Shadow Flicker Assessment

For the

Eigg Mountain Wind Farm Project

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1.0 Introduction

The Eigg Mountain Wind Project is being planned for an area south of the community of Arisaig in Antigonish County, Nova Scotia. The main project area is located on Eigg Mountain and three turbines are planned for the height of land west of Pleasant Valley, Antigonish County. The project will consist of 22 wind turbines which will use the Nordex N163 6.X 7000 kW turbine.

The rotating blades of a wind turbine create moving shadows know as shadow flicker that are noticeable in close proximity to the turbine. The potential impact depends on the time of year, the physical characteristics of the wind turbine, the orientation of the blades relative to the sun, the presence of wind and of course, the presence of sunlight.

The following report summarizes the results of shadow flicker assessment which will be incorporated into the Nova Scotia Environmental Assessment Registration Document.

2.0 Methodology

2.1 Shadow Flicker Analysis

The shadow flicker analysis was completed using WindPro 4.1.292 which provides a comprehensive suite of wind farm design and modeling software.

The locations of the 22 proposed turbines are summarized in Table 1. In addition to the proposed turbines, existing turbines that are located within 3.0 km of the proposed wind farm were included in the model. A total of 9 turbines from the Glen Dhu wind project, located to the west of the project and 2 from the Maryvale Wind Project, located to the east of the project were included in the analysis. The locations of the existing Glen Dhu turbines are summarized in Table 2 and the Maryvale Turbines are summarized in Table 3. The model specific parameters of the proposed turbines are shown in Table 4. Table 5 and Table 6 show the specifications of the existing Glen Dhu and Maryvale turbines respectivly.

The shadow flicker analysis was based on developing a theoretical or worst-case, scenario and realistic scenario that provides an understanding of the extent of shadow flicker as a result of the existing and proposed turbines.

2.2 *Digital Elevation Model*

A digital elevation model (DEM) that was derived from aerial Lidar data was used to model the shadow

Table 1: Proposed Turbine Locations.

Id	Model	Easting (m)*	Northing (m)*
1	N163/6.X	570,545	5,058,998
2	N163/6.X	569,700	5,058,273
3	N163/6.X	569,164	5,062,249
4	N163/6.X	568,681	5,063,090
5	N163/6.X	569,513	5,063,730
6	N163/6.X	569,118	5,063,394
7	N163/6.X	563,890	5,060,471
8	N163/6.X	564,493	5,061,297
9	N163/6.X	569,808	5,063,046
10	N163/6.X	563,880	5,062,749
11	N163/6.X	564,965	5,063,248
12	N163/6.X	567,616	5,063,868
13	N163/6.X	567,707	5,063,249
14	N163/6.X	566,808	5,063,304
15	N163/6.X	566,307	5,062,693
16	N163/6.X	570,212	5,062,220
17	N163/6.X	570,191	5,058,629
18	N163/6.X	570,275	5,062,730
19	N163/6.X	564,685	5,060,756
20	N163/6.X	569,507	5,061,851
21	N163/6.X	567,557	5,062,063
22	N163/6.X	565,663	5,063,883

* UTM, NAD83(CSRS), Zone 20

Table 2: Existing Turbine Locations within 3 km – Glen Dhu.

Id	Model	Easting (m)*	Northing (m)*
1	E-82	562,130	5,059,751
2	E-82	561,800	5,059,596
3	E-82	561,769	5,059,192
4	E-82	561,362	5,059,386
5	E-82	562,329	5,059,198
6	E-82	561,575	5,058,622
7	E-82	561,867	5,058,457
8	E-82	562,394	5,058,428
9	E-82	562,600	5,058,049

* UTM, NAD83(CSRS), Zone 20

Table 3: Existing Turbine Locations within 3 km – Maryvale.

Id	Model	Easting (m)*	Northing (m)*
1	Vensys 77	572,478	5,064,309
2	Vensys 77	572,749	5,064,258

*UTM, NAD83(CSRS), Zone 20

Table 4: Proposed Turbine Specifications

Item	Specification
Manufacturer	Nordex
Model	N163 6.X 7000
Hub Height	118 m
Rotor Diameter	163 m
Operation Mode	Full Power
Rated Power Output	7,000 kW

Table 5: Existing Turbine Specifications – Glen Dhu

Item	Specification
Manufacturer	Enercon
Model	E-82
Hub Height	78 m
Rotor Diameter	80 m
Operation Mode	Full Power
Rated Power Output	2,000 kW

Table 6: Existing Turbine Specifications - Maryvale

Item	Specification
Manufacturer	Vensys
Model	77
Hub Height	85 m
Rotor Diameter	77 m
Operation Mode	Full Power
Rated Power Output	1,500 kW

flicker in this analysis. The original DEM was resampled from 1 m to 4 m resolution to minimize the file size for the project and adjacent areas.

2.3 Theoretical (Worst) Case

In this highly conservative scenario, existing shadowing objects such as forests, trees and out buildings were not included in the analysis. This scenario provides an understanding of the maximum amount of shadow flicker that could theoretically be experienced at the modeled receptors under the following conditions:

- The sun shines 100% of the time when it is above the horizon;
- The turbine rotor is always perpendicular to the sun;
- Shadow flicker starts as the sun moves above 3 degrees from the horizon;
- The shadows dissipate at a maximum distance from the blade as a result of atmospheric conditions and light diffusion, and;
- The rotor blades are always spinning.

The total length of the shadow influence in the atmosphere is calculated from the physical dimensions of the turbine blade. In this analysis, the maximum shadow distance for the N163 6.X 7000 kW was calculated to be 1,788 m. This scenario represents conditions that will not be experienced in the real world with continuous sunshine, constant operation of the turbines, no obstacles or trees and turbine rotors are always located between and the receptor window.

2.4 Realistic Case

The realistic case was modeled by incorporating site specific wind conditions and monthly sunshine probabilities into the analysis. As with the theoretical case, shadowing objects were not included in the model; therefore there still is some conservatism with this case as the model does not provide an accurate representation of the forests and outbuildings within the study area.

Statistical climate data in the form of average sunshine probabilities per month were obtained from the closest, representative coastal weather station (that records sunshine data). The long term hub height wind direction frequency data derived from on-site measurements and provided by the project developer. These data were used to determine the direction the turbines are oriented through a typical year.

2.5 Climate Data

Monthly sunshine data were used to provide a realistic condition for calculating shadow flicker. The realistic scenario was modeled using site specific wind conditions and monthly sunshine probabilities obtained from the closest observatory at Charlottetown, PEI. The monthly daily sunshine hours used in the analysis are shown in Table 7. The average long term wind direction frequency at hub height (118 m) data are summarized in Table 8. The wind direction frequency was calculated using all data recorded at the onsite lidar and met mast.

Table 7: Monthly Average Sunshine Hours for Charlottetown, Prince Edward Island.

Month	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Average Daily Sunshine Hours	3.37	4.18	4.42	5.04	6.34	7.54	7.95	7.19	5.76	3.98	2.63	2.31

Table 8: Long Term Wind Directional Hub Height Frequency at the Project Location.

Direction (Deg)	0	30	60	90	120	150	180	210	240	270	300	330	Total
Avearge Hours per Year	737	548	302	346	355	357	533	747	1,058	1,727	1,224	826	**8,760**

2.6 Shadow Receptors

A total of 31 non-participating receptors were identified and modeled in this analysis. All receptors were identified using satellite and aerial imagery to locate buildings that can be considered as dwellings and CBCL conducted field verification of the receptors in September and October of 2025. Each building was assumed to have windows facing in all directions. This modeling approach is referred to as ‘greenhouse mode’ and ensures that the orientation of individual receptor windows are not a factor in estimating shadow flicker. These factors ensure that the modeling results are based on the best available data. Table 9 shows the locations of the 31 non-participating receptors used in the analysis.

3.0 Shadow Flicker Analysis Results and Discussion

A generally accepted guideline that originates from Europe is that shadow flicker exposure be limited to a maximum of 30 hours per year. In Nova Scotia, developers are required to demonstrate that no receptor will receive more than 30 hours per year or more than 30 minutes per day off shadow flicker.

Figure 1 shows the results of the modeling and the spatial extent of the threshold 30 shadow hours per year. Receptor specific results are provided for in Table 10.

Table 9: Shadow Flicker Receptor Locations

Receptor ID	Easting* (m)	Northing * (m)	Elevation (m)
A	572,000	5,059,371	124.3
B	571,825	5,059,864	119.4
C	572,025	5,059,865	116.9
D	572,092	5,059,870	116.1
E	571,907	5,059,898	118.9
F	571,873	5,059,898	119.4
G	571,654	5,060,100	135.9
H	570,198	5,060,824	193.6
I	570,226	5,060,875	198.8
J	571,197	5,061,747	145.6
K	571,141	5,062,106	190.2
L	571,141	5,062,128	191.3
M	571,989	5,062,355	111.8
N	571,676	5,059,288	148.9
O	571,267	5,059,366	202.7
P	568,726	5,058,948	258.1
Q	569,683	5,059,799	200.1
R	569,600	5,059,925	205.0
S	569,702	5,060,167	198.2
T	571,991	5,062,357	111.8
U	571,594	5,059,935	121.0
V	571,793	5,059,690	120.7
W	571,071	5,061,921	197.2
X	570,867	5,061,455	151.9
Y	571,289	5,058,160	242.6
Z	562,850	5,064,260	154.5
AA	565,065	5,065,369	96.8
AB	565,302	5,065,388	104.1
AC	565,305	5,065,323	101.6
AD	565,868	5,065,658	85.8
AE	565,936	5,063,334	264.6

* UTM, NAD83(CSRS), Zone 20

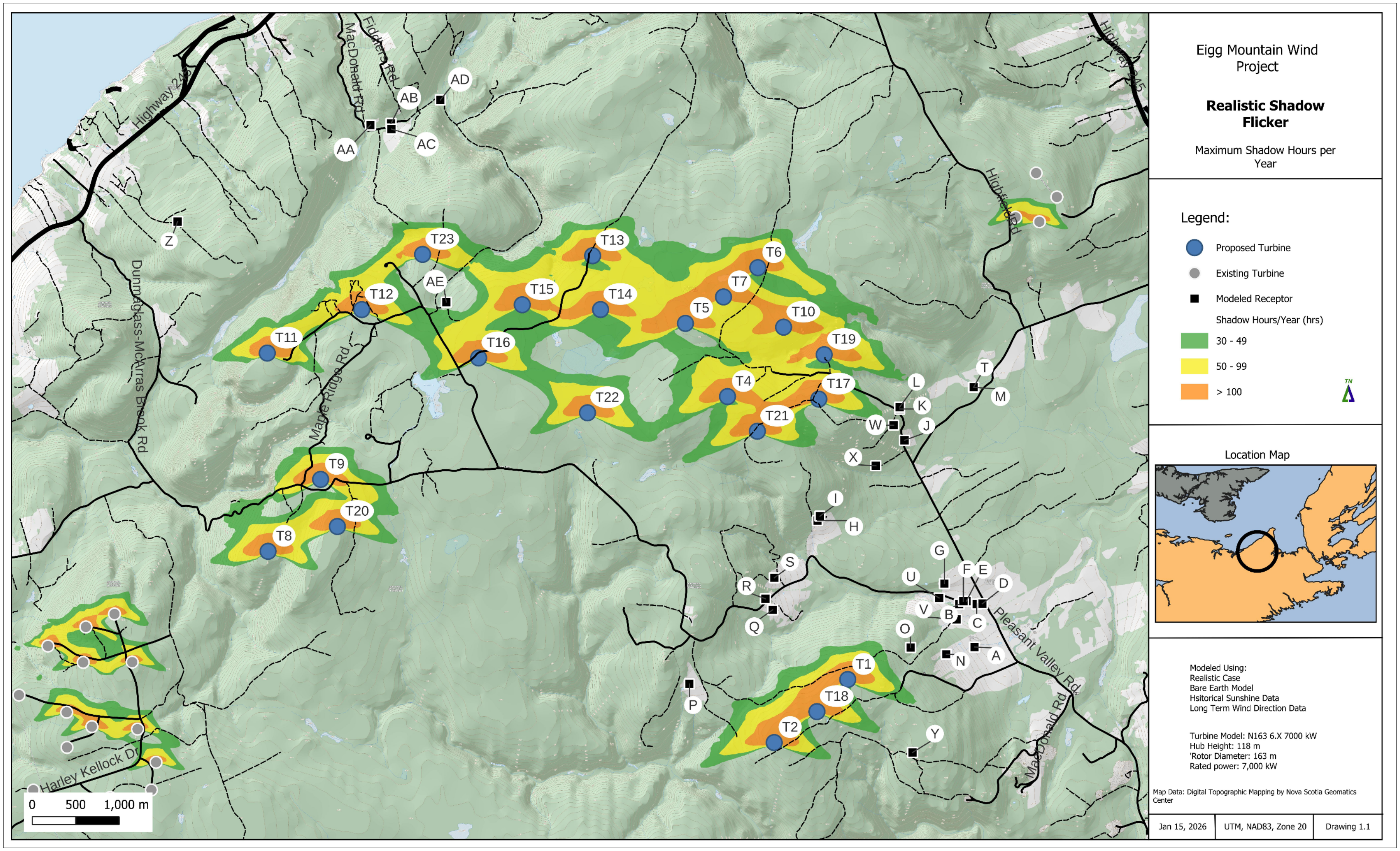

Figure 1: Shadow Flicker per Year Based on the Realistic Scenario for the Proposed Eigg Mountain Wind Project.

Table 10: Predicted Shadow Flicker for Local Receptors Based on Theoretical (Worst) and Realistic Case Scenario's.

Receptor ID	Theoretical Case		Realistic Case
	Shadow Hours per Year	Max. Shadow Minutes per Day	Shadow Hours per Year
A	9.9	32	2.7
B	12.3	38	2.9
C	9.4	33	2.4
D	0.0	0	0.0
E	11.0	37	2.6
F	11.6	38	2.8
G	26.1	72	5.2
H	0.0	0	0.0
I	0.0	0	0.0
J	0.0	0	0.0
K	35.3	82	10.8
L	34.3	81	10.4
M	10.3	36	3.1
N	12.2	50	3.3
O	43.2	93	10.9
P	37.8	104	8.3
Q	40.0	82	7.6
R	28.6	64	5.2
S	0.0	0	0.0
T	10.3	36	3.1
U	18.8	55	4.1
V	12.2	37	3.2
W	50.3	100	15.9
X	0.0	0	0.0
Y	50.7	116	15.8
Z	0.0	0	0.0
AA	0.0	0	0.0
AB	0.0	0	0.0
AC	0.0	0	0.0
AD	0.0	0	0.0
AE	86.9	142	22.1

The results of the theoretical (Worst) case indicates that 8 of 31 receptors would experience greater than 30 hours of shadow flicker per year and 20 receptors would experience more than 30 minutes per day (Table 10). This analysis is completed to obtain a baseline understanding of project impact on receptors. Exceedance of the maximum shadow hours per year or 30 minutes per day is common when using the worst case scenario due to the conservative nature of the analysis. Exceedance of the worst case scenario has been reported for a number of approved Environmental Assessments for wind projects in Nova Scotia (Setapuktuk Wind Project, Kmtnuk Wind Power Project , Bear Lake Wind Project and Wedgeport Wind

Farm Project).

The realistic case scenario provides a more comprehensive analysis as the assumptions in the theoretical case are very conservative in nature and do not represent conditions which would occur in the real world. By applying monthly sunshine probabilities and the long term wind direction frequencies into the model, more precise annual results can be generated, however the maximum shadow flicker per day cannot be calculated. This is a result of using monthly sunshine probabilities which cannot be scaled to minute time steps. The realistic case scenario, which includes the sunshine probabilities and wind frequency distribution, shows that all the receptors are expected to receive less than 30 hour per year of shadow flicker (Table 10). It is noted that the realistic case is also conservative as it does not include any obstacles or trees, assumes turbines are always operating and that receptor windows are always facing the turbine.

4.0 Conclusion

The shadow flicker analysis based on the realistic case indicate that the modeled non-participating receptors are expected to receive less than 30 hours per year of shadow flicker. The realistic values range from 0 to 22.1 hours per year which are well below the 30 hour per year threshold value.

These modeled results indicate that the proposed wind project meets the current guidelines as defined by the Nova Scotia Department of Environment and Climate Change.

5.0 References

Nova Scotia Department of Environment and Climate Change. Environmental Assessment Supplemental Checklist: Wind Energy Projects, https://novascotia.ca/nse/ea/docs/environmental-assessment-supplemental-checklist-wind-energy-projects-en.pdf

Nova Scotia Topographic Database, https://nsgi.novascotia.ca/datalocator/indexing.html

Nova Scotia Elevation Explorer, https://nsgi.novascotia.ca/datalocator/elevation/