Algonquin Power Co.

Final Shadow Flicker Impact Assessment

For

Amherst Island Wind Project

H340642-0000-50-124-0001
Rev. 3
November 28, 2013

Algonquin Power Co. (on behalf of Windlectric Inc.) voluntarily authorized the development of this report. This report is not a requirement of O. Reg. 359/09 and as such is not a required component for a Renewable Energy Approval application.

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Project Report

November 28, 2013

Algonquin Power Co.
Amherst Island Wind Project

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Final Shadow-Flicker Assessment

Date	Rev.	Status	Prepared By	Checked By	Approved By
Nov 28/2013	3	Approved	J. Moran	R. Ilett	A. Tsopelas
HATCH					Client

Safety • Quality • Sustainability • Innovation

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Report Disclaimer

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1. Introduction

Hatch was retained by Algonquin Power Co. (Algonquin) to carry out a shadow-flicker assessment for the 75-MW Amherst Island Wind Project. This memorandum presents a description of the methodology used and results obtained in the assessment of the project, located in the Loyalist Township, Ontario. Algonquin Power Co. (on behalf of Windlectric Inc.) voluntarily authorized the development of this report. This report is not a requirement of O. Reg. 359/09 and as such is not a required component for a Renewable Energy Approval application. It is important to note that no Canadian jurisdiction, including Ontario, has seen fit to develop a nuisance based shadow flicker guideline.

The project consists of thirty-six (36) wind turbine generators. The turbines will be manufactured by Siemens, and will correspond to model SWT 2.3-113. The rated capacity of the turbines is 2.3 MW, with a rotor diameter of 113 m, located at 99.5 m above ground level.

2. Shadow Modeling

2.1 Model Description

WindPRO, a commercial software developed by EMD International A/S (EMD) (www.emd.dk) was used to determine the shadow-flicker at receptors surrounding and within the wind farm boundaries. WindPRO is a fully integrated modular software package that is recognized and accepted worldwide by developers, planners, utilities and wind turbine manufacturers. The model is widely used for design and planning of large wind farms.

2.2 SHADOW – The Shadow-Flicker Module

SHADOW is the WindPRO calculation module that estimates how often and in which intervals a specific neighbour or area will be affected by shadows generated by one or more wind turbines. These calculations are usually worst-case scenarios (astronomical maximum shadow, e.g., calculations which are solely based on the positions of the sun relative to the wind turbine). Shadow flicker may occur when the blades of a wind turbine pass through the sun's rays as seen from a specific position (e.g., a window in an adjacent settlement). If the weather is overcast or calm, or if the wind direction forces the rotor plane of the wind turbine to stand parallel with the line between the sun and the neighbour, the wind turbine will not produce shadow flicker, but the flicker will still appear in the calculations. The calculation of the astronomical shadow scenario represents the maximum potential shadow flicker.

Apart from calculating the potential shadow flicker at a given location, Hatch has created a map rendering the isolines of the shadow flicker (see Appendix C). The map shows the areas where shadow flicker is expected to be higher than the suggested guidelines.

2.3 Model Setup and Calculation Procedure

For the shadow-flicker calculations, the model utilizes the position of the sun relative to the wind turbine rotor disk, and the resulting shadow is calculated in steps of 1 minute throughout a complete year. If the shadow of the rotor disk (which in the calculation is assumed solid) at any time casts a shadow reflection on a shadow receptor object, then this step will be registered as

1 minute of potential shadow flicker (see Figure 1). A shadow receptor object is defined as a window with a certain orientation and dimensions.

The parameters required for the calculations are as follows:

1. Location of the wind turbines
2. Hub height and rotor diameter
3. Position (coordinates) of the shadow receptors
4. Typical size of the window and its orientation, both directional (relative to south) and inclination (angle of window plane to the horizontal)
5. Geographic position and time zone of the project area
6. Simulation model, which holds information about the earth's orbit and rotation relative to the sun.

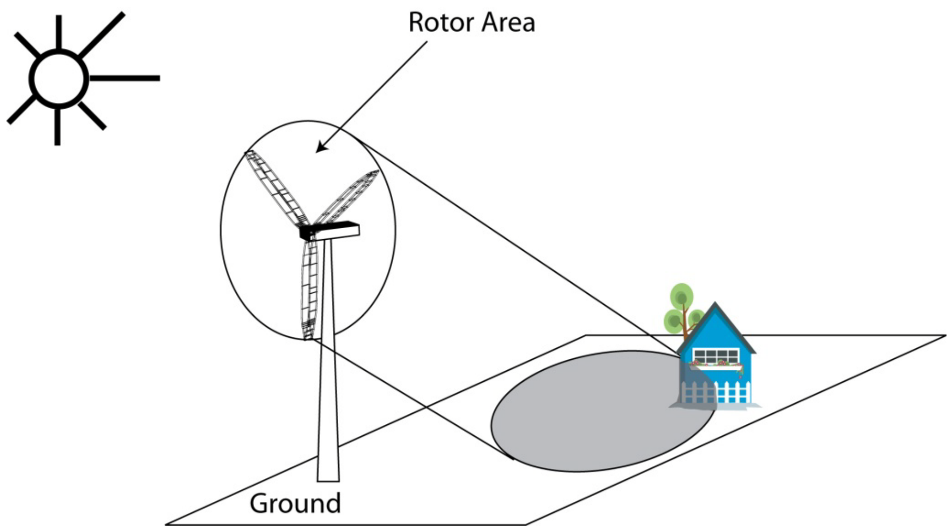

Figure 1: Schematic Diagram of Shadow Cast from a Wind Turbine on a Receptor

Two cases of shadow can be explored using the WindPRO model: the "Astronomical maximum shadow" and the "Meteorological probable shadow" (also called real shadow). The astronomical shadow assumes that every day of the year is a sunny, clear day, the wind turbine is operating all the time and the rotor plane is always parallel to the receptor windows. The real shadow considers the hours of sun light that are typical for every month, as well as the wind direction and speed. For the real shadow, two statistical parameters should be provided:

- Operational hours statistics – This is the period that the wind turbine will be in operation from the different wind directions during the year.

- Sunshine probability statistics – This is the percentage of sunshine hours in daytime (from sunrise to sunset).

For this project, the primary inputs consisted of a digital elevation model that spans the entire area of interest and the locations of shadow receptors and wind turbine generators. The contours were provided by Land Information Ontario (LIO) in 2011. For the estimation of the real shadow, the wind speed data has been gathered using three meteorological masts installed on the island from 2005 to 2008. The wind data is required to determine the time periods where the turbine is moving and the position of the rotor plane relative to the receptors. If the turbine is not moving, no shadow flicker is produced.

The location of receptors and wind turbine generators is shown in Figure A.1, Appendix A. The total number of receptors considered is 427, and their location was based on the existing noise receptors associated with the Amherst Island Wind Project.

2.4 Shadow-Flicker Guidelines and Model Assumptions

Currently, Germany has guidelines on limits and conditions for calculating shadow flicker [Ref 1]. Sweden and Denmark have no official guidelines but for practical purposes, 10 hours (Denmark) and 8 hours (Sweden) are used if the sunshine statistics and wind speed information are taken into account.

According to the German guidelines, shadow flicker may occur if:

1. The angle of the sun over the horizon is at least 3 degrees.
2. The blade of the wind turbine covers at least 20% of the sun.

For this project, the SHADOW module of WindPRO was used to determine the time intervals (maximum hours per year and minutes per day) in which the presence of the wind turbines could cast shadows over nearby receptors based on the German and Danish guidelines. The assumptions used for the shadow modelling were:

1. Wind turbines are Siemens SWT-2.3, with a rotor diameter of 113 m and hub height of 99.5 m
2. The shadow flicker receptors locations are based on existing dwellings on the island
3. Window at the receptor is assumed to be facing perpendicular to the wind turbines (worst case)
4. Window dimensions considered: 1 m x 1 m, at 1 m from the ground. The window was oriented at 90 degrees (normal vertical window).

3. Shadow Flicker Results

3.1 Astronomical Shadow

The shadow flicker results for each of the receptors are presented in Table B.1, Appendix B. For the astronomical shadow case, a total of 47 receptors are above the 30 h/yr and 59 receptors result in greater than 30 shadow minutes-per-day on some days, 41 of these receptors are also in the greater than 30 h/yr group. In addition to Table B.1, the shadow-flicker results from WindPRO can be presented as a shadow map (shown in Figure C.1, Appendix C). The shadow map allows for a quick qualitative observation of the shadow receptors, presenting the different levels of shadow flicker in hours/year.

Figures C.2 present the "shadow flicker calendar" for the Amherst Island Wind Project, which indicates the approximate hours of the day and months of the year where the flicker from each turbine may potentially occur at certain locations. These figures are for reference purposes and were derived based on the astronomical shadow scenario presented in Table B.1. It can be seen that shadows are potentially cast mostly around sunrise and sunset, when the sunlight is diffuse (rather than direct) and with lower intensity than in the middle of the day.

3.2 Meteorological Case

In order to determine shadow-flicker on potential receptors based on the Danish guidelines, the local meteorological conditions were taken into consideration. This method considers both the time where the wind is not blowing and the sky conditions above the project area. Since sunshine data was not available at the site, the sunshine statistics were taken from the Kingston A Weather Station (Climate Normals, 1971-2000), which is located less than 10 km away from the project site. Table 1 presents the sunshine statistics used in the calculations as a percentage of daylight hours. The wind speed frequency distribution and direction are shown in Appendix D.

Table B.1 shows the shadow flicker results for the meteorological shadow case. Based on the meteorological methodology, the number of residences exceeding 10 h per year is 19. This assessment can be further refined by describing more accurately the location and orientation of the windows. Note that the SHADOW module of WindPRO does not estimate the shadow minutes per day for the meteorological shadow case, given that the sunshine statistics are recorded in a per month basis. The shadow map for the meteorological shadow case is shown in Figure C.1, Appendix C.

Table 1: Sunshine Statistics – Kingston A (WMO ID 71620)

Month	Total Hours of	Days with	% of Possible
Jan	66	21.2	33.1
Feb	92	21.8	40.4
Mar	120	23.4	38.2
Apr	162	24.8	43.8
May	221	27.8	48.6
Jun	243	28.0	52.5
Jul	262	29.9	59.7
Aug	222	29.4	55.7
Sep	163	26.0	43.3
Oct	128	26.1	42.8
Nov	70	21.0	30.4
Dec	52	19.5	27.1

4. Summary

Algonquin power Co. (on behalf of Windlectric Inc.) voluntarily authorized the development of this report. This report is not a requirement of O. Reg. 359/09 and as such is not a required component for a Renewable Energy Approval application. Hatch undertook the shadow-flicker assessment using the two guidelines referenced in previous sections, however, the meteorological probable shadow methodology (using the sunshine statistics provided by Environment Canada) is the most practical. The results for the meteorological probable shadow suggest that 19 receptors are above 10 hr/yr. Please note the following:

1. Five (5) of the 19 receptors are between 10.0-11.0 h/year (one receptor is a participant)
3. Five (6) of the 19 receptors are between 11.1-12.6 h/year
4. Four (4) of the 19 receptors are between 12.7 -15.8 h/year
5. Two (2) of the 19 receptors are between 15.9 -18.9 h/year
6. One (1) of the 19 receptors is between 18.9 -21 h/year
7. One (1) of the 19 receptors is between 35 -37.3 h/year (participating).

For the potential shadow receptors, the number of shadow hours per year could be further refined by defining the real window orientation and size for each case. It is important to note that no Canadian jurisdiction, including Ontario, has seen fit to develop a nuisance based shadow flicker guideline.

5. References

[1] EMD International A/S. WindPRO 2.6 User Guide. Denmark, 2008.

Appendix A

Wind Turbine Layout and Shadow Receptors

Figure A.1
Windlectric Inc.
Amherst Island Wind Project
Potential Shadow Flicker Impact: Layout S20

Path: P:\ALGONQUI\340642\SPECIALIST_APPS\GIS\Map Documents\Layout\WindLayout_LayoutS20_ShadowLayout.mxd Date Saved: 2/15/2013 1:11:17 PM

Table A.1 Wind Farm Layout – Amherst Island Wind Project (36 wind turbines)

ID	Equipment Make and Model	UTM NAD 83, Zone 18	
		X[m]	Y[m]
S01	Siemens SWT-2.3-113	359,172	4,889,551
S02	Siemens SWT-2.3-113	366,489	4,890,373
S03	Siemens SWT-2.3-113	361,257	4,887,434
S04	Siemens SWT-2.3-113	360,408	4,890,076
S05	Siemens SWT-2.3-113	362,668	4,888,881
S06	Siemens SWT-2.3-113	363,743	4,891,454
S07	Siemens SWT-2.3-113	366,812	4,891,637
S08	Siemens SWT-2.3-113	359,618	4,887,487
S09	Siemens SWT-2.3-113	360,951	4,887,104
S10	Siemens SWT-2.3-113	359,083	4,887,184
S11	Siemens SWT-2.3-113	361,641	4,887,206
S12	Siemens SWT-2.3-113	368,952	4,892,526
S13	Siemens SWT-2.3-113	367,813	4,891,841
S14	Siemens SWT-2.3-113	366,790	4,891,157
S15	Siemens SWT-2.3-113	365,379	4,891,960
S16	Siemens SWT-2.3-113	361,904	4,889,060
S17	Siemens SWT-2.3-113	358,685	4,887,302
S18	Siemens SWT-2.3-113	367,607	4,892,193
S19	Siemens SWT-2.3-113	365,107	4,889,563
S20	Siemens SWT-2.3-113	362,894	4,889,249
S21	Siemens SWT-2.3-113	364,881	4,889,039
S22	Siemens SWT-2.3-113	361,447	4,890,656
S23	Siemens SWT-2.3-113	361,586	4,888,696
S25	Siemens SWT-2.3-113	360,694	4,888,128
S26	Siemens SWT-2.3-113	367,371	4,892,536
S27	Siemens SWT-2.3-113	365,916	4,890,146
S28	Siemens SWT-2.3-113	369,091	4,893,127
S29	Siemens SWT-2.3-113	359,562	4,889,909
S30	Siemens SWT-2.3-113	367,040	4,892,941
S31	Siemens SWT-2.3-113	362,343	4,891,028
S32	Siemens SWT-2.3-113	359,530	4,887,967
S33	Siemens SWT-2.3-113	369,337	4,892,806
S34	Siemens SWT-2.3-113	363,324	4,889,901
S35	Siemens SWT-2.3-113	361,299	4,888,183
S36	Siemens SWT-2.3-113	364,589	4,888,397
S37	Siemens SWT-2.3-113	365,501	4,889,854

Appendix B

Shadow-Flicker Results

Table B.1 Shadow-Flicker Results: Astronomical Shadow and Meteorological (Real) Shadow. The highlighted receptors correspond to Participant owners

Shadow Receptor ID	UTM NAD 83, Zone 18 Coordinates		Astronomical Shadow German Guidelines 30 h/year or 30 min/day max		Real Shadow Danish Guidelines 10 h/year max.
	X[m]	Y[m]	Hours per Year	Minutes per Day	Hours per Year
R002	356,792	4,886,911	0.0	0	0.0
R003	363,941	4,885,595	0.0	0	0.0
R005	359,893	4,890,564	46.1	40	7.3
R007	364,239	4,892,296	7.9	22	1.8
R010	364,153	4,885,327	0.0	0	0.0
R011	366,872	4,893,632	0.0	0	0.0
R012	356,186	4,889,116	0.0	0	0.0
R014	366,786	4,893,503	0.0	0	0.0
R015	**365,758**	**4,889,070**	**22.6**	**30**	**5.4**
R018	364,059	4,892,107	5.7	20	1.4
R020	362,062	4,886,820	9.3	23	2.6
R021	360,101	4,890,790	5.6	19	1.3
R022	362,789	4,891,859	11.5	26	2.7
R024	363,071	4,886,339	0.0	0	0.0
R025	367,198	4,890,237	32.2	37	9.1
R026	367,812	4,891,038	20.9	26	6.0
R028	364,459	4,892,309	12.3	27	2.9
R029	367,962	4,891,160	19.3	22	5.5
R030	357,966	4,885,928	0.0	0	0.0
R031	359,345	4,888,662	4.0	16	0.9
R032	355,872	4,888,987	0.0	0	0.0
R033	360,714	4,891,207	25.8	30	4.5
R034	363,968	4,892,164	4.7	18	1.1
R035	361,623	4,891,803	0.7	6	0.1
R036	368,045	4,894,070	7.8	17	1.2
R040	365,623	4,888,851	35.6	35	9.9
R041	359,946	4,890,749	0.0	0	0.0
R043	357,651	4,886,179	0.0	0	0.0
R056	364,908	4,890,729	14.3	23	3.2
R057	364,082	4,892,061	5.9	20	1.4
R058	364,563	4,892,351	16.0	30	3.6
R059	357,052	4,889,574	0.0	0	0.0
R060	358,523	4,889,966	36.2	35	7.6

Shadow Receptor ID	UTM NAD 83, Zone 18 Coordinates		Astronomical Shadow German Guidelines 30 h/year or 30 min/day max		Real Shadow Danish Guidelines 10 h/year max.
	X[m]	Y[m]	Hours per Year	Minutes per Day	Hours per Year
R061	364,298	4,892,572	9.0	22	1.8
R063	360,135	4,885,467	0.0	0	0.0
R065	365,563	4,893,048	0.0	0	0.0
R067	364,146	4,892,216	6.5	21	1.5
R068	364,914	4,890,629	9.2	24	2.0
R069	367,873	4,894,024	0.0	0	0.0
R070	357,913	4,889,708	6.4	21	1.5
R071	355,922	4,889,025	0.0	0	0.0
R074	369,960	4,893,872	15.4	24	2.9
R078	360,762	4,891,155	26.8	33	4.8
R079	359,604	4,890,575	18.0	29	3.5
R080	362,200	4,887,075	72.5	9	21.0
R083	365,430	4,893,185	0.0	0	0.0
R085	360,668	4,891,181	19.7	29	3.6
R087	364,076	4,892,451	5.7	19	1.3
R090	358,709	4,890,096	40.0	36	7.3
R091	366,966	4,889,848	12.1	25	3.4
R092	368,778	4,894,417	0.0	0	0.0
R093	359,060	4,888,604	0.0	0	0.0
R094	367,581	4,893,976	0.0	0	0.0
R096	362,996	4,891,908	20.5	31	4.0
R097	368,666	4,894,336	0.0	0	0.0
R098	359,161	4,890,353	0.0	0	0.0
R099	368,290	4,891,445	0.0	0	0.0
R100	357,760	4,889,636	4.8	18	1.2
R101	361,821	4,891,454	53.4	41	9.0
R102	360,008	4,885,371	0.0	0	0.0
R103	363,864	4,892,163	0.0	0	0.0
R104	364,124	4,892,384	6.3	20	1.5
R105	367,259	4,890,334	25.1	34	6.6
R107	363,640	4,888,526	36.7	35	10.7
R108	357,116	4,889,471	0.0	0	0.0
R109	362,949	4,888,140	0.0	0	0.0
R111	357,658	4,889,573	0.0	0	0.0
R113	364,528	4,892,413	15.1	28	3.2
R114	366,256	4,889,386	18.9	23	5.2

Shadow Receptor ID	UTM NAD 83, Zone 18 Coordinates		Astronomical Shadow German Guidelines 30 h/year or 30 min/day max		Real Shadow Danish Guidelines 10 h/year max.
	X[m]	Y[m]	Hours per Year	Minutes per Day	Hours per Year
R118	367,227	4,893,765	0.0	0	0.0
R122	363,067	4,891,931	27.4	33	5.0
R124	364,014	4,892,185	5.1	19	1.2
R125	369,190	4,893,990	0.0	0	0.0
R126	360,677	4,891,064	18.1	31	4.0
R127	363,902	4,889,092	45.8	27	11.6
R128	366,068	4,889,271	15.5	27	4.4
R129	362,558	4,885,712	0.0	0	0.0
R130	366,563	4,889,572	15.9	25	4.3
R131	366,560	4,893,285	63.5	46	11.6
R132	364,448	4,892,350	12.2	26	2.8
R133	357,130	4,889,553	0.0	0	0.0
R134	**367,322**	**4,890,451**	**20.6**	**31**	**5.1**
R135	357,513	4,885,995	0.0	0	0.0
R137	364,030	4,892,155	5.3	19	1.2
R138	359,899	4,890,759	0.0	0	0.0
R139	360,377	4,885,708	0.0	0	0.0
R140	**363,261**	**4,892,098**	**0.0**	**0**	**0.0**
R142	364,168	4,889,387	57.7	34	15.8
R145	364,482	4,890,164	47.3	43	9.0
R146	364,160	4,885,362	0.0	0	0.0
R157	360,805	4,891,182	39.3	34	6.5
R159	358,305	4,889,843	20.9	29	5.0
R160	366,960	4,889,781	17.8	25	5.1
R161	364,165	4,892,220	6.8	21	1.6
R162	357,982	4,889,754	7.3	22	1.7
R163	355,549	4,888,133	0.0	0	0.0
R164	361,050	4,891,333	5.6	20	1.3
R165	359,814	4,890,699	21.3	31	3.3
R166	363,313	4,890,643	17.9	27	5.4
R167	359,113	4,888,625	0.0	0	0.0
R168	361,769	4,886,562	0.0	0	0.0
R169	364,759	4,892,564	25.9	33	4.0
R171	364,080	4,892,096	5.8	20	1.4
R172	364,572	4,892,441	17.5	29	3.4
R173	364,889	4,890,554	8.7	24	2.0

Shadow Receptor ID	UTM NAD 83, Zone 18 Coordinates		Astronomical Shadow German Guidelines 30 h/year or 30 min/day max		Real Shadow Danish Guidelines 10 h/year max.
	X[m]	Y[m]	Hours per Year	Minutes per Day	Hours per Year
R174	357,177	4,889,515	0.0	0	0.0
R177	**366,495**	**4,889,660**	**17.3**	**27**	**4.8**
R178	364,284	4,892,521	8.8	22	1.9
R182	360,558	4,890,989	13.5	28	3.1
R190	365,881	4,893,230	7.2	22	1.6
R192	366,628	4,889,597	9.7	23	2.7
R193	360,787	4,891,238	35.3	32	5.7
R194	366,226	4,893,109	24.3	31	5.5
R195	357,110	4,886,952	0.0	0	0.0
R196	357,086	4,889,557	0.0	0	0.0
R197	368,995	4,891,793	13.9	22	3.7
R198	363,999	4,892,125	5.0	18	1.2
R199	363,909	4,892,311	0.0	0	0.0
R200	364,469	4,885,927	0.0	0	0.0
R201	357,805	4,889,647	5.3	19	1.3
R202	367,665	4,894,018	0.0	0	0.0
R203	360,989	4,886,500	0.0	0	0.0
R204	360,702	4,885,983	0.0	0	0.0
R207	364,040	4,885,784	0.0	0	0.0
R208	364,074	4,892,408	5.7	19	1.3
R209	355,665	4,887,048	0.0	0	0.0
R210	357,393	4,889,358	0.0	0	0.0
R221	363,994	4,885,653	0.0	0	0.0
R222	359,277	4,890,416	0.0	0	0.0
R227	365,574	4,888,708	52.8	37	15.7
R229	363,988	4,892,236	4.8	18	1.1
R230	364,061	4,892,209	5.5	19	1.3
R231	362,126	4,891,540	0.0	0	0.0
R232	364,063	4,892,147	5.6	19	1.3
R233	358,904	4,888,447	39.2	35	6.6
R236	364,784	4,886,837	0.0	0	0.0
R237	364,222	4,892,513	7.4	21	1.7
R238	364,680	4,892,516	34.8	32	5.8
R239	366,019	4,889,228	27.9	28	8.0
R240	356,964	4,886,961	0.0	0	0.0
R241	356,866	4,889,595	0.0	0	0.0

Shadow Receptor ID	UTM NAD 83, Zone 18 Coordinates		Astronomical Shadow German Guidelines 30 h/year or 30 min/day max		Real Shadow Danish Guidelines 10 h/year max.
	X[m]	Y[m]	Hours per Year	Minutes per Day	Hours per Year
R242	355,590	4,888,836	0.0	0	0.0
R244	360,730	4,891,215	30.8	30	5.2
R245	365,893	4,893,153	7.9	23	1.8
R246	366,902	4,889,729	24.6	26	7.2
R247	360,436	4,890,915	10.5	25	2.4
R254	**360,129**	**4,890,712**	**5.9**	**20**	**1.4**
R258	364,002	4,885,706	0.0	0	0.0
R261	364,674	4,890,296	26.1	29	5.9
R262	355,507	4,888,255	0.0	0	0.0
R263	364,092	4,892,390	5.9	20	1.4
R264	364,356	4,892,322	10.0	24	2.3
R265	368,058	4,891,269	13.6	21	3.7
R266	368,149	4,894,137	0.0	0	0.0
R267	365,616	4,893,060	4.2	17	1.0
R268	358,467	4,889,930	30.5	34	7.0
R270	358,452	4,887,973	14.9	24	3.7
R271	360,734	4,891,167	24.7	32	4.4
R272	364,271	4,892,333	8.5	23	2.0
R273	364,132	4,892,204	6.4	21	1.5
R274	363,976	4,892,355	4.6	18	1.1
R275	361,386	4,891,597	12.2	25	2.3
R276	365,906	4,893,126	8.2	23	1.9
R277	356,850	4,886,941	0.0	0	0.0
R278	366,657	4,889,616	9.0	23	2.5
R280	364,392	4,890,113	49.1	47	9.4
R283	362,698	4,891,900	9.6	24	2.2
R290	357,026	4,889,597	0.0	0	0.0
R291	363,359	4,888,447	13.9	20	3.8
R292	359,462	4,890,503	0.0	0	0.0
R293	366,725	4,893,495	0.0	0	0.0
R297	**365,371**	**4,888,610**	**17.6**	**32**	**4.4**
R298	364,002	4,892,399	4.9	18	1.1
R299	356,542	4,889,318	0.0	0	0.0
R300	359,452	4,888,735	5.4	18	1.2
R301	360,046	4,890,779	5.1	19	1.2
R302	364,059	4,885,842	0.0	0	0.0

Shadow Receptor ID	UTM NAD 83, Zone 18 Coordinates		Astronomical Shadow German Guidelines 30 h/year or 30 min/day max		Real Shadow Danish Guidelines 10 h/year max.
	X[m]	Y[m]	Hours per Year	Minutes per Day	Hours per Year
R303	355,850	4,887,098	0.0	0	0.0
R304	357,141	4,886,966	0.0	0	0.0
R305	366,313	4,889,429	36.1	31	10.8
R306	369,559	4,893,778	0.0	0	0.0
R307	360,208	4,890,842	6.8	21	1.6
R308	360,481	4,889,210	17.7	22	4.4
R309	360,738	4,891,222	33.4	31	5.6
R310	**363,457**	**4,892,030**	**0.0**	**0**	**0.0**
R311	363,960	4,892,107	4.6	18	1.1
R312	364,228	4,892,321	7.8	22	1.8
R313	355,813	4,886,914	0.0	0	0.0
R314	358,234	4,889,849	18.0	27	4.3
R315	369,384	4,893,953	0.0	0	0.0
R316	358,861	4,890,030	41.2	36	8.2
R322	365,833	4,889,090	18.8	28	4.5
R333	362,146	4,891,676	0.0	0	0.0
R334	364,084	4,892,284	5.8	20	1.3
R335	367,376	4,893,735	0.0	0	0.0
R336	364,175	4,892,438	6.9	21	1.6
R337	**368,133**	**4,891,327**	**11.1**	**20**	**3.0**
R338	361,116	4,886,227	0.0	0	0.0
R339	366,644	4,893,340	67.9	49	10.9
R340	364,514	4,892,388	14.5	28	3.2
R341	364,097	4,892,228	5.9	20	1.4
R342	368,512	4,891,540	46.7	37	14.3
R343	364,162	4,892,263	6.7	21	1.5
R344	364,542	4,892,328	15.0	29	3.5
R345	364,254	4,892,556	8.0	21	1.7
R346	356,275	4,889,208	0.0	0	0.0
R347	357,871	4,889,681	5.9	20	1.4
R348	360,487	4,890,950	11.6	26	2.6
R349	363,772	4,888,688	38.6	31	10.6
R350	366,311	4,893,115	29.8	35	6.6
R353	359,505	4,890,524	0.0	0	0.0
R361	364,006	4,885,727	0.0	0	0.0
R364	358,796	4,888,349	19.3	33	4.2

Shadow Receptor ID	UTM NAD 83, Zone 18 Coordinates		Astronomical Shadow German Guidelines 30 h/year or 30 min/day max		Real Shadow Danish Guidelines 10 h/year max.
	X[m]	Y[m]	Hours per Year	Minutes per Day	Hours per Year
R368	356,297	4,889,198	0.0	0	0.0
R369	360,965	4,890,937	47.7	48	10.6
R370	364,908	4,892,724	0.0	0	0.0
R371	356,438	4,889,232	0.0	0	0.0
R372	356,365	4,889,224	0.0	0	0.0
R373	**369,538**	**4,892,176**	**9.3**	**23**	**2.8**
R374	369,808	4,893,889	0.0	0	0.0
R375	357,788	4,889,639	5.1	19	1.2
R376	**362,412**	**4,889,866**	**13.6**	**29**	**3.7**
R377	356,609	4,889,319	0.0	0	0.0
R378	364,102	4,892,355	6.0	20	1.4
R379	364,062	4,892,364	5.5	19	1.3
R380	362,677	4,891,770	8.8	24	2.0
R381	364,083	4,892,222	5.7	20	1.3
R382	364,514	4,886,095	0.0	0	0.0
R383	**367,296**	**4,890,391**	**22.3**	**32**	**5.6**
R386	364,270	4,890,005	33.1	48	7.6
R387	366,670	4,893,402	42.3	47	6.8
R391	363,703	4,884,834	0.0	0	0.0
R394	359,641	4,890,604	21.3	30	3.9
R396	361,426	4,891,626	14.4	25	2.6
R397	364,010	4,885,618	0.0	0	0.0
R402	363,945	4,892,249	0.0	0	0.0
R403	364,660	4,892,504	31.4	31	5.3
R404	365,210	4,893,014	0.0	0	0.0
R405	362,809	4,886,297	0.0	0	0.0
R406	357,013	4,889,619	0.0	0	0.0
R407	360,590	4,891,007	14.4	29	3.4
R408	364,184	4,892,238	7.0	21	1.6
R409	364,214	4,892,234	7.6	22	1.7
R410	356,713	4,886,827	0.0	0	0.0
R411	362,360	4,892,437	0.0	0	0.0
R412	367,587	4,890,848	39.1	33	11.5
R413	359,675	4,884,957	0.0	0	0.0
R414	357,207	4,887,086	0.0	0	0.0
R415	360,594	4,891,137	15.4	28	3.2

Shadow Receptor ID	UTM NAD 83, Zone 18 Coordinates		Astronomical Shadow German Guidelines 30 h/year or 30 min/day max		Real Shadow Danish Guidelines 10 h/year max.
	X[m]	Y[m]	Hours per Year	Minutes per Day	Hours per Year
R416	362,577	4,891,721	7.1	22	1.6
R417	362,565	4,887,449	17.4	28	4.3
R418	364,078	4,892,326	5.7	20	1.3
R419	355,937	4,888,922	0.0	0	0.0
R420	368,977	4,891,757	14.8	23	4.0
R421	361,093	4,891,340	6.1	20	1.4
R422	368,133	4,894,055	0.9	6	0.1
R425	369,291	4,893,952	0.0	0	0.0
R428	364,219	4,892,470	7.4	21	1.7
R431	366,520	4,893,262	60.6	44	11.6
R436	362,930	4,891,822	16.0	30	3.7
R439	365,949	4,889,171	9.1	24	2.3
R441	**361,668**	**4,886,460**	**0.0**	**0**	**0.0**
R442	364,265	4,892,287	8.3	23	1.9
R443	364,378	4,892,243	10.4	25	2.3
R444	364,258	4,892,501	8.3	22	1.8
R445	355,541	4,888,682	0.0	0	0.0
R446	360,211	4,885,546	0.0	0	0.0
R447	360,700	4,891,163	21.4	31	3.9
R449	364,023	4,885,738	0.0	0	0.0
R450	367,116	4,890,118	63.1	41	18.9
R452	364,340	4,892,217	9.6	25	2.2
R453	356,236	4,889,175	0.0	0	0.0
R454	368,019	4,891,231	15.4	22	4.2
R455	357,175	4,889,475	0.0	0	0.0
R456	359,916	4,885,248	0.0	0	0.0
R459	367,339	4,893,889	0.0	0	0.0
R460	358,748	4,890,166	16.0	31	3.6
R461	357,452	4,885,074	0.0	0	0.0
R466	361,721	4,886,415	0.0	0	0.0
R467	363,656	4,888,940	67.8	34	18.6
R468	360,663	4,891,152	18.7	29	3.6
R474	359,973	4,890,759	0.0	0	0.0
R475	357,620	4,886,072	0.0	0	0.0
R476	362,890	4,887,884	6.5	18	1.4
R477	366,920	4,893,657	0.0	0	0.0

Shadow Receptor ID	UTM NAD 83, Zone 18 Coordinates		Astronomical Shadow German Guidelines 30 h/year or 30 min/day max		Real Shadow Danish Guidelines 10 h/year max.
	X[m]	Y[m]	Hours per Year	Minutes per Day	Hours per Year
R478	360,615	4,891,158	16.5	28	3.3
R479	360,802	4,891,262	31.3	32	4.9
R480	359,029	4,890,238	30.3	41	6.9
R481	367,777	4,893,927	0.0	0	0.0
R482	357,143	4,889,539	0.0	0	0.0
R483	360,249	4,889,075	32.2	24	7.5
R484	355,806	4,888,916	0.0	0	0.0
R485	364,070	4,892,182	5.6	20	1.3
R486	363,949	4,892,360	0.0	0	0.0
R487	361,390	4,886,229	0.0	0	0.0
R488	362,754	4,887,614	7.8	22	2.1
R489	364,327	4,892,571	10.0	23	1.9
R490	355,464	4,888,172	0.0	0	0.0
R491	364,510	4,892,291	13.8	29	3.2
R492	364,093	4,892,417	5.9	20	1.4
R493	363,947	4,889,535	54.7	38	14.4
R499	359,933	4,885,143	0.0	0	0.0
R507	362,913	4,891,806	15.3	30	3.6
R510	364,094	4,892,193	6.0	20	1.4
R511	366,940	4,893,673	0.0	0	0.0
R512	364,183	4,892,505	6.9	20	1.6
R514	361,461	4,886,275	0.0	0	0.0
R515	364,434	4,892,293	11.7	27	2.7
R516	364,116	4,889,770	53.8	35	12.6
R517	368,681	4,894,038	0.0	0	0.0
R518	359,892	4,890,709	4.5	16	0.7
R519	367,020	4,890,008	9.5	24	2.6
R520	359,123	4,885,906	0.0	0	0.0
R521	364,824	4,892,666	0.0	0	0.0
R522	359,403	4,890,491	0.0	0	0.0
R523	361,324	4,891,465	9.7	24	2.3
R524	361,123	4,891,395	6.6	21	1.5
R525	359,206	4,890,382	0.0	0	0.0
R526	362,022	4,891,479	34.6	45	5.6
R527	361,306	4,891,547	9.7	24	2.1
R528	367,900	4,894,004	0.0	0	0.0

Shadow Receptor ID	UTM NAD 83, Zone 18 Coordinates		Astronomical Shadow German Guidelines 30 h/year or 30 min/day max		Real Shadow Danish Guidelines 10 h/year max.
	X[m]	Y[m]	Hours per Year	Minutes per Day	Hours per Year
R533	359,064	4,890,367	0.0	0	0.0
R538	360,529	4,890,971	12.7	27	2.9
R541	359,436	4,890,475	0.0	0	0.0
R547	360,683	4,891,197	21.6	30	3.9
R548	364,600	4,892,460	19.5	30	3.6
R549	360,940	4,891,214	31.2	36	5.2
R550	364,362	4,892,284	10.0	25	2.3
R551	357,981	4,889,730	7.4	22	1.7
R552	359,148	4,888,646	0.0	0	0.0
R553	364,289	4,892,295	8.8	23	2.0
R554	364,070	4,892,343	5.6	19	1.3
R555	363,019	4,888,085	0.0	0	0.0
R556	**366,391**	**4,889,653**	**22.7**	**29**	**6.2**
R557	363,796	4,892,015	0.0	0	0.0
R558	364,246	4,892,246	8.0	23	1.8
R559	364,319	4,892,230	9.1	24	2.1
R560	366,733	4,889,671	23.8	27	7.0
R561	358,595	4,888,104	21.1	28	4.5
R562	359,240	4,890,437	0.0	0	0.0
R563	356,775	4,886,842	0.0	0	0.0
R565	368,500	4,894,374	0.0	0	0.0
R567	365,546	4,893,199	0.0	0	0.0
R570	367,045	4,893,676	0.0	0	0.0
R576	361,477	4,891,672	20.6	25	3.5
R581	357,958	4,889,741	7.0	21	1.6
R582	368,198	4,891,377	9.5	18	2.5
R584	359,512	4,890,469	0.0	0	0.0
R585	362,088	4,891,716	0.0	0	0.0
R587	367,153	4,893,734	0.0	0	0.0
R588	355,832	4,888,972	0.0	0	0.0
R589	356,648	4,889,431	0.0	0	0.0
R590	369,626	4,893,805	0.0	0	0.0
R591	363,953	4,892,194	4.6	18	1.1
R593	360,756	4,891,210	34.7	32	5.8
R594	363,983	4,892,268	4.8	18	1.1
R595	364,229	4,892,241	7.7	22	1.7

Shadow Receptor ID	UTM NAD 83, Zone 18 Coordinates		Astronomical Shadow German Guidelines 30 h/year or 30 min/day max		Real Shadow Danish Guidelines 10 h/year max.
	X[m]	Y[m]	Hours per Year	Minutes per Day	Hours per Year
R596	364,036	4,892,426	5.3	19	1.2
R598	**360,680**	**4,889,284**	**35.7**	**25**	**8.7**
R600	**362,831**	**4,891,653**	**12.8**	**28**	**3.0**
R602	362,078	4,891,512	2.0	13	0.3
R607	364,312	4,889,960	34.2	48	8.0
R612	359,317	4,890,473	0.0	0	0.0
R613	358,798	4,888,273	26.0	34	5.4
R615	366,692	4,889,634	8.2	22	2.3
R617	**358,252**	**4,887,163**	**114.3**	**0**	**37.3**
R618	**363,401**	**4,892,017**	**0.0**	**0**	**0.0**
R619	364,846	4,890,591	7.9	23	1.8
R620	362,854	4,891,844	13.2	28	3.1
R625	362,841	4,891,878	13.0	27	3.0
R626	362,457	4,891,736	5.5	20	1.3
R628	364,176	4,892,227	6.8	21	1.6
R631	364,157	4,892,328	6.7	21	1.5
R632	367,413	4,893,773	0.0	0	0.0
R633	362,614	4,891,873	8.0	22	1.9
R636	360,541	4,891,112	13.3	27	3.0
R637	361,463	4,886,045	0.0	0	0.0
R641	361,144	4,891,459	7.1	21	1.6
R643	361,178	4,891,489	7.6	22	1.8
R656	364,060	4,885,825	0.0	0	0.0
R657	364,579	4,886,267	0.0	0	0.0
R658	364,035	4,885,723	0.0	0	0.0
R659	364,041	4,885,701	0.0	0	0.0
R661	355,739	4,887,974	0.0	0	0.0
R662	355,945	4,886,550	0.0	0	0.0
R663	355,928	4,886,563	0.0	0	0.0
R670	361,834	4,891,347	39.9	45	8.2
R671	356,458	4,889,002	0.0	0	0.0
R672	356,472	4,889,037	0.0	0	0.0
R673	366,974	4,890,051	10.2	25	2.7
R677	364,118	4,892,402	6.1	20	1.4
R679	356,919	4,889,601	0.0	0	0.0
R680	356,555	4,888,908	0.0	0	0.0

Shadow Receptor ID	UTM NAD 83, Zone 18 Coordinates		Astronomical Shadow German Guidelines 30 h/year or 30 min/day max		Real Shadow Danish Guidelines 10 h/year max.
	X[m]	Y[m]	Hours per Year	Minutes per Day	Hours per Year
R681	355,505	4,888,693	0.0	0	0.0
R682	355,547	4,888,245	0.0	0	0.0
R683	355,480	4,888,166	0.0	0	0.0
R684	356,392	4,887,106	0.0	0	0.0
R685	356,780	4,886,926	0.0	0	0.0
R686	357,305	4,887,726	3.9	16	0.9
R688	357,448	4,889,331	0.0	0	0.0
R690	358,008	4,885,892	0.0	0	0.0
R691	359,074	4,885,854	0.0	0	0.0
R692	360,327	4,885,664	0.0	0	0.0
R693	361,775	4,886,598	9.4	19	2.8
R694	358,435	4,889,082	0.0	0	0.0
R695	359,183	4,890,360	0.0	0	0.0
R696	359,353	4,890,487	0.0	0	0.0
R697	359,774	4,890,703	25.1	32	3.9
R698	360,402	4,890,935	9.8	24	2.2
R699	362,107	4,891,706	0.0	0	0.0
R700	362,391	4,892,427	0.0	0	0.0
R701	**363,294**	**4,892,136**	**0.0**	**0**	**0.0**
R702	363,925	4,892,260	0.0	0	0.0
R703	364,024	4,892,195	5.2	19	1.2
R704	364,126	4,892,157	6.4	21	1.5
R705	364,195	4,892,263	7.2	22	1.6
R707	364,963	4,892,327	72.4	50	12.2
R708	365,565	4,893,159	0.0	0	0.0
R710	364,665	4,890,379	26.1	28	5.4
R712	362,837	4,886,350	0.0	0	0.0
R713	364,067	4,885,854	0.0	0	0.0
R714	364,089	4,885,830	0.0	0	0.0
R715	364,052	4,885,812	0.0	0	0.0
R718	364,043	4,885,736	0.0	0	0.0
R723	366,870	4,893,610	0.0	0	0.0
R724	367,973	4,891,218	17.4	22	4.8
R726	368,834	4,894,356	0.0	0	0.0
TOTAL ABOVE GUIDELINES			**47**	**59**	**19**

Appendix C

Shadow-Flicker Map

Legend

- Substation
- Turbine
- Shadow Flicker Receptor - Existing
- Ferry Connection
- Road
- Watercourse
- Parcel
- Shadow Flicker - Over 10 Hours / Year (Meteorological)
- Shadow Flicker - Over 30 Hours / Year (Worst Case)
- Waterbody
- Wetland
- Woodland

Notes:
1. Produced by Hatch under licence from Ontario Ministry of Natural Resources, Copyright (c) Queens Printer 2011.
2. Spatial referencing UTM NAD 83.

0 250 500 1,000 Metres

The results of the use of the meteorological probable shadow real case suggest that 19 receptors are above 10 hr/yr.
Please note the following:

- Five (5) of the 19 receptors are between 10.0-11.0 h/year (one receptor is a participant)
- Six (6) of the 19 receptors are between 11.1-12.6 h/year
- Four (4) of the 19 receptors are between 12.7 -15.8 h/year
- Two (2) of the 19 receptors are between 15.9 -18.9 h/year
- One (1) of the 19 receptors is between 18.9 -21 h/year
- One (1) of the 19 receptors is between 35 -37.3 h/year (participating).

Windlectric Inc.

HATCH

Figure C.1
Windlectric Inc.
Amherst Island Wind Project

Potential Shadow Flicker Impact: Meteorological and Worst Case Shadow

H340642-1000-50-015-0011 Rev. 0

Path: P:\ALGONQUI\340642\SPECIALIST_APPS\GIS\Map Documents\Layout\WindLayout_LayoutS20_ShadowCombo.mxd Date Saved: 2/26/2013 10:06:04 AM

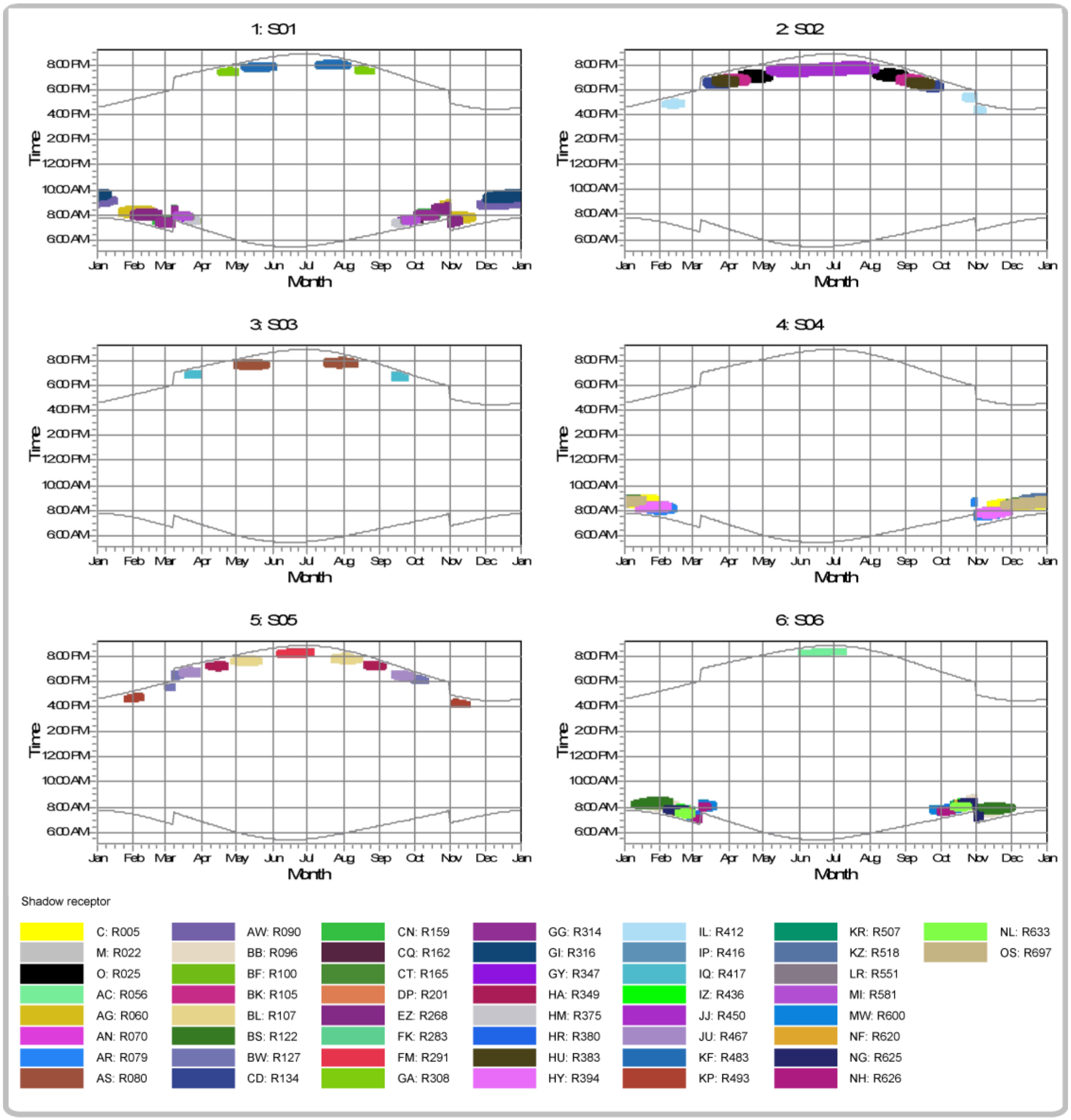

Figure C.2: Shadow flicker (astronomical in hours/year) for each wind turbine. The tiles indicate time of the day and month of the year, and refer to specific points of reception.

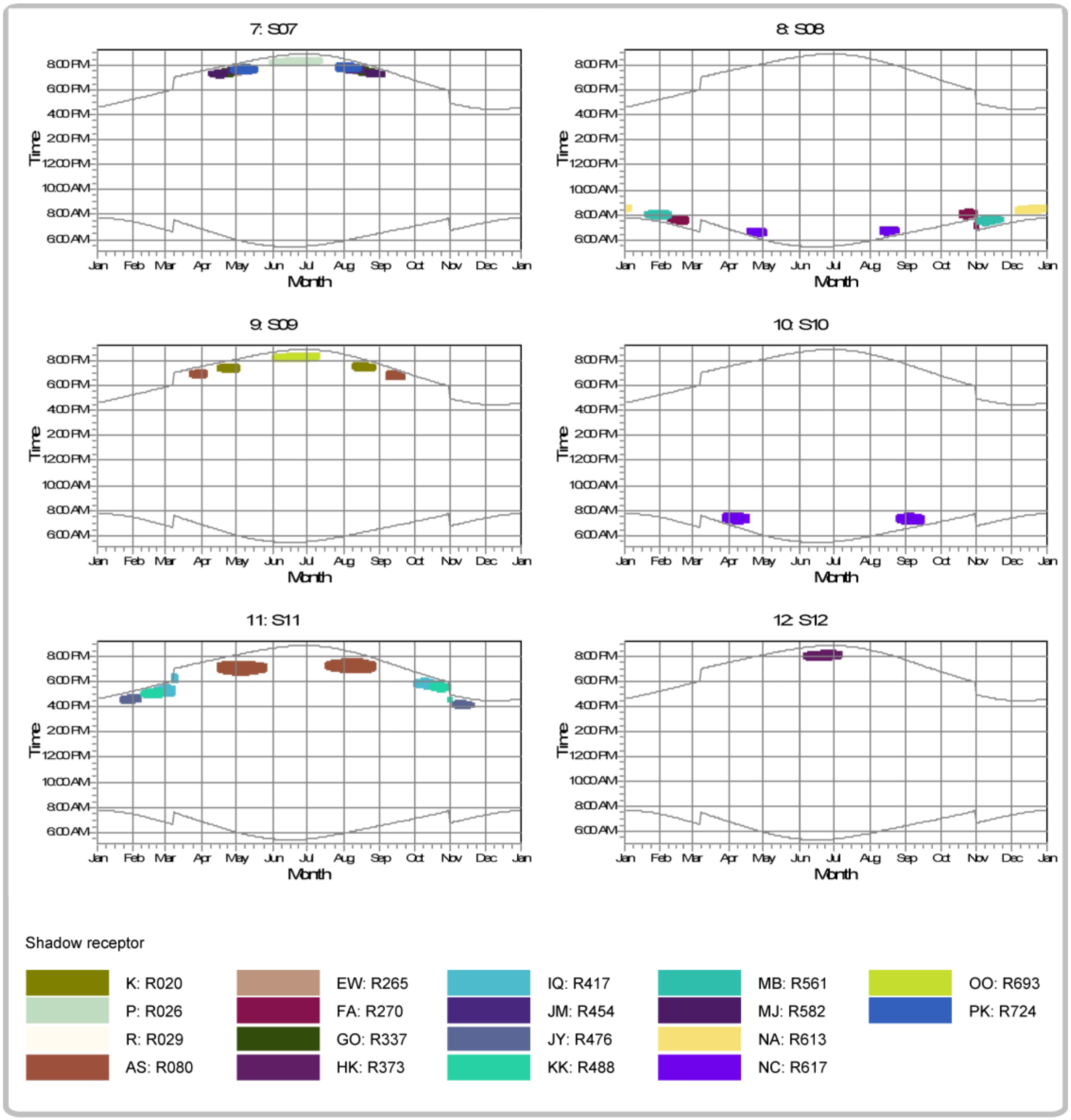

Figure C.2: Shadow flicker (astronomical in hours/year) for each wind turbine. The tiles indicate time of the day and month of the year, and refer to specific points of reception.

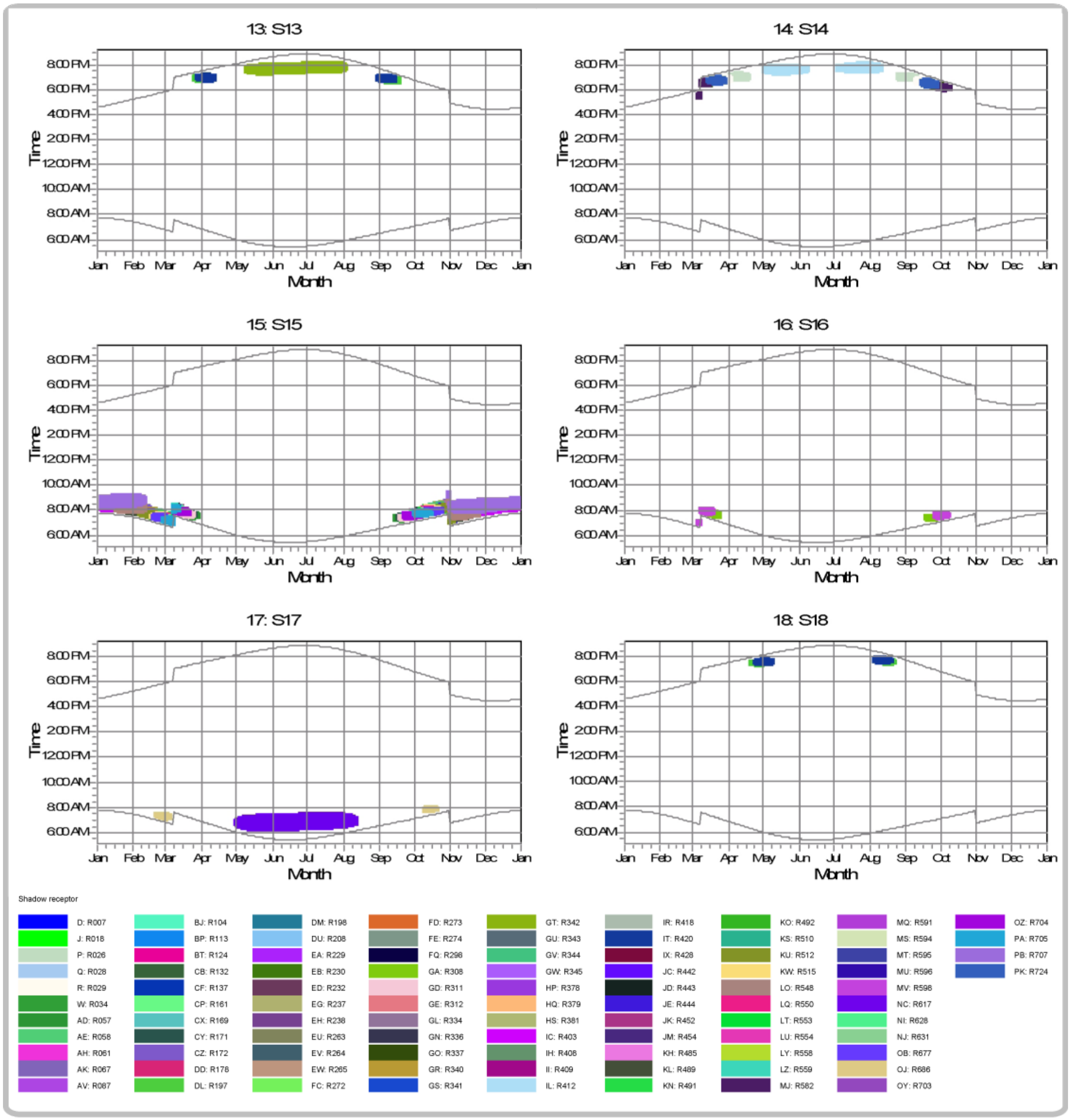

Figure C.2: Shadow flicker (astronomical in hours/year) for each wind turbine. The tiles indicate time of the day and month of the year, and refer to specific points of reception.

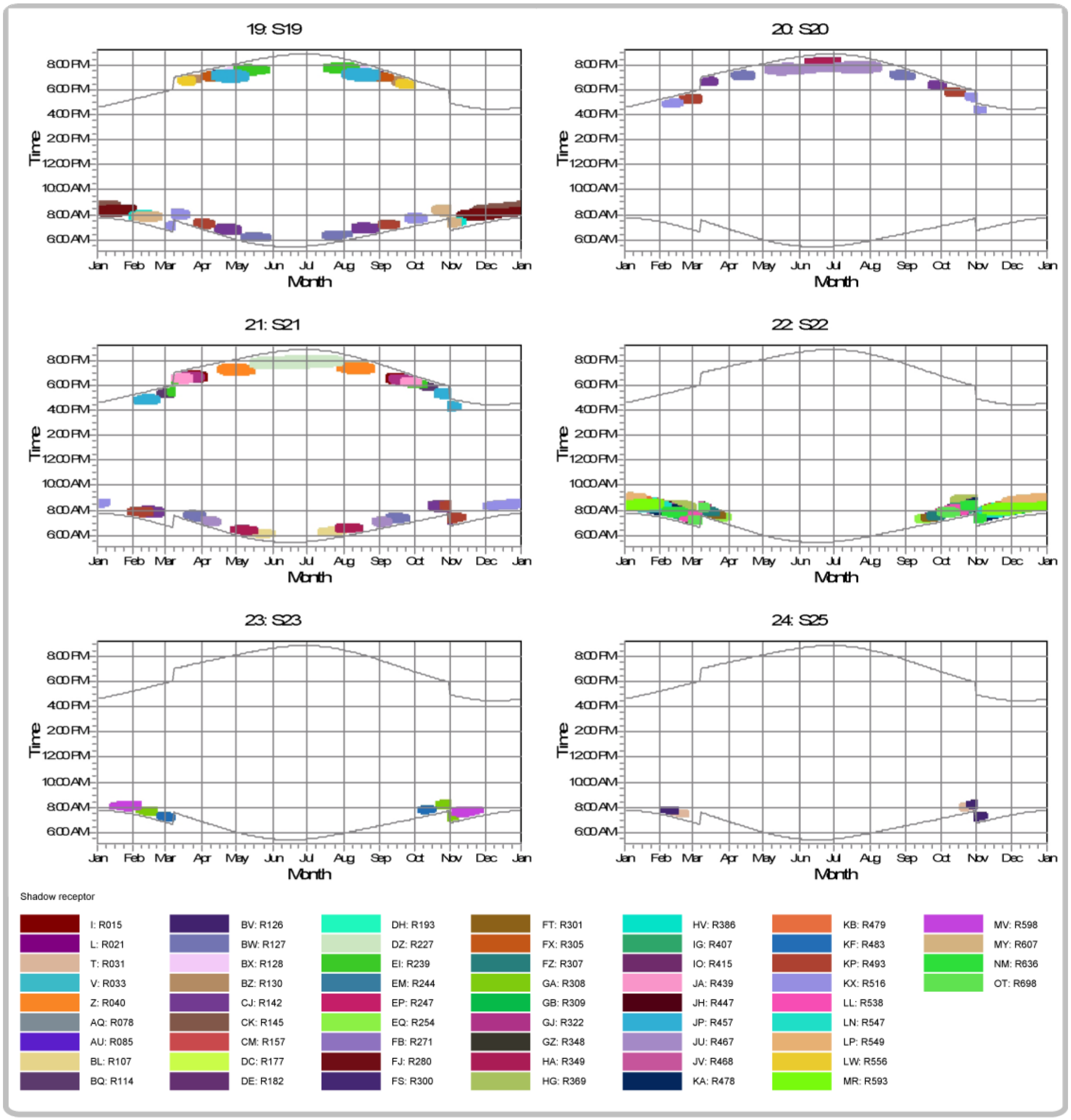

Figure C.2. Shadow flicker (astronomical in hours/year) for each wind turbine. The tiles indicate time of the day and month of the year, and refer to specific points of reception.

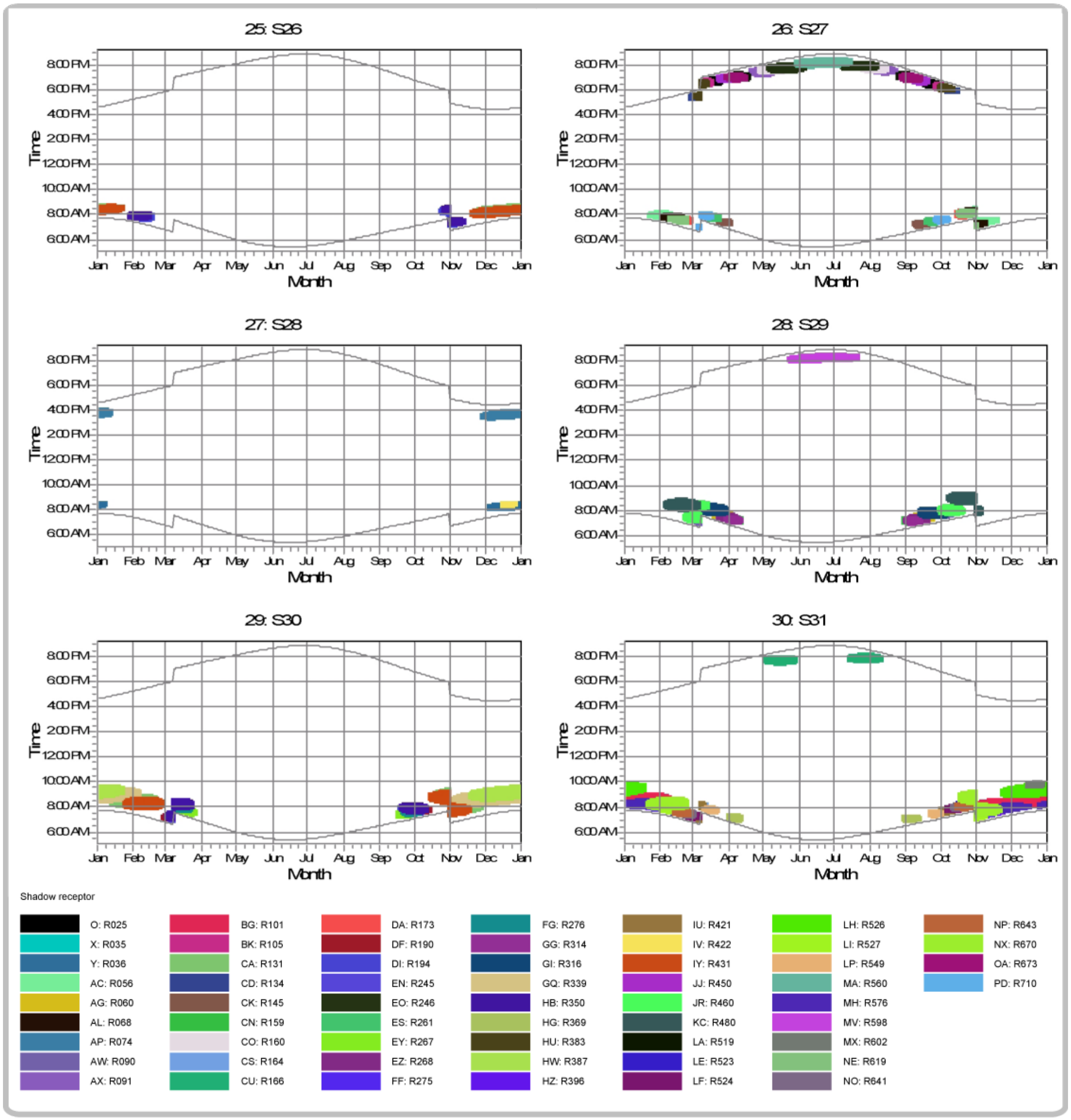

Figure C.2. Shadow flicker (astronomical in hours/year) for each wind turbine. The tiles indicate time of the day and month of the year, and refer to specific points of reception.

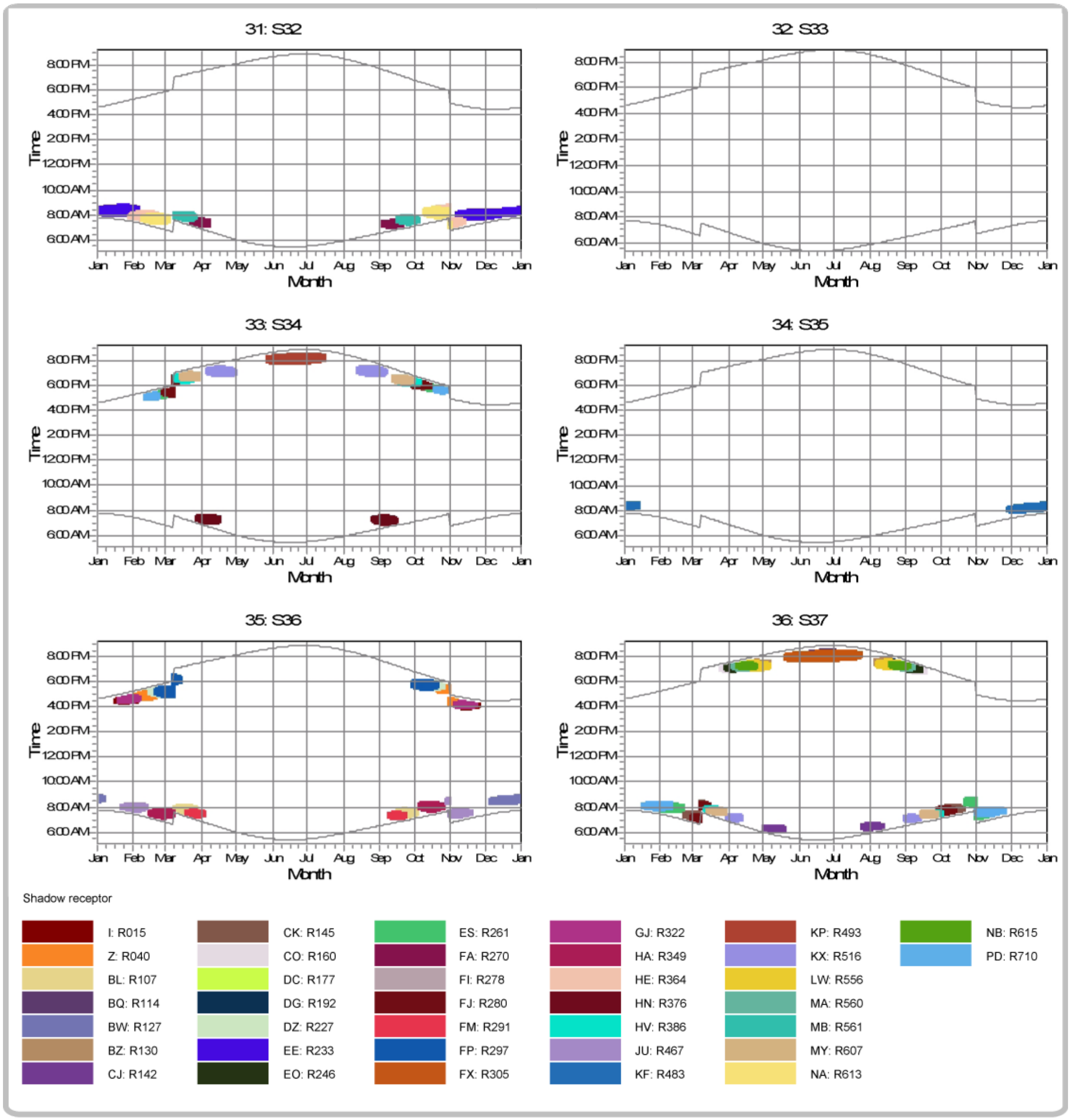

Figure C.2: Shadow flicker (astronomical in hours/year) for each wind turbine. The tiles indicate time of the day and month of the year, and refer to specific points of reception.

Appendix D

Summary of Wind Data – Meteorological Shadow

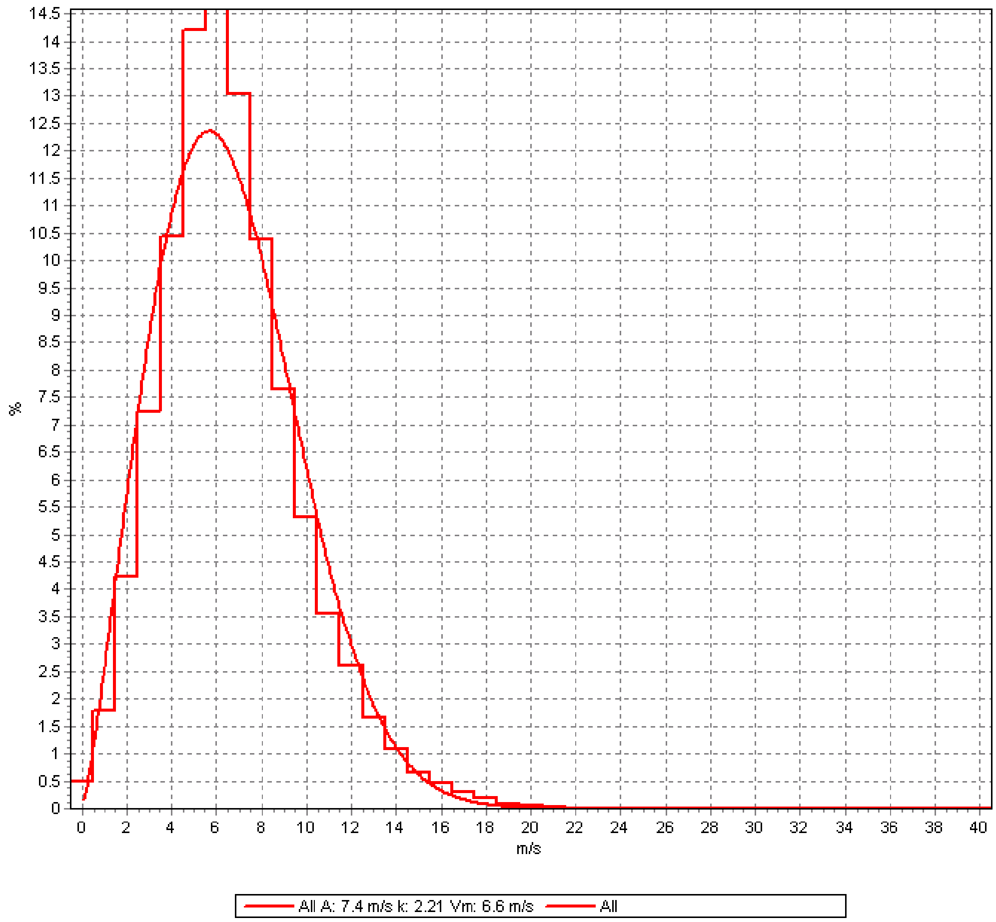

Figure D.1: Weibull Distribution at Tower 5908 site, 60 m above ground level

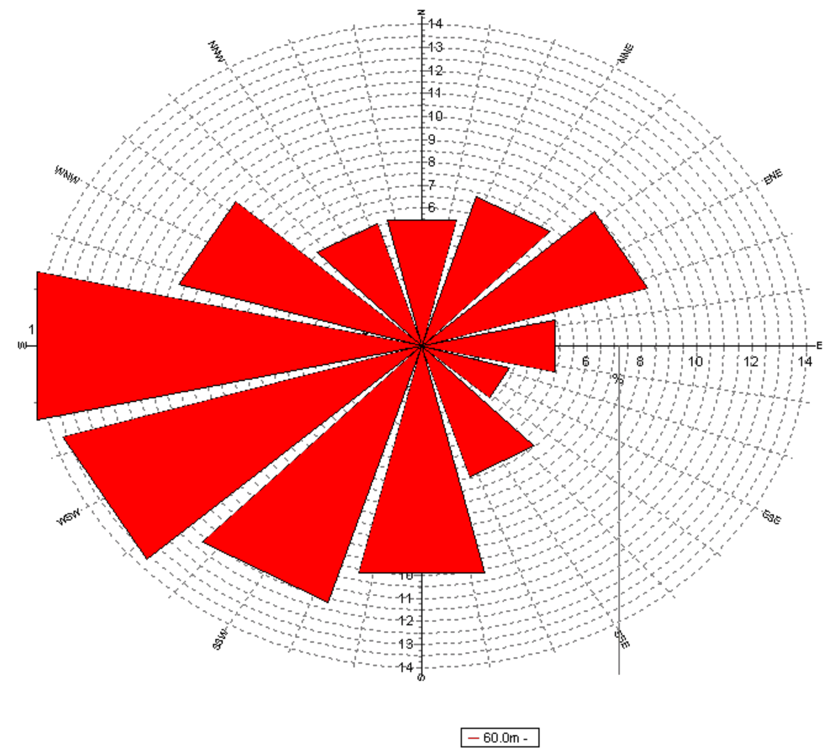

Figure D.2: Wind Rose at Tower 5908 site, 60 m above ground level

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