the appropriate mitigation measures will be employed such as Environmental Impact Assessment and Archeological Assessment Sage 1 to 4 for the purpose of REA approval.

Grid interconnection proposal suggests that the Project is to be connected to the Duart TS located in the Chatam-Kent municipality which has an approximately length of 19.9 km to the Project’s switch gear station. Operation and Maintenance Plan entails the turbine monitoring controls and SCADA system and the average of $31,000/MW is considered for the O&M budget during the operational period.

1 Introduction

This report will illustrate the major steps required for the development of a new wind farm at a minimum of 10 MW in Ontario in accordance with Renewable Energy Approval (REA) process and relevant connection assessment requirement. The site analysis will be conducted for choosing the optimal project site in Ontario and the appropriate turbine model will be selected to be best matched with the proposed site location considering available wind resources at the site.

This site analysis and design of the wind farm will consider all regulations and permits required for siting a wind farm and generating electricity from the wind and putting it back into the Ontario gird network.

The tasks involved in the development of a wind farm include the initial site evaluation focusing on the availability of a strong wind resource, wind turbine selection and energy production at our site. It further explores requires REA process as well as the connection requirement for the grid integration. Finally, the plan for the operation and maintenance will be provided for the effective and safe operation of the proposed Project.

2 Site Analysis and Selection

This section provides the overview on the selection of project site including the individual turbine location based on the calculation of available wind resource and other site considerations. It further discusses the selection of the turbine manufacturer and model type as well as the calculation of the estimated power output.

2.1 Wind Resources and Site Location

The first step in choosing an appropriate location for the wind farm is to analyze the wind resource in Ontario. The Canadian Wind Energy Atlas (CWEA 2014) was used to choose potential locations based on acceptable wind speeds. Along with high wind speeds, the following basic site selection criteria were used to select potential locations:

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- The prospect of available land that would meet the criteria of having the turbines located at a minimum of 550m distance from the nearby house and also located at a minimum of the height of the tower plus the length of the blade away from the closest road; and
- Enough available land to potentially meet the minimum turbine spacing requirements; and
- Low roughness and little obstacles; and
- Proximity to transmission substations; and
- Safe distance to airports; and
- Any actual or planned projects in the immediate area according to the information provided by Ontario Wind Turbines site (Ontario Wind Turbines, 2014) and Ontario Power Authority (OPA) (OPA, 2014).
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Based on the available wind resource and the above criteria provided, three candidate locations were considered for further analysis as illustrated in Table 1 below.

Table 1: GPS Coordinates of 3 Candidate Sites in Ontario

Site Location	General Coordinates
Leamington	41.999720° N, 82.542167° W
New Glasgow	42.498194° N, 81.648675° W
McGaw	43.746902° N, 81.621984° W

- In order to compare the available wind resources at three candidate sites, the mean wind speed at 80m Above Ground Level (AGL) for each site is analyzed as below. The Leamington shows the best wind resource with 8.33 m/s average wind speed at 80m Above AGL. However, this site is excluded due to the close proximity to the airport.
- The McGaw site has the lowest average wind speed at 7.53 m/s at 80m AGL but has other advantages such as sufficiently available land, low obstacles and roughness.

The New Glasgow site shows the relatively high wind speed, an average wind speed of 8.02 m/s at 80m AGL but has more wooded areas and a higher density of properties. The

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New Glasgow site is selected as the site of the Project (named as 'New Glasgow Wind Farm Project'**)** due to its high wind speeds despite of its site constraints, as careful turbine selection and siting can overcome the site obstacles.

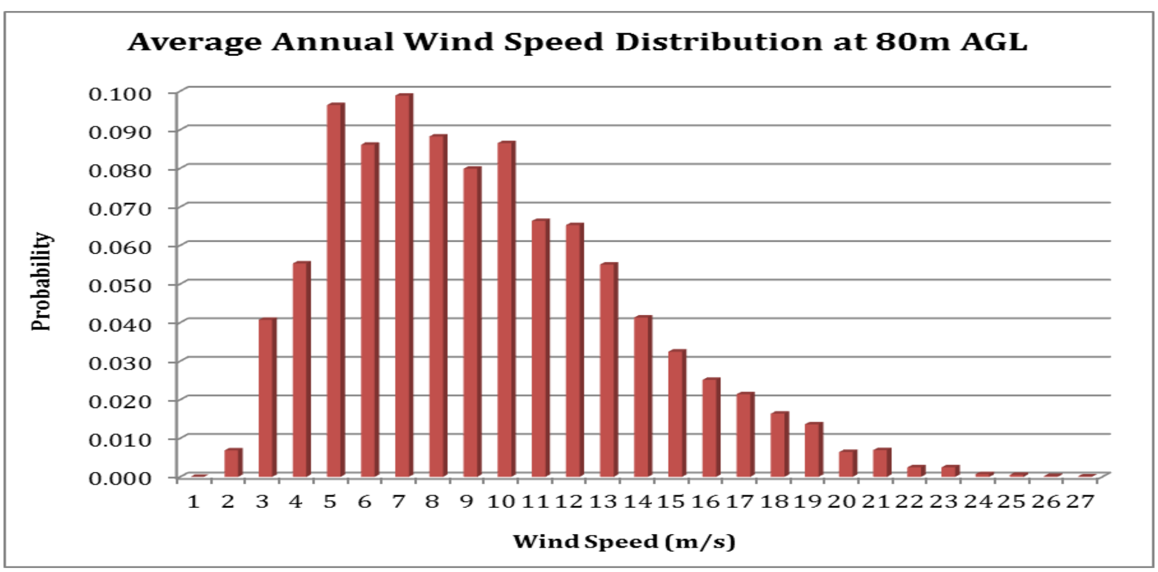
The Table 2 provides the seasonal and average wind resources data including the mean wind speeds at 80m AGL for the New Glosgow Site according to the CWEA (CWEA, 2014).

Table 2: Wind Resources Data for the New Glasgow Site (CWEA, 2014)

Period	Mean Wind Speed	Mean Wind Energy	Weibull shape parameter (k)	Weibull scale parameter (A)
Annual	8.02 m/s	512.00 W/m2	1.93	9.04 m/s
Winter (DJF)	9.26 m/s	698.25 W/m2	2.18	10.46 m/s
Spring (MAM)	8.01 m/s	492.75 W/m2	1.99	9.03 m/s
Summer (JJA)	6.28 m/s	245.63 W/m2	1.92	7.07 m/s
Fall (SON)	8.32 m/s	548.00 W/m2	2.01	9.39 m/s

The wind speed distribution at the New Glasgow site according to the CWEA is illustrated in Figure 1 as below (CREA, 2014). This distribution will be used in conjunction with the wind shear to calculate the available power in the wind at the turbine hub height. The tabulated values can be also found in the Appendix 1.1.

Figure 1: Wind Speed distribution (CWEA, 2014)



Average annual wind speed at different height of 30m, 50m, 80m based on the CWEA data are presented as Table 3 for the wind shear calculation (CWEA,2014).

Table 3: Average Annual Wind Speed (m/s) at New Glosgow Site (CWEA, 2014)

Height (m)	Average Annual Wind Speed (m/s)
30	6.41
50	6.73
80	8.02

The wind shear can be calculated by using the following formula according to Gipe (2004, p45):

$$\alpha = ln(V/V_o)\,/ln(H/H_o) \quad (1)$$

Where V and V_o are the wind speed at the higher height and lower height respectively, and H and H_o are the higher and lower heights respectively. The wind shear was calculated by comparing the wind speeds at 50m and 30m; 80m and 30m; and 80m and 50m. The average of the wind shear is calculated as 0.2323 as illustrated in Table 3 and will be employed to estimate the wind speeds at the final hub height. Although the calculated wind shear is larger than the 1/7 typical value according to Gipe (2004), this value will be employed as there are sufficient data at the Project site to rationalize this value. However, it is more ideal scenario if anemometer readings at different heights for a period of approximately one year are available to accurately estimate the wind speeds and associated wind shear value. In the absence of such measurements, the wind shear calculation of 0.2323 will be used to calculate wind speeds at the selected hub height.

Table 4: Wind Shear Calculation at New Glosgow Site 5

Wind shear calculated between 50m and 30m	0.0954
Wind shear calculated between 80m and 30m	0.2285
Wind shear calculated between 80m and 50m	0.3731
Average Wind Shear	**0.2323**

To correct the wind speed from the Wind Atlas distribution at 80m to the final hub height, the following formula is used:

$$V = V_o(H/H_o)^{\alpha} \quad \text{(m/s)} \quad (2)$$

Where

V is the wind speed at the hub height,

V_o is the wind speed at 80m,

H is the hub height in m,

H_o is 80m,

α is the wind shear = 0.2323

In conclusion, the location of the Project site is decided in New Gloscow which shows the average wind shear of 0.2323. In the following section, the process and rational for the turbine selection are to be provided optimizing the best result of electricity output at the proposed location.

2.2 Turbine Selection

In order for the appropriate turbine selection for the Project, two leading wind turbine com

In comparison, both companies have a long track record of success stories in innovation and leadership in the wind energy industry. As both companies are fairly tied in its reputation for product performance, maintenance and global market share, the selection of turbine is decided based on the suitability of the turbine best matched with the wind speed at the Project Site.

2.2.1 Comparison of Turbine Model

Our initial investigation into the wind speed at our proposed site shows the annual average wind speed of 8.02 m/s and a mean energy in the wind of 512 W/m^2 (CWEA, 2014). The calculated Weibull shape parameter is provided as 1.93. This data was used to evaluate how each of wind turbines made from Siemans and Vestas are performing at its best capacity at this proposed Site Location.

- Siemens has the D3 platform which is described as onshore direct drive wind turbines with a power rating of 3.0-MW and 3.2-MW. The Siemens SWT 3.2-MW-113 turbine is rated at 14,402 MWh at an annual wind speed of 8.5 m/s. The swept area of the 55 meter blade length is 10,000 square meters. In terms of the power curve, the equivalent information for the Siemens 3.2 MW-113 was not available to draw a direct comparison.

- Vestas' V112 and the V117 can be referenced as the most similar product line for evaluation with Siemens SWT model. Although both Vestas turbines have the same rated capacity of 3.3MW, there exists slight difference in the maximum output as V117 model shows 12.5 m/s, whereas V112 has 13 m/s. In terms of the power curve, the Vestas 3.3 MW turbines have the range of a 14,500 to 15,000 MWh annual output at 8.5 m/s.

Considering the power output determined by the wind speed and swept area, the Vestas V117-3.3 MW turbine was selected as the turbine for this Project as it has slightly out-sized turbine than Siemans model (Gipe, 2004). Other factors such as the optional hub height and diameter of steel tower were also taken into account for the final decision. For instance, the Vestas model has the optional hub heights of 91.5 m and 116.5 m and an impressive large diameter steel tower with a hub height of 141.5 m. Although, the Siemens model reported a range of 79.2 – 142 m in the hub height, the height is fixed in a site-specific manner, whereas the Vestas model provides the detailed options for the hub height. This factor can provide greater flexibility with regard to minor speed adjustments, which allows higher efficiencies of the turbine matched with various wind speeds available at different heights at the proposed Project Site.

2.2.2 Vestas V117-3.3 MW Model Specification/Efficiency

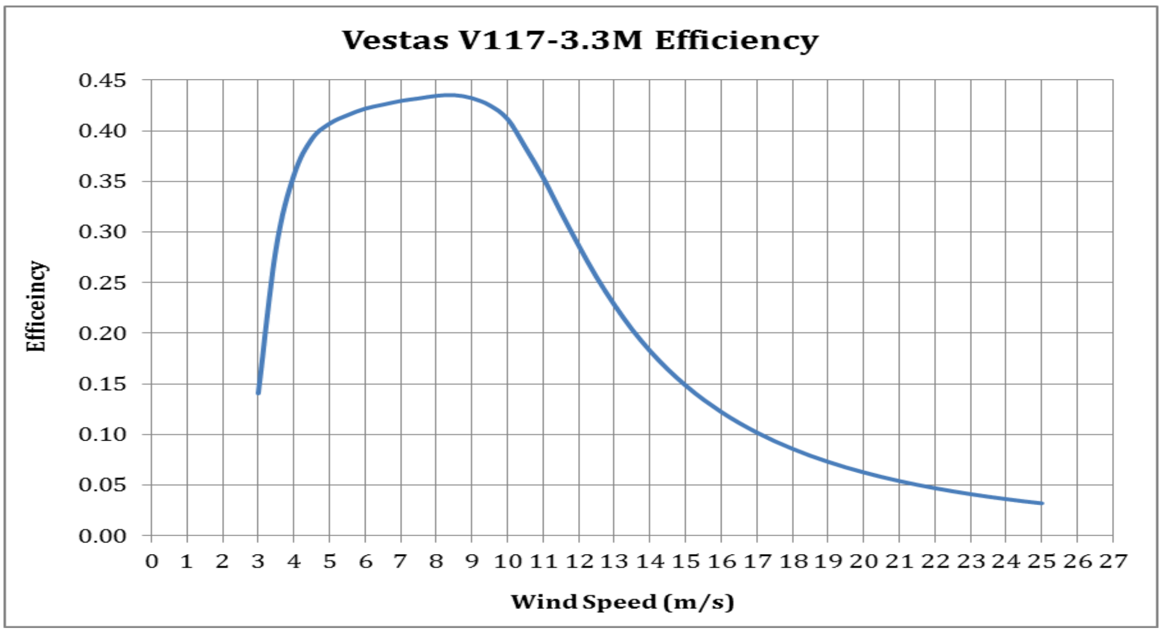
Specification: The Vestas model comes with a blade length of 57.15 meters and a total rotor diameter of 117 meters. This translates into a swept area of 10,751 m^2 and an estimated Annual Electric Output (AEO) of 14,000 MWh at a mean wind speed of 8.0 m/s, assuming 100% vailability, 0% losses, and a K factor = 2 and standard air density of 1.225 with the 3 m/s cut-in wind speed (Vestas, 2014).

Weather Factor: Considering the severe condition for Southern Ontario, the Vestas specification also has the optional de-icing system and operating capability at -30 ^{o}C with ice detection. The Vestas V117-3.3MW is designed for moderate to light wind sites and can handle turbulent wind conditions without sacrificing efficiency.

OCAS: In regards to the minimizing the interference with the aviation system, the Vestas model also features aviation markings on the blades and aviation lights on the towers, full system monitoring, fire suppression and shadow detection and an obstacle collision avoidance system (OCAS) (Vestas, 2014).

Efficiency: The efficiency at each wind speed of the selected Vestas model is determined by dividing the power output provided in Appendix 1.2 by the power available at each incremental 0.5m/s wind speed. The calculated efficiency curve shows that the efficiency is at a maximum, above 40%, at wind speeds between 5m/s and 10m/s as provided in Figure 2 below.

Figure 2: Calculated Efficiency of the Vestas V117-3.3M



Now that the turbine has been selected, the wind resource will be analyzed further to try and come to a conclusion as to which hub height would be best suited for this Project.

2.3 Energy & Power Output

Using the data from Table 2 above and the formula from Gipe (2004):

$$P = \frac{1}{2}\, r\, V^3 \qquad (3)$$

where r = standard air density of 1.225kg/m^3 and V is the wind speed in m/s.

P = 0.5 x 1.225 x $(8.02)^3$ = 315.96 W multiplied by the K factor of 1.93 = 609.80 W/m2.

This P value is larger than the mean energy of 512.00 W/m2 reported by CWEA (CWEA, 2014), which led to questioning the accuracy of the CWEA data. The aim of the wind atlas information is to provide data for site developers and may have factored in some efficiency factors. Nevertheless, the wind speed distribution from the CWEA was used to calculate the expected power in the wind. The power available in the wind and the expected energy output is also shown in Appendix 1.2. The Power P_W and Energy E_W in the wind in one year are calculated by summing the weighted power at each wind speed by using the following equations:

$$P_W = \sum_{V=1}^{26} {}^{1}/_{2}\, \rho V^3 A P_V \qquad \text{(W)} \qquad (4)$$

$$E_W = P_W(8760)/1000 \qquad \text{(kWh/yr)} \qquad (5)$$

Where

□ is the air density in kg/m3,

V is the wind speed in m/s,

A is the swept area of the turbine blades, and

P is the probability of achieving each wind speed.

The following relationship was then used to calculate the expected Power and Energy output from the VestasV117 – 3.3MW turbine:

$$P_T = \sum_{V=3}^{25} {}^{1}/_{2}\, \rho V^3 A P_V\,(eff_V) \qquad \text{(W)} \qquad (6)$$

$$E_T = P_T(8760)/1000 \qquad \text{(kWh/yr)} \qquad (7)$$

Where eff_V is the efficiency of the Vestas turbine at each wind speed as shown in Figure 1. The wind speed V, is the corrected wind speed at the hub height calculated by using

Equation 2 in Section 1.1. Equations 4 to 7 are used for each possible hub height; 91.5m, 116.5m, and 141.5m to help determining which hub height would be more appropriate. The findings are summarized in the Table 5 below.

Table 6: Wind Data, Efficiency and Output at Different Hub Heights

Hub Height (m)	Average Wind Speed (m/s)	Mean Power in the Wind P_W (MW)	Mean Power Produced per Turbine, P_T (MW)	Mean Energy in the Wind E_W (MWh/yr)	Mean Energy Produced per Turbine, E_T (MWh/yr)	Efficiency per Turbine (%)
91.5	8.65	8.00	1.67	70095	14646	20.9
116.5	9.15	9.47	1.78	82946	15625	18.8
141.5	9.57	10.84	1.86	94981	16337	17.2

Using the wind sheer justified in the previous section, Table 5 shows how the average wind speed and the mean energy produced by the turbine increases with hub height. Based on the analysis of the data provided in Appendix 1.2, and Figure 2, the efficiency of the Vestas turbine becomes the highest at wind speeds of 4.4 to 10.9 m/s. At those wind speeds the efficiency ranges from 38% to 36% with a maximum efficiency of 44% and 42% occurring at 8.7 m/s and 9.8 m/s respectively. Considering the average wind speed is 9.15 m/s at a 116.5 m hub height, the V 117 model can become the perfect turbine selection with a 116.5 m hub height.

Although efficiency decreases with increasing wind speed, at the 141.5 m hub height the energy in the wind and the total annual output continue to increase. As the goal of this exercise is to develop a minimum of 10 MW electricity annually generated from this Project, the number of turbines can be modified from 7 to 6 if the performance at 141.5 m hub height is optimized, As single turbine at 116.5 m can generate 1.78 MW and 16MWh annually, with 7 turbines at the same height, the Project can achieve 11.2 MW total capacity with an array efficiency of 0.9. However, at a hub height of 141.5m, only 6 turbines would be needed to produce 10.1 MW. Therefore, the financial analysis needs to be conducted, considering a vast range of expenses associated with increased hub heights and one less number of turbine connected to the Project.

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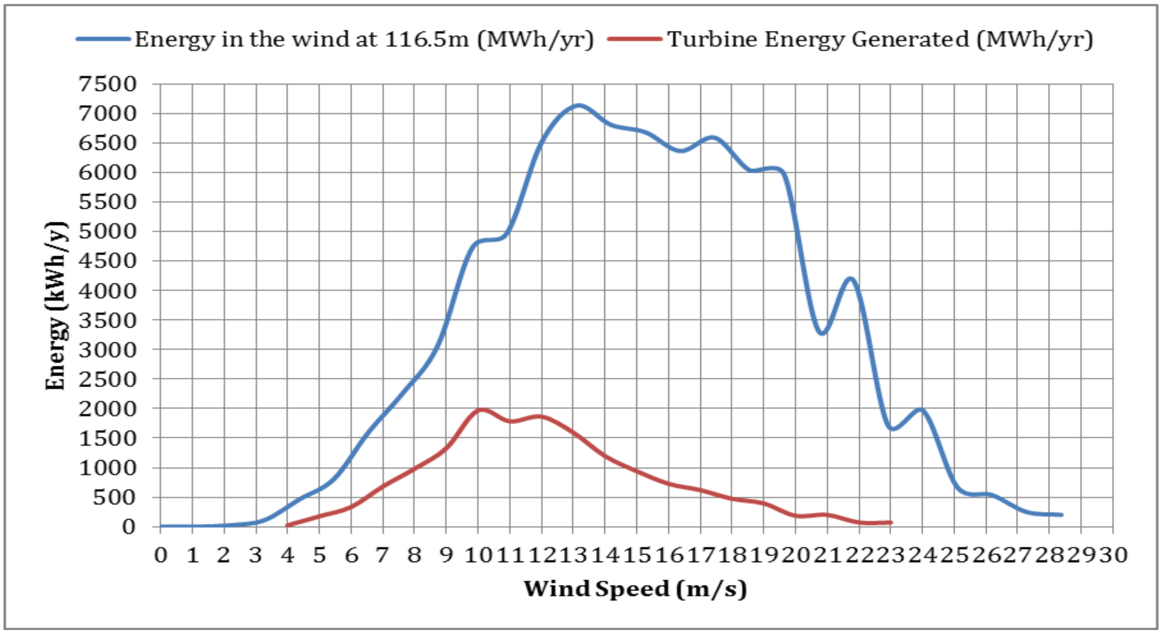
The evaluation of the seven 11.2 MW turbine Project versus the six 10.1 MW turbine project should be based on various factors in the context of installation, transport, maintenance, available space, cost of land and other financial concerns. The seven 11.2 MW turbine Project at a hub height of 116.5m is selected with the six turbines at 141.5 m hub height as a backup option. The distribution of energy available in the wind and energy produced by the 116.5m turbine is shown below in Figure 3

Figure 3: Distribution of Energy available in the wind and energy produced by the 116.5m turbine



The total power and energy output at each hub height is shown below in Table 6.

Table 7 : Project Power and Energy Output

Hub Height (m)	Number of Turbines	Array Efficiency (%)	Total Mean Annual Power Produced (MW)	Total Mean Energy Produced (MWh/yr)
91.5	7	90	10.5	92272
116.5	7	90	11.2	98440
141.5	6	90	10.1	88221

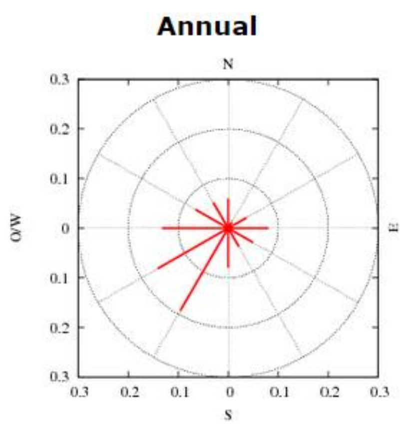
To summarize, seven 116.5m Vestas V117-3.3MW turbines will be used for this Project. Each turbine is expected to produce 1.78 MW of power and have an efficient of 18.8%.

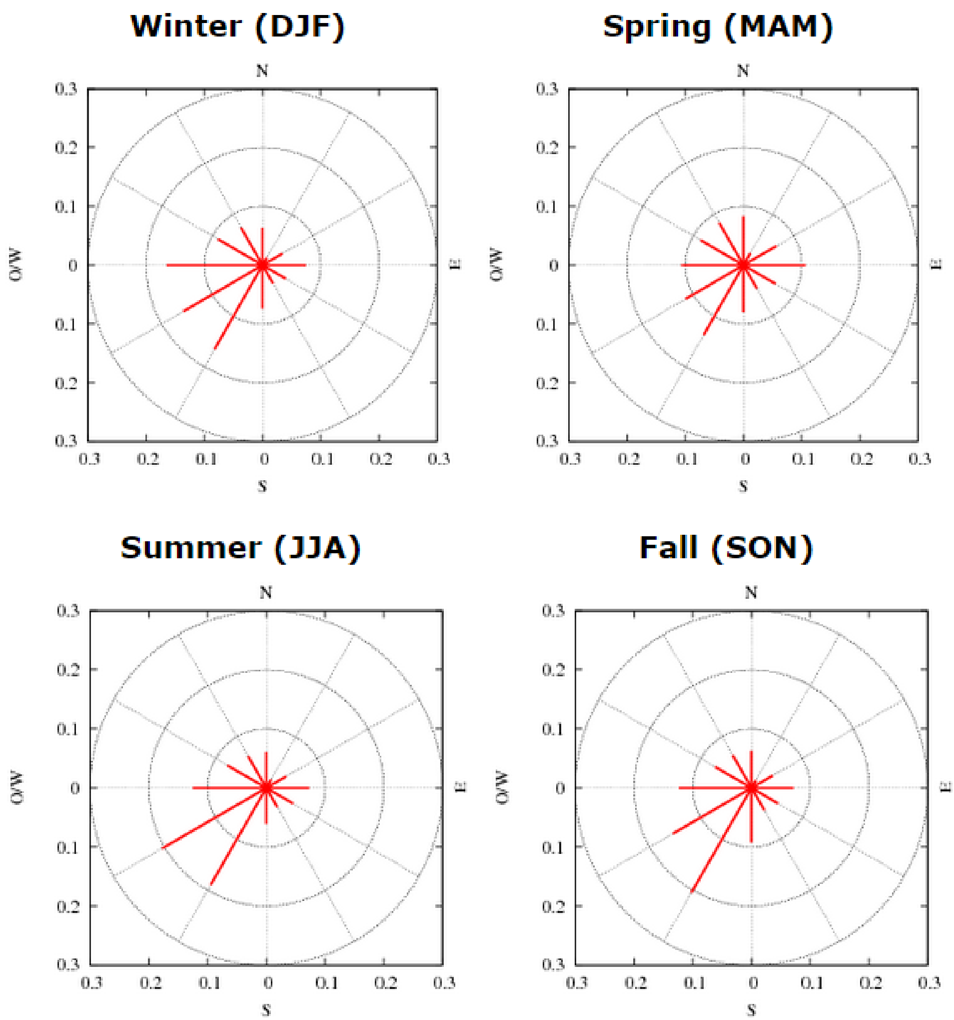
Assuming an array efficiency of 90% to account for any turbulence, O&M outage time, and other uncertainties, the mean annual power and energy expected from the 7 turbines is 11.2 MW, 98440 MWh/yr respectively. Now that the power and energy has been determined, the final turbine placement will be determined.

2.4 Turbine Height, Number and Location

Generally, a turbine may be sited closer to the property line to a limit of the length of the turbine blade plus ten meters. Based on this restriction, the pros and cons of all three hub heights are explored. Turbine spacing is relevant to the blade diameter from a technical level and must have the 550 m setback from any dwelling. Gipe (2004) also states that spacing between turbines requires a minimum of 3-5 times of the blade diameter perpendicular to the wind and 5-9 times of the blade diameter parallel to the wind. With a blade diameter of 117 m, the minimum spacing at any hub height should be 351 m perpendicular to the wind and 819 m parallel to the wind. According to the wind rose data, the prevailing wind at the site is mostly from the south-west direction, as illustrated in Figure 4 below (CWEA 2014). This will be considered when choosing the placement of the turbines.

Figure 4: Wind Rose for the New Glasgow Site (CWEA, 2014)





The 7 turbine locations that meet all the above criteria are listed in WGS 84 projection and are shown in Figure 5 and Table 7 as below. Two locations (B1 and B2) have been identified as the backup locations in case there are challenges with property owners or any other unforeseen factors. The turbine locations are sited close to the shoreline as possible in order to take advantage of the higher wind speeds.

Table 8: GPS Coordinates of 7 turbines

Turbine Reference	GPS Coordinate	
Turbine 1 (T1)	42°28'54.05"N,	81°40'14.92"W
Turbine 2 (T2)	42°29'24.44"N,	81°39'37.65"W
Turbine 3(T3)	42°29'53.54"N,	81°38'57.75"W
Turbine 4(T4)	42°30'11.05"N,	81°38'27.59"W
Turbine 5(T5)	42°30'49.04"N,	81°38'57.88"W
Turbine 6(T6)	42°30'34.80"N,	81°39'44.33"W
Turbine 7 (T7)	42°30'2.93"N,	81°40'24.18"W

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Turbine Backup 1: (B1)	42°29'47.03"N,	81°40'51.96"W
Turbine Backup 2: (B2)	42°29'22.67"N,	81°41'6.49"W

Figure 5: Locations of 7 turbines at the New Gloscgow Site.

3 Permitting /Environmental Assessment

3.1 REA Process

Under the Environmental Protection Act, the REA process is required to be undertaken for developing the renewable energy project including the on-shore wind farm as described in Ontario Regulation 359/09.(MOECC, 2013). This section is to explore the necessary steps and required technical reports in accordance with O.Reg 359/09(MOECC, 2013). Table 8 is the summary of the list of REA technical reports as well as other supplementary reports along with the relevant approval ministries. Besides REA requirements, possible coordination may be required in dealing with local radar and radiocommunication systems within the area (RABC, CanWEA, 2010)

Table 9: List of REA Required Reports (MOECC, 2013)

Name of the Reports	Approval Authority
Project Description Report	Ministry of Environment and Climate Change(MOECC)
Construction Plan Report	
Operation and Maintenance Report	
Decommissioning Report	
Water Assessments and Water Body Report	
Noise Study Report	
Natural Heritage Assessment Report	Ministry of Natural Resources and Forestry (MNRF)
Archaeological Assessment Report Stage 1	Ministry of Tourism and Cultural and Sports(MTCS)
Cultural Heritage Report	

Project Description: The Project is to develop 23.3 10 MW name plate capacity of on-shore wind farm in New Glosgow situated in the municipality of West Elgin and Elgin County, in Ontario which includes the seven Vestas V117 3.3MW wind turbines. The Project is classified as the Class 4 wind farm as per the O.Reg 359/09 (MOECC, 2013). In below subsections, the summary of the each technical reports are provided along with the finding of the respective studies.

3.1.1 Project Description Report (PDR)

As per O.Reg 359/09, PDR needs to provide overview of the project description including the applicable technology and the land accessibility as below.

Technology: Most of today's larger and medium sized wind turbines use key aerodynamic features seen in airplanes, helping blades create lift (Gipe, 2014). Wind energy from the turbine then goes to the hub which eventually converts the wind power into electricity (Gipe, 2014).

Land Accessibility: Either option to lease or purchase agreements are to be obtained with the participating private landowners where the seven proposed turbines are to be situated.

Municipal Permits/Support Resolution:WETG In order to obtain the Municipal Support Resolution as the willing host of the Project, the consultation process will be undertaken with the Municipality of West Elgin and Elgin Country. Prior to the commencement of the construction, road use agreements and associated construction permits are also to be obtained which allow the usage of municipal roads from the Municipality and the County.

We plan on seeking land lease or purchase agreements by working with the municipality of West Elgin and Elgin Country as plan is not on any Ontario crown land. Elgin County has an economic development branch and assists in promoting economic growth for municipalities within the region. They also have been helpful with other renewable energy projects, including another wind farm within the region (County of Elgin, 2014). Based on previous mentioned use of seven Vestas 117-3.3MW wind turbines, at 21.3MW total our wind farm based on the Ontario Environmental Act criteria is class four (Ontario, 2013).

We will also require key permits for temporary roads and construction ahead of construction of siting. This will involve temporary construction permits from West Elgin and Elgin County. We also expect land excursion during the process of turbine construction. Land restoration will occur once the turbines are in operation. Air pollution is a concern during the construction phase. We anticipate minor air pollution during this period, despite motor vehicles transporting necessary equipment. An assessment of the Ontario Air Pollution- Local Air Pollution Act O. 419/05 (Ontario Ministry of the Environment, 2011) notes this act applies only to key oil, fossil fuel, mineral, manufacturing industries not motor vehicles or renewable energy projects .

3.1.2 Construction Plan Report (CPR)

In the CPR, the detailed process and the expected time-line of the construction as well as any negative impacts will be explained along with mitigation measures.

Construction Timelines: An average time and construction for a wind farm takes 1 - 1.25 years (Stantec Consulting, 2013). This includes surveying, getting the site ready, foundation building for the turbines, site report on fixing temporary work areas. (Stantec Consulting, 2013). Building the actual wind farm can take as little as 2 months for 2MW (EWEA, 2014). Considering the scale of the Project, approximately one year is expected to take place for the construction.

Construction Process: The turbines will be transported by air, land or sea. Once they arrive, a flatbed truck will pick them up to the proposed spots. There are a few candidate flatbed companies within the West Elgin/London Ontario region which include: Churchill Logistics, Becker Brothers, Ross Towing and Transportation and Mike Nesbitt Trucking (Yellow Pages, 2014).Siemens D3 platform system will be used as part of the transportation setup to ensure a smooth transition from place of original arrival to the proposed site (Siemens, 2014).

Other Construction Permits: Permits from Ontario Ministry of Transportation (MTO) is required for oversized materials like wind turbines and to ensure safe passage point of transport to site destination (MOECC, 2013).

Negative Environment Impacts: Air pollution is a concern during the construction phase. Minor air pollution is expected during this period, despite motor vehicles transporting necessary equipment. Furthermore, possible environmental concerns from construction involve as below; construction noise, water excavation, mistreatment of lubricant oils, and increase in carbon emissions on site during construction. This cause 80% of all emissions relating to wind farms (Wind Energy: the Facts, 2009).

Mitigation Measures: Mitigation will include reducing risk onsite noise, ensuring minimal use of waste, storing lubricant oils safely and disposing them in a proper manner at a local disposal site.

3.1.3 Design and Operations Report (DOR)

DOR is required to provide the details of how the Project will be designed and operated during the 20 years of operation phase. (MOECC, 2013). It also appends the Environment Effects and Monitoring Plan (EEMP) which entails how negative environmental impacts will be mitigated during the operation stage.

Negative Environmental Impacts:

- ✓ **Air Pollution:** Wind energy produces very little air pollutants and zero carbon emissions (Jauber, S. 2011). Carbon emissions are produced mostly during construction of wind farms (Wind Energy: The Facts, 2009). Wind energy also has the lowest carbon emissions among all renewables energies, at 25g/kWh (Evans, A. et al, 2009). The Project is expected to have the minimal air contaminants released during in operation.
- ✓ **Waste**: Constructional waste involves creating, packaging, cleaning materials, lubricants, paints and degreasers (AWEA, 2008). AWEA (2008) also notes operational waste examples as: waste fluids from turbines (i.e. lubricants). Some of these materials may be considered hazardous and will need proper disposing of at a local waste maintenance company in West Elgin.

EEMP: Any birds and bats hazards will be also addressed in the EEMP.

3.1.4 Decommissioning Plan Report (DPR)

Decommissioning takes place at the end of the operation mostly, a 20 year cycle for commercial wind farms (Gipe, 2004). DPR describes how the Project components are decommissioned and the surrounding environments such as land and water are restored to the original stage. Once the life cycle of 20 years is completed, the decision will be made whether the turbines will be updated or torn down.

EEMP: Decommissioning will be undertaken in accordance with the EEMP which entails the avoidance of any potential conflict with local bird species during the decommissioning process (MOECC, 2013). Once an EEMP has been filed, land clearing can occur for heavy equipment to decommission the wind farm. Clearing of land must respect REA setback criteria during the decommissioning process, including the blade's length and 10 meters from railways and public roads (MOECC, 2013).

Required Permits: Permits for overweight equipment to take out the turbines and for upgrading roads to ensure that proper vehicles come into the vicinity are required by MTO (MOECC, 2013)

Waste Handling: American Wind Energy Association Siting Handbook (AWEA) (2008) recommends all materials and waste will need proper discarding in order by a locally licensed place that meets the local requirements. Materials and waste that need correct disposing include: steel, turbine blades, hubs, gear boxes, metrological devices and nacelles.

Land/Water Restoration: Once all Project components have been removed, restoring local land and water to its original state can begin. This will involve re-vegetation of land based on the EEMP analysis. Water analysis will also be required based on the water impact report. Possible pitfalls including ruining the water and minimizing risk is critical in restoring waterways within the area.

3.1.5 Consultation Plan Report (CPR)

Under Environmental Protection Act, CPR is required to entail the consultation activities with the Pubic, Aboriginal Groups, and Municipalities (MOECC, 2013).

Aboriginal Consultation: Upon identified by MOECC on the list of aboriginal communities, draft REA reports are required to be sent to respective communities throughout the REA process (MOECC, 2013).

Public/Municipal Consultation: The flowing is the process fulfilling the consultation requirement with the Public and Municipality under the O.Reg 359/09(MOECC, 2013).

- ✓ **Notice of Project:** A Notice of Proposals to engage in a Project will be sent at least 30 days prior to the first Public Meeting. Draft PDR is made available to the general public of West Elgin residents (120 meter boundary of the Project Boundary) as well as to the government stakeholders including the municipality.

- ✓ **1st Public Meeting:** The 1st Public Meeting will take place, inviting interested public as well as other stake holders to raise concerns or other issues on the development of the Project.
- ✓ **Project Development:** During this stage, the Project layout and other draft technical reports and field studies such as natural heritage, archeological works are to be prepared in consultation with the public.
- ✓ **Municipal Consultation:** 90 days prior to the final Public Meeting, the draft REA reports need to be sent out to Municipality of West Elgin along with the Municipal Consultation Form for their input.
- ✓ **Draft REA Report Release:** 60 days prior to the final Public Meeting, the draft REA reports are to be publicized to the Project's website and are to be circulated to the general public and relevant stakeholders for further input.
- ✓ **2nd Public Meeting:** At this stage, all relevant stakeholders and public are invited to participate to provide final inputs prior to submission of final REA technical reports to MOECC.
- ✓ **REA Submission to MOECC:** After final Public Meeting, along with final REA technical reports, CPR is also prepared to include all the consultation log, feedback and will be submitted to the MOECC as a package to the REA application.
- ✓ **Setback Requirement**: For wind facility, a minimum of 120 meter setback is required from the natural features such as provincial significant wetland, and 50 meter for placing transmission lines (MNRF, 2012). Upon the record review, if the Project is falling within this setback boundary, further Environmental Impact Studies are required.

3.1.6 Water Assessment and Water Body Report

The water assessment report is required to be filed to MOECC for Class 4 wind farm along with REA technical reports to assess whether there exists any water bodies within certain setback from the Project boundary.

Setback Requirement: Wind farms must also meet setback criteria of not being near 30 meter of high yearly average of respected water bodies (MOECC, 2013) which means wind blades must be 30 meter away from all bodies of water.

Site Analysis: An area records review is required to determine if the wind farm is located within 120 meter of the yearly highest lake, stream, seepage average or 300 meter for lake trout and preliminary findings found no significant or permanent intermittent streams (MOECC, 2013). Lake Erie is the only permanent lake with the region with smaller pocket of water, including Port Glasgow (Google Maps, 2014). Therefore, if Water Assessment and applicable Water Body reports are prepared, there should be no stopover on development of the Project as designed.

Negative Impact: The Project will not cause any major water quality concerns. Wind farms use very little water at 1kg per 1 kWh and water has the lowest life cycle consumption in producing renewable energy compared to solar, hydro and geothermal (Evans, A et al, 2009)

3.1.7 Noise Report

Class four wind projects over 102 Dba are required to submit a noise report to the Minister of the Environment. Procedures were based on *Noise Guidelines for Wind Farms (MOECC, 2008).* Vestas is the turbine manufacturer supplying seven V117-3.3MW wind turbines, while the Duart is the transformer substation around the proposed wind farm. Possible parts that may cause noise include the blades, mechanical elements including the gear box, and transformer station. We meet the minimum noise requirement of 550M from the closest noise receptor.

3.1.8 Natural Heritage Assessment (NHA)

NHA is required to be conducted and submitted to MNRF to obtain the Confirmation Letter prior to the final Public Meeting as part of the REA Process (MOECC, 2013). NHA consists of four reports including Record Review, Site Investigation, Evaluation of Significance and Environmental Impact Studies.

New Glosgow Wind Farm Project

Site Description: New Glasgow is located in a mixwood Plains ecozone, and Ontario's most southern eco-zone (Crins W.J, Gray P.A et al, 2009). This region has both hot and cold summers as its close to Lake Erie. Approximately78% of this region is agriculture (cropland and pasture). Forest covers around 12% and urban land 7% (Crins W.J., Gray P.A. et. al, 2009). This region is the most densely populated with cities including Toronto, Hamilton, St. Catherine's, and close by London..

Natural Features: Project Site has two woodlots in the surrounding area: Port Glasgow Woodlot and New Glasgow Woodlot (West Elgin, 2014a). New Glasgow's wood lot is located in parts of Lot C, Lot D, North and South of the Grey Line and South of Lot A. (West Elgin, 2014b, 2014c) Port Glasgow's woodlot is located between McCool Road.

Setback /EIS Requirement: For wind facility, a minimum of 120 meter setback is required from the natural features such as provincial significant woodland, and 50 meter for placing transmission lines (MNRF, 2012). Upon the record review, the Project is falling within this setback boundary from the candidate woodlands. However, as long as further Environmental Impact Studies (EIS) is prepared to provide the mitigation measures for any negative impacts caused by the Project, the Project is allowed to develop within this setback area. Therefore, for the purpose of this assignment, the Project can proceed on those wooded area with appropriate mitigation measure being undertaken.

3.1.9 Environmental Effects and Monitoring Plan (EEMP): Birds and Bats

The assessment of bird and bird habitats is required for class, 3,4,5 wind Ontario wind farms and filed under the Natural Heritage Assessment to MNRF. EEMP addresses steps required in mitigating potential harmful effect of birds and bats from wind energy (MOECC, 2013)

Bird Mortality Threshold: MRNF also suggests various thresholds for bird mortalities including the following (MNRF, 2011).

- 14 birds at each turbine once a year at wind farm groups or individual wind turbines.

- A wind project has 0.2 raptors at each turbine every year.
- 0.1 yearly for provincially tracked raptors per turbine yearly at a wind power plant, or 2 raptors with less than wind turbines.

Based on the projections with around 7 wind turbines, the Project would allow 2 raptor deaths yearly. Although West Elgin has bird watching areas, none are within the 120 meter requirement for wind turbine placements (MNRF, 2012).

Monitoring Plan: However, bird mortality surveys will be undertaken once a week at each turbine as per MNRF guideline (MNRF, 2011). After construction, monitoring methods will involve: Carcass searches, raptor Morality Surveys, Search efficiency Trials, Proportion Area Searches (MNRF, 2011) Three year post construction monitoring report will be also addressed for the bird fatalities. Operational alterations are needed if significant bird fatalities occur (MNRF, 2011).

3.1.10 Archaeological Assessment/Cultural Heritage Assessment

Archeological Assessment (AA) Stage 1is required to be submitted to MTCS by professional archaeologists to obtain the Consent Letter confirming the AA1 report met its requirements, if following criteria are met for the Project (MTCS, 2013)

1- Protected properties or registered archeologically
2- Becoming one under the municipal archeological plan

Site Analysis: For the purpose of this assignment, it is assumed that the Project is falling under the one of above criteria in the absence of available data. Therefore, the following 4 stages are summarized as below, with the approach that the Project will proceed the development by undertaking the necessary AA reports and excavation, if there are to be any archaeological findings (MTCS, 2013). Therefore, no setbacks from the archeological resources are to be considered for the development of the Project.

- ✓ Archeological Assessment 1: Consultant will look at historical information, land use, and local geography around the surrounding area.

- ✓ Archeological Assessment 2: Stage two involves the consultant looking on site (field studies) to see if archeological sites exist by either test pit method or ploughing the field.
- ✓ Archeological Assessment 3: The size of the archaeological site is determined by the archeologist's recommendations, for a stage 4 assessment along with deciding on any cultural interest or value on the land.
- ✓ Archeological Assessment 4: Last stage involves developing mitigation ideas including the excavation for archeological area working with property owner, aboriginal communities, municipalities, or other heritage groups.

3.1.11 Cultural Report

In agreement with O. Reg 359/09, submission of the Cultural Heritage Report (CRP) is submitted to the MTCS. MTCS acknowledges two types of heritage resources: Built and Cultural Landscape (MTCS, 2013). If low risk heritage resources exist, a self-assessment can be done. If there is a higher risk of a cultural heritage resource found, then a qualified personal will have to do an assessment. We will ensure a qualified cultural assessor who is required to have a post-secondary education, qualified study and work experience in the field do a study to ensure no risk of infringing on a cultural resource.

3.1.12 Radiocommunication and Radar Systems Coordination

Coordination may be needed to Radiocommunication and Radar Systems in the area close to the proposed Project. Wind turbines; being large metal objects, may interfere in various ways with radar and navigation systems, point-to-point microwave links, AM, FM, and TV broadcast stations, satellite systems, and land mobile systems in the VHF and UHF frequency ranges. Radio Advisory Board of Canada (RABC) and Canadian Wind Energy Association (CanWEA) have developed some guidelines and coordination zones for wind turbines (RABC, CanWEA, 2010). A list of the coordination zones are reproduced from (RABC, CanWEA, 2010) and located in Appendix 1.3. The impact from the consultation zone on the proposed turbine location is shown in the right column in the chart. The systems present within the consultation zones were determined by referencing Industry Canada's Spectrum Direct (2014) and SPECTRAweb (2014) databases. The proposed Project is outside of the consultation zone of many of these systems. However, detailed analysis of Point-to-Point and Radar and DND systems would be required. The detailed table of all consultation zones is shown in Appendix 1.3

4 Grid Integration and Operation/Maintenance

In order for the proposed Project to be integrated to the Hydro One ('HONI') transmission network, multiple steps are required to be followed. This section, therefore, will layout the appropriate steps needed for the grid integration as well as will explore the types of stakeholders along this process.

4.1 Selection of Transformer Station

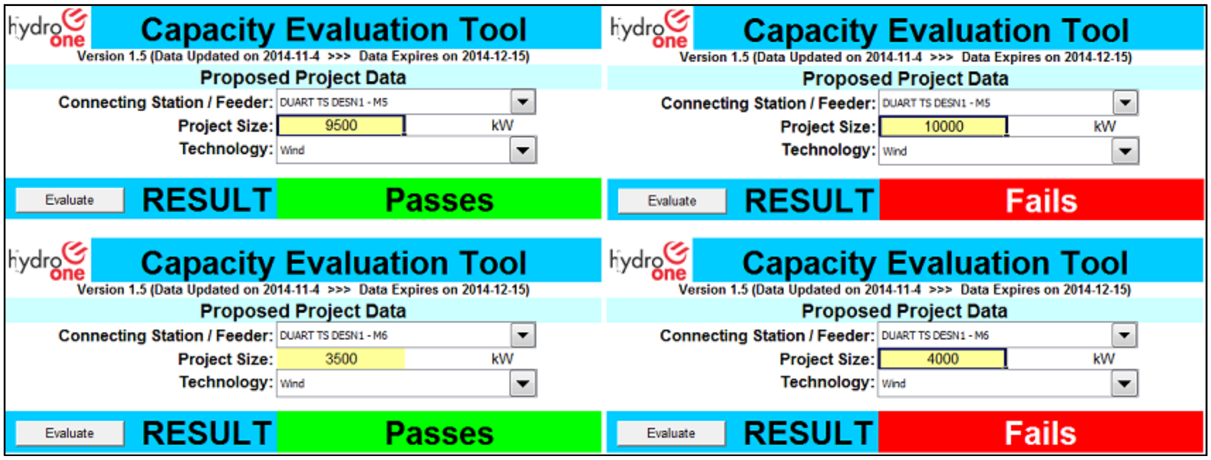
Based on the available HONI Transmission System Map for Southern Ontario (HONI ed 2, 2012), the nearest transmission substation to the proposed Project Site is Kent TS (transformer station) located in the City of Chatam-Kent, Ontario, approximately 61.5 km SW from New Glasgow. However, Kent TS is excluded for the further consideration as the information is not readily available and new substation has been built at the end of 2012 just 20 km NW from the proposed Project Site
Duart TS is the TS which HONI is planning to construct to provide additional connection point on HONI's existing transmission grid and which will step down electricity from the adjacent 230kV transmission line to 27.6 kV (HONI ed1, 2014). The following table 9 provides the available capacity at the Duart transformer station (HONI ed3, 2014).

Table 11: Available Capacity at the Duart Transformer Station (HONI ed3, 2014)

Station	Feeder Name	Voltage (kV)	Minimum Load	Short Circuit Capacity	Thermal Capacity (MW)
Duart TS	M5	27.6	0.0	84.0	25.0
Duart TS	M6	27.6	0.0	81.7	25.0

However when evaluating the available capacity at the above M5 and M6 feeders using the HONI's online tool Capacity Evaluation Tool V1.5, the feeders fails to accommodate the needed capacity for our proposed Project showing a maximum capacity available of 9,500 kW for feeder M5 and 3,500 kW for feeder M6, respectively as illustrated in Figure 6 (HONI ed3, 2014).

Figure 6: Duart TS Capacity Results (HONI ed3, 2014)



After further investigation to find TS alternatives to accommodate the proposed Project without the need of relay on the Kent TS located far away from the site, it is identified that the Duart TS is equipped with two 75/100/125 MVA and 230/27.6-27.6 kV transformers and a 27.6 kV air insulated switchyard comprising of electrical equipment to reliably connect up to twelve 27.6 kV distribution (HONI ed 1, 2014) and the following Single Line Diagram (SLD) also confirms the same information in Figure 8.

Figure 7: Duart TS Electrical Single Line Diagram (HONI ed 1, 2014)

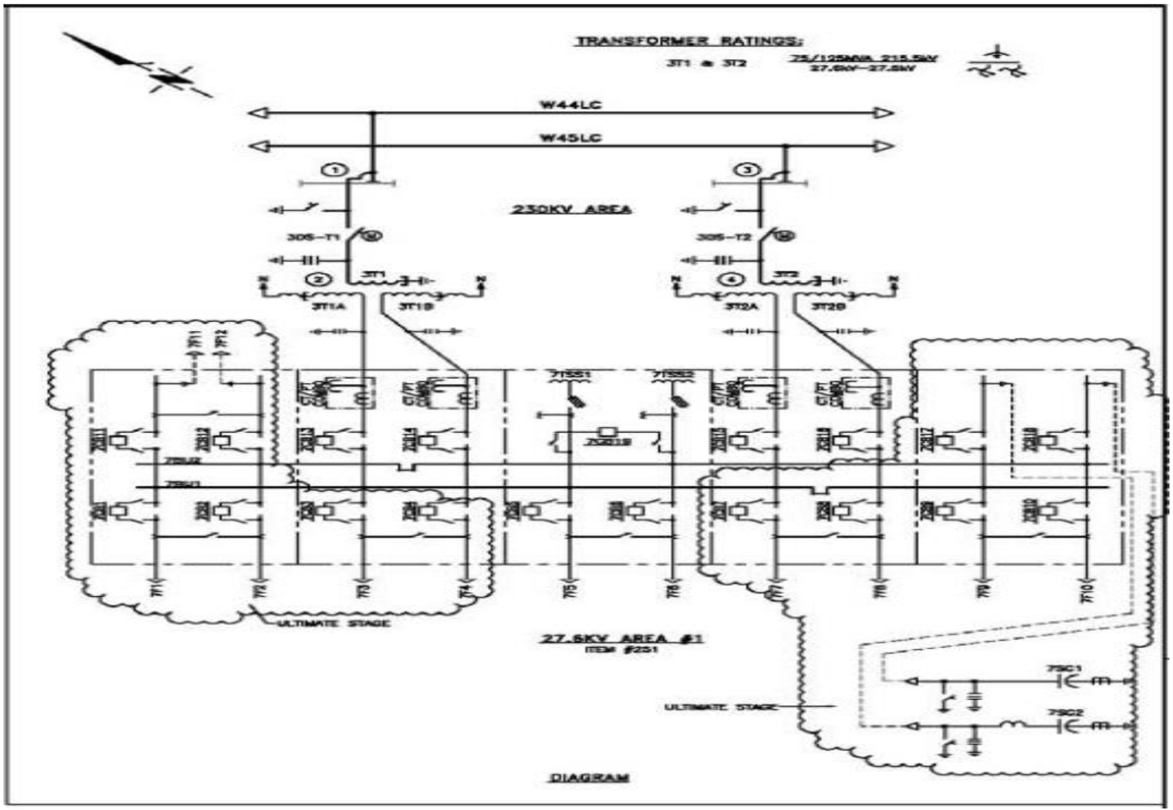
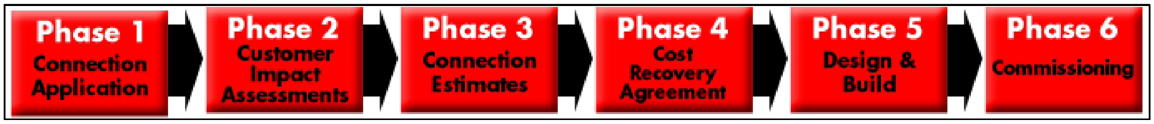


Figure 7 confirms that the actual electrical arrangement of Duart TS has in place an installed capacity for twelve feeders but only two of them are currently in use and operational to distribute electricity. Due to the lack of clarity in terms of the overall available capacity in the Duart TS based on HONI's website, it is assumed for the purpose of this assignment, and based on the researched information that the Duart TS has the available capacity in the remaining spare feeders to allow the proposed Project to be interconnected to the transmission network and also that HONI will accommodate one of the spare feeders for this Project.

As part of the Project component, a dedicated feeder and switching station will be constructed and step up the output of the generated electricity to a 26.7 kV dedicated feeder of approximately 16.9km from the Duart TS. HONI's Connection Process HONI requires the arrangement of pre-consultation meeting with the developer to discuss about the proposed Project.

Once HONI understands the Project, then the developer can move to the connection application process as illustrated in Figure 9as below (HONI ed 4, 2014).

Figure 8: HONI's Connection Process (HONI ed 4, 2014)



Phase 1 - Connection Application: The application for the System Impact Assessment (SIA) and Customer Impact Assessment (CIA) are to be submitted in the Phase 1. HONI will discuss and review available connection facilities (the Duart TS) and requirements in general. Each SIA and CIA application needs to be submitted to HONI and the Independent Electricity System Operator (IESO), respectively. This phase takes around 30 days.

Phase 2 – Customer Impact Assessment: IESO generates a final draft of the SIA and HONI analyzes any impacts on other transmission customers in the CIA, which draft a preliminary terms and conditions of the agreement. Finally, HONI issues a final CIA report. This process takes approximately 3 to 4 months to be completed.

Phase 3 – Connection Estimates: Cost estimates are calculated for the transmission facilities based on SIA and CIA assessments. Construction responsibilities, permits and schedules are also determined together with the Pre-Connection Cost Recovery Agreement (CCRA) to procure long lead materials in advance for the execution. This phase takes 4 to 8 months.

Phase 4 – Cost Recovery Agreement: CCRA report is finalized and includes final term and conditions which establishes back-feed dates, details the scope of work and responsibilities. This report is used as the basis for the final approval and establishes the date for the start of the construction; it takes 1 to 2 months.

Phase 5 – Design and Build: The detailed engineering and project design is completed in this phase together with the procurement of the materials and construction of the generation station. This phase can take up to 18 months depending on the complexity of other factors.

<u>Phase 6 – Commissioning:</u> The facility is inspected and tested in preparation to be put in service. A commissioning plan will need to be submitted at least 45 days in advance prior to in-service date. HONI will also negotiate with the customer on the final Transmission Connection Agreement (TCA). This phase could take up to 3 months.

4.2 Independent Electricity System Operator (IESO) Connection Assessment and Approval

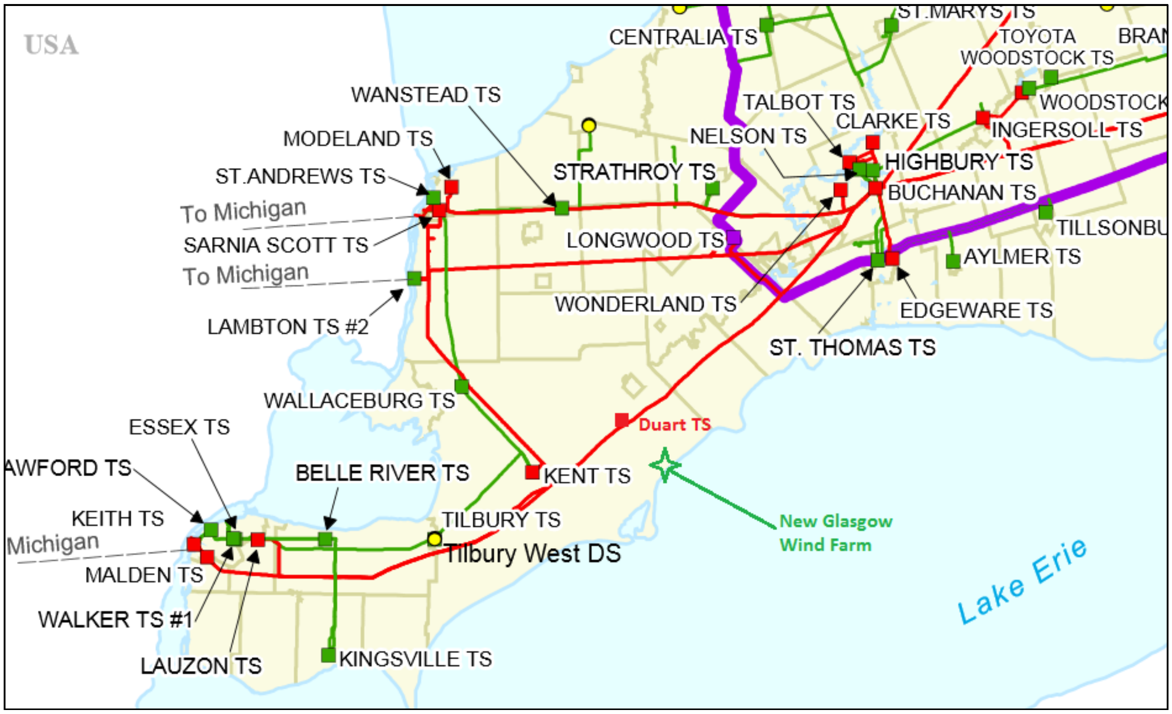
1. The IESO mandates that anyone planning to build a generation facility over 10MW that will be incorporated to the IESO–controlled grid completes the Connection Assessment and Approval (CAA) IESO assesses the impact of new or modified connections on the reliability and stability if any changes and modifications on the integrated power system requires the mitigation of the potential adverse impact.

2. In addition, IESO will conduct a mandatory SIA to assess the impact of the proposed connection to the grid.

Grid Integration Proposal

The following is the proposal for the grid integration on the proposed Project, assuming all above required steps with HONI and IESO are properly approved.
The Duart TS will be the HONI's transmission station to be used for grid integration as illustrated in Figure 10 below.

Figure 9: Southern Ontario Transmission Map (HONI ed0, 2012)



The Duart TS is located in the intersection of Duart Road and Spence Line in the Chatam-Kent municipality in Southern Ontario. A dedicated feeder from the Duart TS will be built and will have an approximately length of 19.9 km to the Project's switching station, located in between Duart Road and Furnival Road over the Talbot Trail Line. In addition, two underground lines will be built to bring the electricity generated from turbines T5, T6 and T7 to the north side of the switch station and a second underground cable will accommodate T1, T2, T3 and T4 from the south side, with the first one with a length of approximately 3.0 km and the second one 3.6 km as shown in Figure 11. TB1 and TB2 are alternate turbine locations in case where the consultation with property owners does not proceed as planned.

Figure 10: Google Earth View of the proposed Project and Turbine Locations.

Operation and Maintenance

A key component to properly operate the proposed Project is to constantly monitor its performance. In order to do so, a Supervisory and Control And Data Acquisition system (SCADA) will be put in place to remotely monitor the operation of the turbines and the reliability of the local substation, protection electronic devices and interconnection with the transmission grid. In addition, a local weather station will be also installed to properly monitor local weather conditions and to prepare for any major storms and track lighting to protect maintenance crews. A proper in-house Operation and Maintenance Plan and budget will be set aside on top of the turbine vendor warranty; this program should be cost-effective and ensure proper operation on the wind turbines during their lifespan. The following are some of the components that will be put in place in order to guarantee a proper operation of the Project.

4.2.1 Turbine Monitoring and Control

The same turbine manufacturer monitoring package named as “VestasOnline Power Plant Controller” is selected for the Project considering the scale of the wind farm. With this SCADA software, remote monitor and control of each individual turbine can be undertaken with access to the real-time information (Vestas, 2014).

4.2.2 SCADA System

A key component of the monitoring is to properly read the kilowatt-hour meter that measures the amount of electrical energy that passes through them and this information is useful to monitor the electricity consumption and production of each wind turbine (Gipe, 2004). In order to avoid downtime and reach out maximum production the VestasOnline Business SCADA software will provide us with not only the information provided by the turbine monitoring system but also integration with the meteorological information and substation grid information.

The SCADA system will provide, in the event of failure, instant alarms in order to take appropriate actions and minimize down time which can increase the reliability of the Project. This system will also have an historian in order to log all type of data for later fault and production analysis; it will also generate monthly and yearly generation reports that will be used for predictive maintenance purposes.

4.2.3 Weather Forecasting

Wind turbines are subject to lighting strikes due to their height, also, maintenance crews need advance warning of lighting in the area to safety evacuate from both the turbines and the wind farm itself. The crews need to have visibility for the right moment of the leave of and return to the Project site. For this and other reasons, the Schneider Electric which provides the weather forecasting services in 60% of the wind farms\in North

America will be retained to continuously provide 24hr real-time information of the weather conditions (Schneider-electric , 2014). Onboard wind sensors will be mounted on each turbine to monitor and measure wind speed, wind direction and temperature which will be used in conjunction with the meteorological tower. Operators will be trained in all operation and maintenance systems directly by the manufacturers.

4.2.4 Communications

The site will have radio and land communication systems that will be tied to the SCADA system in order to properly alarm the maintenance crew in case of any failure or malfunction. The radio system will ensure maintenance crew and operation personnel are in continues communication.

4.2.5 Operation and Maintenance Crew

Due to the relatively small size of the Project, there will be only 3 full time employees allocated to the maintenance and operation of the Project. A crew of two will work always in tandem and will be in charge of the schedule maintenances; they will work 8 hours a day and will be living no further than 30 minutes from the Project Site. The third employee will monitor the Project Site from the main headquarter and will have remote access to all the information in the Project Site.

4.2.6 Operation and Maintenance Plan, Schedule and Budget

The following O&M Plan will ensure a long term strategy to properly operate, maintain and repair the Project.

As the failure rates of wind turbines decreases after the first two years, a maintenance plan in conjunction with the turbine manufacturer will be in place in intervals of 4, 6, 12, 24 and 48 months. This maintenance will be undertaken together with the turbine vendor technical personal in order for the maintenance personal to be trained and to gain exposure to potential problems (In-House Wind, 2008).

During extreme or unexpected conditions the wind farm operations, staff may be required to initiate emergency shutdown of one or more wind turbines or mitigation measures to protect personnel and wind farm assets. This includes wind conditions that exceed the wind turbines rated speeds, extreme cold and icing, and/or other weather events. The below table summarizes the extreme events as well as the associated mitigation measures that the wind farm operations staff can adopt (Dufferin, 2012).

Table 12: Mitigation Plan for the Extreme Events (Dufferin, 2012)

Extreme Events Mitigation Actions		
Event	Effect	Mitigation Measure
Heavy Rain / Flooding	Surficial drainage to remain intact and continue to convey water	None Required
Hail	Damage to turbine blades	Turbine blades are constructed to withstand hail impact
Heavy Snow	No effect anticipated	None Required
Ice Storm / Freezing Rain	Icing on turbine blades resulting in the potential of ice fall or throw	Turbine automatically powers down when it senses an imbalance in blades due to ice loading
High Wind / Tornado	No effect anticipated	Turbine blades designed to stop moving at wind speeds greater than 25 m/s. Turbine and foundation structures are designed to withstand a Level 2 tornado (200 km/h winds)
Lighting	Potential for fire in the nacelle	Lighting receptors installed along blades and surge protection in electrical components
Earthquake	Not located on an active fault area. No effects anticipated	Structure will be designed to meet the earthquake loads as per the Ontario Building Code

North America WindPower magazine exemplifies the O&M budget, based on the results of data collected at more than 8GW of installed wind projects throughout North America over the last 10 years(Houston, 2014). It suggests that the O&M costs reveals an average of US$ 31,000 /MW per turbine as 2011 with the expected increase in the cost every year (Houston, 2014). However, this average figure of US $31,000 per MW produced is considered for the purpose of this assignment.

4.2.7 Operation and Maintenance Agreements

In addition to the full time employees, the following **O&M** agreements and contracts will be set in place for effective maintenance.

- Additional maintenance crew members for major repairs and maintenance twice a year
- Service roads maintenance crew to properly maintain the access to the towers including snow plowers during winter
- Specialized maintenance contract to maintain the weather tower and sensors and substation equipment.

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1 APPENDICES

1.1 Wind Speed, Power, and Energy Distribution for the Vestas V117-3.3MW

Wind Speed, Power, and Energy Distribution for the Vestas V117-3.3MW at 91.5m hub Height								
Wind Speed at 80m (m/s)	**Wind speed at 91.5m (m/s)**	**Probability of wind speed**	**Efficiency 91.5m**	**Power in the wind at 91.5m (W/m2)**	**Power in the wind at 91.5m (kW)**	**Energy produced at 91.5m (MWh/yr)**	**Turbine Power Generated (kW)**	**Turbine Energy Generated (MWh/yr)**
0	0.0	0.000	0.00	0.0	0	0	0	0
1	1.0	0.007	0.00	0.0	0	0	0	0
2	2.1	0.041	0.00	0.2	2	21	0	0
3	3.1	0.055	0.17	1.0	11	95	2	16
4	4.1	0.096	0.36	4.1	45	391	16	143
5	5.2	0.086	0.410	7.2	78	682	32	279
6	6.2	0.099	0.42	14.4	154	1352	65	573
7	7.2	0.088	0.43	20.4	219	1918	94	826
8	8.3	0.080	0.43	27.5	296	2591	129	1127
9	9.3	0.087	0.43	42.4	456	3995	195	1711
10	10.3	0.066	0.39	44.6	480	4203	189	1655
11	11.3	0.065	0.33	58.4	628	5504	207	1815
12	12.4	0.055	0.26	64.0	688	6026	181	1584
13	13.4	0.041	0.21	61.1	656	5751	137	1196
14	14.4	0.032	0.17	59.9	644	5644	107	939
15	15.5	0.025	0.14	57.1	614	5376	83	727
16	16.5	0.021	0.11	59.1	635	5566	71	620
17	17.5	0.016	0.09	54.2	582	5100	54	474
18	18.6	0.014	0.08	53.5	575	5039	45	395
19	19.6	0.006	0.07	29.7	319	2798	21	186
20	20.6	0.007	0.06	37.4	403	3526	23	201
21	21.7	0.002	0.05	15.4	166	1450	8	72
22	22.7	0.002	0.04	17.7	190	1667	8	72
23	23.7	0.001	0.04	6.0	64	564	2	21
24	24.8	0.001	0.03	4.8	52	454	2	15
25	25.8	0.000	0.00	2.2	24	211	0	0
26	26.8	0.000	0.00	1.8	19	170	0	0

Wind Speed, Power, and Energy Distribution for the Vestas V117-3.3MW at 116.5m hub Height								
Wind Speed at 80m (m/s)	**Wind speed at 116.5m (m/s)**	**Wing Speed Probability**	**Efficiency at 116.5m**	**Power in the wind at 116.5m (W/m2)**	**Power in the wind at 116.5m (kW)**	**Energy in the wind at 116.5m (MWh/yr)**	**Turbine Power Generated (kW)**	**Turbine Energy Generated (MWh/yr)**
0	0.0	0.000	0.00	0.0	0	0	0	0
1	1.1	0.007	0.00	0.0	0	1	0	0
2	2.2	0.041	0.00	0.3	3	24	0	0
3	3.3	0.055	0.22	1.2	13	112	3	24
4	4.4	0.096	0.38	4.9	53	462	20	177
5	5.5	0.086	0.41	8.6	92	807	38	335
6	6.5	0.099	0.43	17.0	183	1600	78	682
7	7.6	0.088	0.43	24.1	259	2269	112	982
8	8.7	0.080	0.43	32.6	350	3066	152	1330
9	9.8	0.087	0.42	50.2	540	4728	225	1969
10	10.9	0.066	0.36	52.8	568	4973	204	1785
11	12.0	0.065	0.29	69.2	743	6513	213	1864
12	13.1	0.055	0.22	75.7	814	7131	182	1594
13	14.2	0.041	0.18	72.3	777	6805	137	1197
14	15.3	0.032	0.14	70.9	762	6679	107	940
15	16.4	0.025	0.11	67.5	726	6362	83	728
16	17.5	0.021	0.09	69.9	752	6587	71	620
17	18.6	0.016	0.08	64.1	689	6035	54	474
18	19.6	0.014	0.07	63.3	681	5963	45	395
19	20.7	0.006	0.06	35.2	378	3311	21	186
20	21.8	0.007	0.05	44.3	476	4172	23	201
21	22.9	0.002	0.04	18.2	196	1716	8	71
22	24.0	0.002	0.04	20.9	225	1973	8	71
23	25.1	0.001	0.00	7.1	76	668	0	0
24	26.2	0.001	0.00	5.7	61	538	0	0
25	27.3	0.000	0.00	2.7	29	250	0	0
26	28.4	0.000	0.00	2.1	23	201	0	0

Wind Speed, Power, and Energy Distribution for the Vestas V117-3.3MW at 141.5m hub Height								
Wind Speed at 80m (m/s)	Wind speed at 141.5m (m/s)	Wing Speed Probability	Efficiency at 141.5m	Power in the wind at 141.5m (W/m2)	Power in the wind at 141.5m (kW)	Energy in the wind at 141.5m (MWh/yr)	Turbine Power Generated (kW)	Turbine Energy Generated (MWh/yr)
0	0.0	0.000	0.00	0.0	0	0	0	0
1	1.1	0.007	0.00	0.0	0	1	0	0
2	2.3	0.041	0.00	0.3	3	28	0	0
3	3.4	0.055	0.26	1.4	15	128	4	34
4	4.6	0.096	0.39	5.6	60	530	24	208
5	5.7	0.086	0.42	9.8	105	924	44	386
6	6.8	0.099	0.43	19.5	209	1833	90	785
7	8.0	0.088	0.43	27.6	297	2598	129	1129
8	9.1	0.080	0.43	37.3	401	3511	172	1511
9	10.3	0.087	0.40	57.5	618	5414	245	2145
10	11.4	0.066	0.33	60.5	650	5695	211	1852
11	12.6	0.065	0.25	79.2	851	7458	215	1881
12	13.7	0.055	0.20	86.7	932	8166	182	1595
13	14.8	0.041	0.15	82.7	890	7792	137	1196
14	16.0	0.032	0.12	81.2	873	7648	107	939
15	17.1	0.025	0.10	77.3	832	7285	83	728
16	18.3	0.021	0.08	80.1	861	7543	71	621
17	19.4	0.016	0.07	73.4	789	6911	54	474
18	20.5	0.014	0.06	72.5	780	6829	45	394
19	21.7	0.006	0.05	40.3	433	3791	21	186
20	22.8	0.007	0.04	50.7	545	4778	23	201
21	24.0	0.002	0.04	20.9	224	1965	8	71
22	25.1	0.002	0.00	24.0	258	2259	0	0
23	26.3	0.001	0.00	8.1	87	765	0	0
24	27.4	0.001	0.00	6.5	70	616	0	0
25	28.5	0.000	0.00	3.0	33	287	0	0
26	29.7	0.000	0.00	2.4	26	230	0	0

1.2 Vestas V117-3.3 MW Specifications

1.3 Radiocommunication and Radar Systems Coordination

System	Consultation Zone	Impact on the Project
Point-to-Point Systems above 890 MHz -Microwave links	Variable dependant on site locations, distance, and frequency. Detailed analysis is required	Some MW point-to-point links in the area. Detailed analysis is required
Broadcast transmitters -AM, FM and TV stations -Multi-channel Multipoint Distribution -Service (MMDS) Systems	AM: 5km for omnidirectional, 15km for directional FM: 2km TV: 2km	-No AM stations within 15km -No FM stations within 2km -No TV stations within 2km
Over-the-Air Reception -TV off-air pickup -Consumer TV receivers	Analog TV reception (NTSC): 15 km Digital TV (DTV) reception (ATSC): 10 km	CFPL-DT is located about 60km from the proposed wind farm. The wind farm is located within CFPL-DT's service contours. A reception analysis for the effected receivers would be needed
Cellular type networks **Land Mobile Radio networks** **Point-to-Point Systems below 890 MHz**	1km	No Cellular, Land Mobile, or Point-to-Point Systems below 890 MHz within 1km from the proposed turbines
Satellite Systems -Direct-to-Home (DTH) -Satellite Ground Stations	500 m radius plus the consultation zone should also include a cone of width "***Lc***" defined as: $Lc = R+104\sqrt{(D/F)}$ ***D*** = Distance from the ground satellite antenna in kilometers (km) (max distance = 10 km) ***F*** = Frequency in GHz ***Lc*** = Width of the cone in m ***R*** = Wind turbine rotor diameter in m	No Satellite Ground stations located within 10km of the proposed turbines. DTH systems have to be analysed further on an individual basis.
Air Defence Radars **Vessel Traffic Radars** **Air Traffic Control Radars** **Weather Radars**	1) 100 km around any DND Air Defence Radar 2) 80 km around any DND or Nav Canada Air Traffic Control Primary Surveillance Radar (PSR) 3) 10 km around any DND or Nav Canada Air Traffic Control Secondary Surveillance Radar (SSR) 4) 40 km around any DND Precision Approach Radar	The information for many of these systems is not public. Contact with DND is required.

	(PAR) 5) 60 km around any Canadian Coast Guard Vessel Traffic Radar System 6) 10 km around a military or civilian airfield; 7) 50 km around Environment Canada Weather Radar.	
VHF OmniRange (VOR)	15km	No VOR systems within 15km

1.4 Wind Speed and Power Calculator Excel File

1.5 Google Earth Turbine and Cable Layout