Appendix K SHADOW FLICKER MODELING ANALYSIS

KENT HILLS 3: KENT HILLS WIND FARM EXPANSION PHASE 3

Appendix K Shadow Flicker Modeling Analysis

Shadow Flicker Analysis – Kent Hills 3 Wind Project

Date: September 5, 2017

Re: **Shadow Flicker Analysis for the Proposed Kent Hills 3 Wind Project**

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1. Introduction and Project Background

The modeling results presented in this report are based on the cumulative impact of the potential shadow flicker to occur at the Kent Hills 3 Wind Project (the Project) considering nine additional turbine locations (5 preferred, 4 alternate) and the existing 50 turbines already in operation from the previous two phases – Kent Hills 1 (KH1) and Kent Hills 2 (KH2). Once constructed, the proposed Kent Hills 3 Project will consist of five Vestas V126-3.45 megawatt (MW) turbines with a 117 m hub-height, in addition to the existing 50 Vestas V90-3 MW wind turbines with 80 m hub height.

The Project area can be described as a mix of hills and flat terrain covered by hardwood and conifer forest in varying stages of regrowth with a history of logging in the area. There is very little residential development in the Project area as the Project is situated on Crown land.

Results from the previous shadow flicker impact assessments completed for the Kent Hills 1 and Kent Hills 2 wind farm phases suggest that maximum number of shadow hours were predicted below 30 hr/yr and 30 min/day at all adjacent known receptors (residences) within 1.5 km of the nearest wind turbine. Incorporating variables such as turbine location, receptor location, topography, rotor diameter, hub height and time zone information the model assumes a “worst case” scenario including the following conditions: the sun is fully shining all year (no clouds or fog), the rotor plane is perpendicular to the sun (biggest shadows), and the rotor is always turning (causing shadow movements) and no visual obstructions (trees, buildings). To date no shadow flicker complaints have been received by TransAlta in relation to the Kent Hills Wind Farm 1-2 (T. Kwas, pers. comm.)

In this report, we will discuss considerations and results to our cumulative shadow flicker modeling of the Kent Hills 3 Project.

2. Shadow Flicker Modeling

Shadow flicker caused by wind turbines is defined as alternating changes in light intensity due to

the moving blade shadows cast on the ground and objects (including windows at residences).

Shadow flicker is more prevalent when the sun is low in the sky at either sunrise or sunset and is less apt to occur during the spring and fall equinoxes (March 21 and September 21), and more likely during the summer and winter solstices (June 21 and December 21) when the sun is low in the sky.

The shadow-flicker frequency is related to the rotor speed and number of blades on the rotor. The modeling results presented in this report are based on the respective wind turbine model parameters of each project phase which include blade length, hub height and nominal rotor speed (of less than 1 alternation per second).

The modeling software used for this analysis is produced by EMD of Denmark and is part of the WindPro Version 3.1.617 modeling software package. The following inputs are used for the simulation:

- Turbine locations
- Receptor locations (Adjacent residences within 1.5 km)
- Area topography map
- Area height contours
- Time zone and daylight saving time information
- Rotor diameter
- Hub height
- Receptor window 1 m x 1 m with the bottom edge 1.5 m above grade regardless of direction.

To determine daylight hours at this specific site the software holds information about the earth's orbit and rotation relative to the sun and in relation to the Project area.

It should be noted that the model intentionally overpredicts shadow flicker effects. Its calculations represent "worst case" scenarios regardless of typical real case conditions minimizing effects such as:

- The reduction of shadow flicker on calm or overcast days where there is insufficient sunlight to cast a shadow. The model presumes sun always shining from sunrise to sunset.
- The rotor orientation not always casting in direction of the dwellings. The model presumes the rotor is always oriented perpendicular to the dwellings (same direction as the sun)
- If there is a non-transparent obstacle between the receptor that would block the

sunlight and any shadow impacts (e.g. trees, buildings)

- Statistics regarding wind conditions and number of hours with clear sky are not considered. The model presumes the turbines always running

3. Modeling Results

Wind turbine names (T1 to T9 for the proposed KH3 project and A1 to I2 for the operating turbines at the KH1 and KH2 phases) and shadow-flicker receptors (A to O) have been named according to the attached Project layout maps (Appendix A). Only shadow-flicker receptors in the immediate vicinity of turbines have been included in the model, as those more distant buildings will not be affected. Shadow-flicker receptors to the north or south of wind turbines are not likely to receive shadow-flicker, because the cast shadow is very short in the north and south directions, as can be seen in the shape of the contour lines on the accompanying analysis.

The model accounts for all of the adjacent dwellings (regardless of their status) within a 1.5 km range of a wind turbine. These dwellings were selected as they represent the potential worst case scenarios based on their locations relative to the proposed turbines.

Presently best industry practices tend to consider the guideline for a maximum of 30 hours per year and 30 min par day as an acceptable threshold of shadow flicker impact using “worst case” scenarios **(**WEA-Schattenwurf-Hinweise, 2002).

As a result of the cumulative shadow flicker impact from the addition of the 9 proposed turbine locations (5 preferred, 4 alternate) to the existing KH1 and KH2 wind farm;

- the maximum number of shadow hours cast per year at any receptor within the Kent Hills Wind Farm is at 22 hours (22 hours, 06 minutes) spread over 82 days during the year at Receptor M. Shadow hours is the sum of the durations of all daily occurrences of shadows being cast on the receptor during over the year. A shadow day is any day in which a shadow occurrence is cast on the receptor;

- the maximum number of shadow minutes per day are at Receptors I & L with 23 minutes. Shadow minutes is the maximum number of minutes for the day of the year a shadow occurrence is the longest of the year (May 6th at receptor I, February 12th & October 30th at Receptor L)

The table below summarizes the results of the shadow flicker report calculations. The shadow flicker map can be found in Appendix A. The detailed results from the WindPro© analysis are in Appendix B.

Table 1. Cumulative Shadow Flicker Results for Nearby Dwellings at the Kent Hills Wind Farm

Receptor	PID	Max Shadow Hrs/Yr	Max Shadow Days/Yr	Max Shadow Mins/day
A	00601708	0:00	0	0:00
B	05073549	4:05	20	0:16
C	05026844	0:00	0	0:00
D	05026836	0:00	0	0:00
E	05026836	0:00	0	0:00
F	00607259	0:00	0	0:00
G	00618371	0:00	0	0:00
H	05043476	0:00	0	0:00
I	00623934	11:11	39	0:23
J	01104942	7:19	30	0:20
K	05017249	0:00	0	0:00
L	00606160	18:13	64	0:23
M	00746610	22:06	82	0:20
N	05043955	9:10	34	0:21
O	05028907	0:00	0	0:00

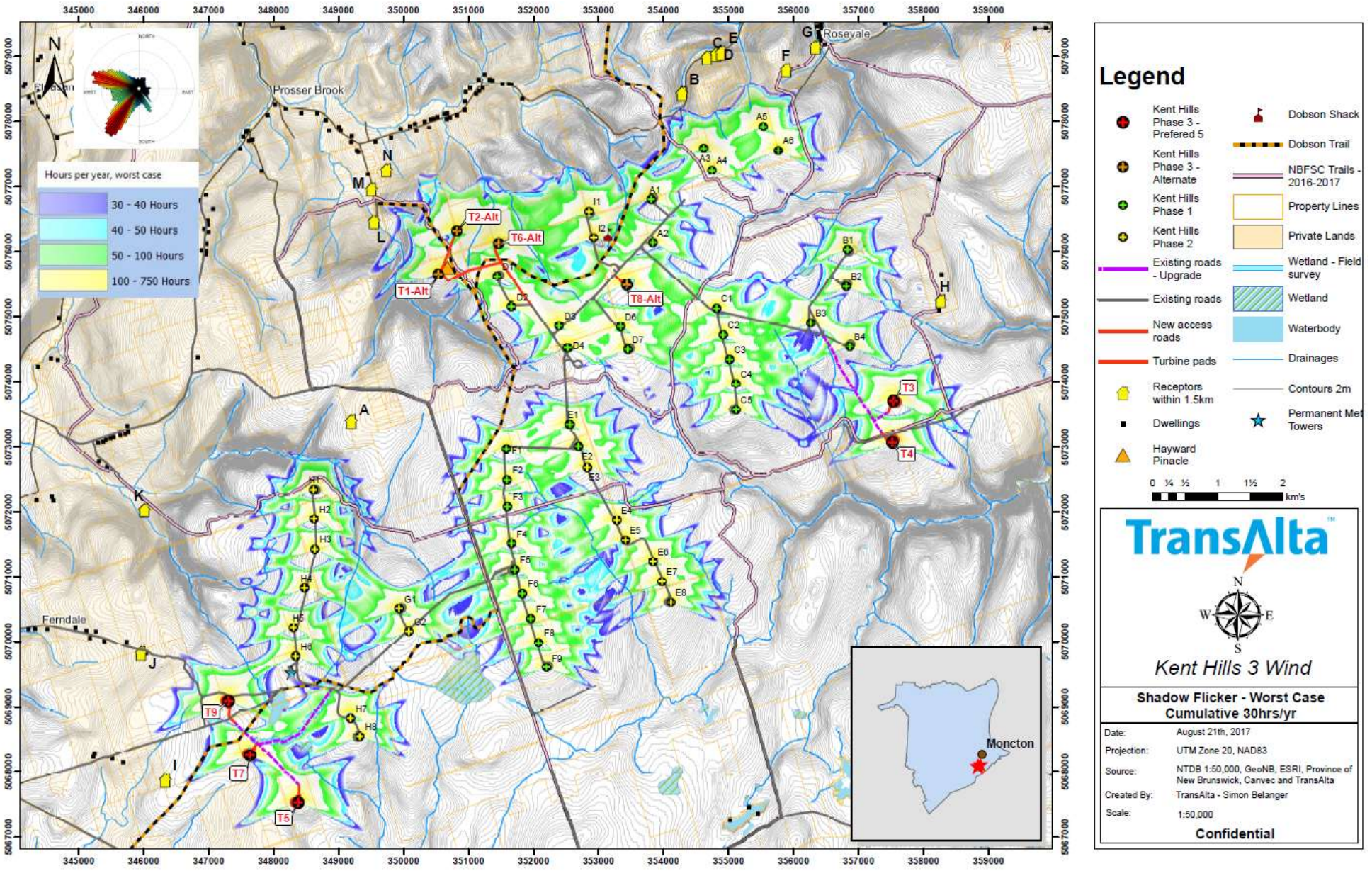
4. Conclusion

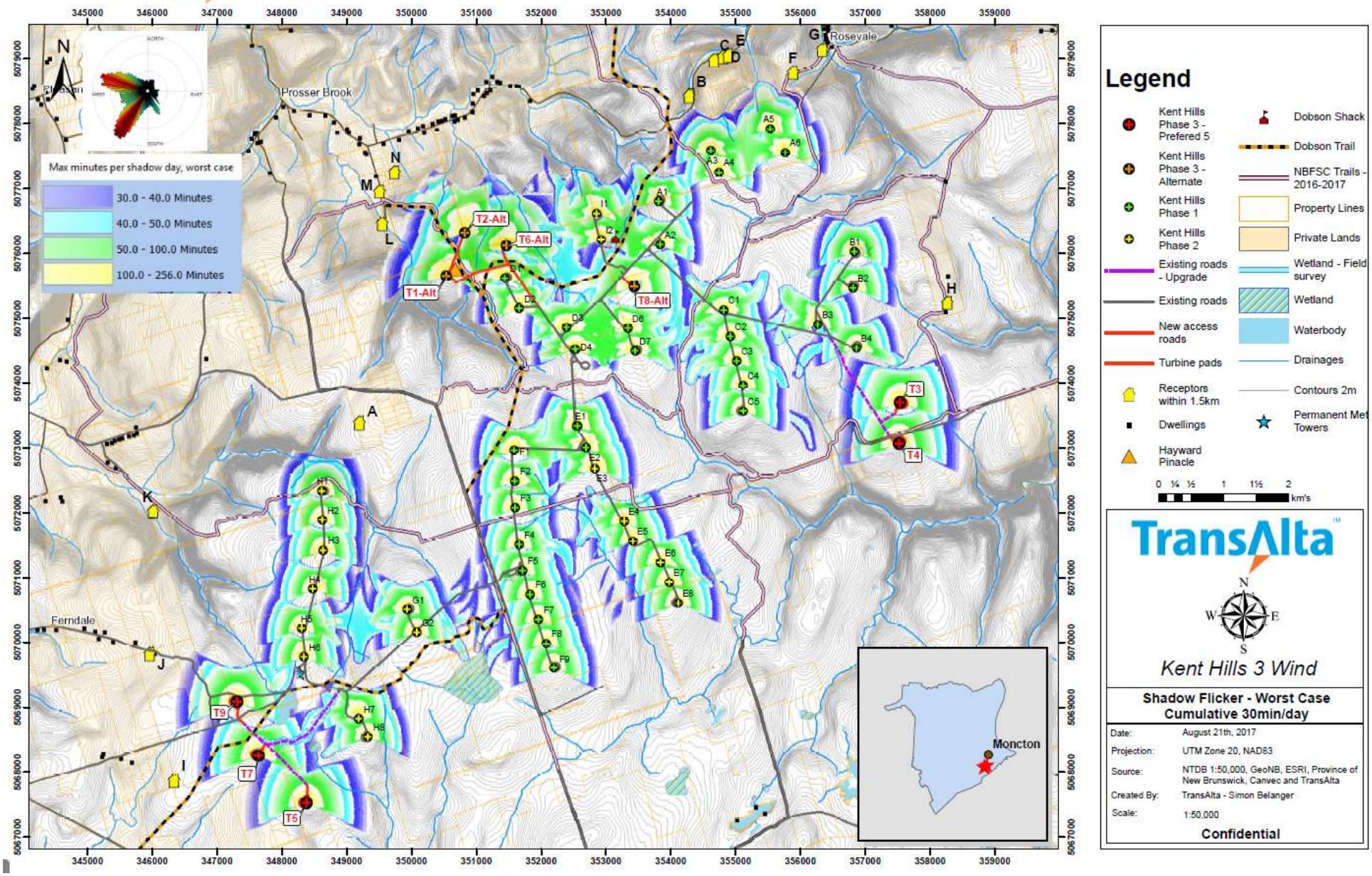
Shadow flicker impact at all dwellings modeled within 1.5 km of all existing and proposed wind turbines are well below generally accepted levels of 30 hours/year and 30 min/day based on a worst-case calculation. Therefore, cumulative shadow flicker from the proposed Kent Hills 3 wind farm, is not expected to cause any significant impact on adjacent receptors nor imply any expected mitigation measure to be required.

5. References

WEA-Schattenwurf-Hinweise. 2002. Hinweise zur Ermittlung und Beurteilung der optischen Immissionen von Windenergianlagen (Notes on the identification and assessment of the optical pollutions of Wind Turbines)

Appendix A – Shadow Flicker maps




Max minutes per shadow day, worst case
30.0 - 40.0 Minutes
40.0 - 50.0 Minutes
50.0 - 100.0 Minutes
100.0 - 256.0 Minutes
Prosser Brook
Rosevale
Ferndale
Moncton
T1-Alt
T2-Alt
T6-Alt
T8-Alt
T3
T4
T5
T7
T9
Legend
Kent Hills Phase 3 - Prefered 5
Kent Hills Phase 3 - Alternate
Kent Hills Phase 1
Kent Hills Phase 2
Existing roads - Upgrade
Existing roads
New access roads
Turbine pads
Receptors within 1.5km
Dwellings
Hayward Pinacle
Dobson Shack
Dobson Trail
NBFSC Trails - 2016-2017
Property Lines
Private Lands
Wetland - Field survey
Wetland
Waterbody
Drainages
Contours 2m
Permanent Met Towers
0 ¼ ½ 1 1½ 2
km's
TransAlta
Kent Hills 3 Wind
Shadow Flicker - Worst Case
Cumulative 30min/day
Date: August 21th, 2017
Projection: UTM Zone 20, NAD83
Source: NTDB 1:50,000, GeoNB, ESRI, Province of New Brunswick, Canvec and TransAlta
Created By: TransAlta - Simon Belanger
Scale: 1:50,000
Confidential

Appendix B – Model results (WindPro)

Project:
Kent_Hills_3

Simon Belanger
P.Eng., Design Renewables
TransAlta
Box 1900, Station "M"

Licensed user:
TransAlta Corporation
Station M 110 - 12th Avenue SW PO Box 1900
CA-T2P2M1 Calgary, Alberta
+1 (403) 267-2000
Simon Belanger / simon_belanger@transalta.com
Calculated:
2017/08/22 7:42 PM/3.1.617

SHADOW - Main Result

Calculation: KH3 (9WTG) Cumulative with KH1-2

Assumptions for shadow calculations

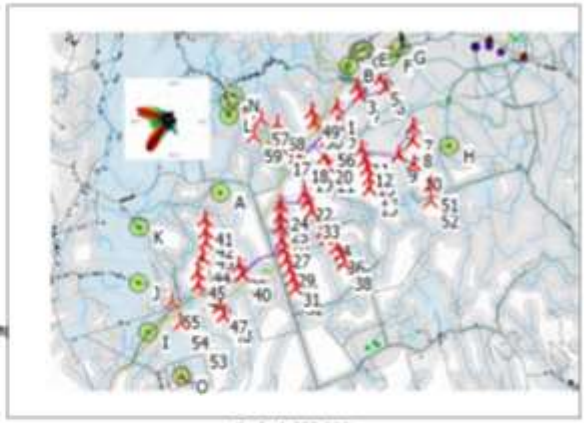
Maximum distance for influence
Calculate only when more than 20 % of sun is covered by the blade
Please look in WTG table

Minimum sun height over horizon for influence	3 °
Day step for calculation	1 days
Time step for calculation	1 minutes

The calculated times are "worst case" given by the following assumptions:
The sun is shining all the day, from sunrise to sunset
The rotor plane is always perpendicular to the line from the WTG to the sun
The WTG is always operating

A ZVI (Zones of Visual Influence) calculation is performed before flicker calculation so non visible WTG do not contribute to calculated flicker values. A WTG will be visible if it is visible from any part of the receiver window. The ZVI calculation is based on the following assumptions:
Height contours used: Height Contours: 2mContours_KentHills_CDEM_20160503.map
Obstacles used in calculation
Eye height: 1.5 m
Grid resolution: 10.0 m

All coordinates are in
UTM WGS84 Zone: 20



Scale 1:250,000

New WTG Shadow receptor

WTGs

	X(East)	Y(North)	Z	Row data/Description	WTG type Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	Shadow data Calculation distance	RPM
			[m]					[kW]	[m]	[m]	[m]	[RPM]
1	353,803	5,076,793	382.4	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
2	353,831	5,076,128	399.6	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
3	354,609	5,077,579	381.9	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
4	354,739	5,077,243	381.7	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
5	355,527	5,077,913	370.1	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
6	355,761	5,077,546	366.6	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
7	356,826	5,076,024	380.6	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
8	356,823	5,075,459	384.7	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
9	356,262	5,074,897	399.5	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
10	356,862	5,074,536	400.0	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
11	354,812	5,075,116	387.8	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
12	354,913	5,074,715	397.3	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
13	355,011	5,074,337	402.0	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
14	355,109	5,073,960	401.2	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
15	355,112	5,073,561	398.0	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
16	351,445	5,075,614	379.8	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
17	351,665	5,075,146	383.2	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
18	352,399	5,074,852	386.6	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
19	352,529	5,074,516	387.8	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
20	353,334	5,074,836	399.3	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
21	353,436	5,074,493	398.6	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
22	352,553	5,073,338	411.1	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
23	352,684	5,073,003	411.2	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
24	351,587	5,072,964	409.2	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
25	351,597	5,072,481	406.8	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
26	351,604	5,072,075	401.2	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
27	351,667	5,071,505	399.3	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
28	351,718	5,071,104	398.2	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
29	351,835	5,070,736	393.5	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
30	351,963	5,070,352	396.2	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
31	352,082	5,069,980	400.2	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
32	352,203	5,069,605	399.2	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
33	352,820	5,072,678	397.6	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
34	353,273	5,071,860	367.9	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
35	353,406	5,071,558	382.0	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
36	353,826	5,071,244	372.8	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
37	353,970	5,070,921	366.3	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1

To be continued on next page...

Project:
Kent_Hills_3

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Simon Belanger / simon_belanger@transalta.com
Calculated:
2017/08/22 7:42 PM/3.1.617

SHADOW - Main Result

Calculation: KH3 (9WTG) Cumulative with KH1-2

...continued from previous page

	X(East)	Y(North)	Z	Row data/Description	WTG type Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	Shadow data Calculation distance	RPM
			[m]					[kW]	[m]	[m]	[m]	[RPM]
38	354,109	5,070,605	360.1	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
39	349,938	5,070,506	398.7	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
40	350,087	5,070,150	398.5	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
41	348,618	5,072,336	352.6	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
42	348,626	5,071,885	363.8	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
43	348,637	5,071,418	378.6	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
44	348,514	5,070,822	382.0	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
45	348,307	5,070,209	390.0	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
46	348,343	5,069,777	384.9	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
47	349,185	5,068,894	396.3	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
48	349,332	5,068,537	397.0	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
49	352,846	5,076,610	375.7	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
50	352,919	5,076,206	397.0	VESTAS V90_1.21 3000 90.0 !O! hub: 8...	Yes	VESTAS	V90_1.21-3,000	3,000	90.0	80.0	1,425	16.1
51	357,536	5,073,700	363.0	VESTAS V126-3.45_HighTor_TA 3450 12...	Yes	VESTAS	V126-3.45_HighTor_TA-3,450	3,450	126.0	117.0	1,716	12.8
52	357,518	5,073,064	360.9	VESTAS V126-3.45_HighTor_TA 3450 12...	Yes	VESTAS	V126-3.45_HighTor_TA-3,450	3,450	126.0	117.0	1,716	12.8
53	348,384	5,067,525	394.0	VESTAS V126-3.45_HighTor_TA 3450 12...	Yes	VESTAS	V126-3.45_HighTor_TA-3,450	3,450	126.0	117.0	1,716	12.8
54	347,640	5,068,253	380.6	VESTAS V126-3.45_HighTor_TA 3450 12...	Yes	VESTAS	V126-3.45_HighTor_TA-3,450	3,450	126.0	117.0	1,716	12.8
55	347,310	5,069,087	383.0	VESTAS V126-3.45_HighTor_TA 3450 12...	Yes	VESTAS	V126-3.45_HighTor_TA-3,450	3,450	126.0	117.0	1,716	12.8
56	353,428	5,075,481	388.1	VESTAS V126-3.45_HighTor_TA 3450 12...	Yes	VESTAS	V126-3.45_HighTor_TA-3,450	3,450	126.0	117.0	1,716	12.8
57	350,826	5,076,312	348.1	VESTAS V126-3.45_HighTor_TA 3450 12...	Yes	VESTAS	V126-3.45_HighTor_TA-3,450	3,450	126.0	117.0	1,716	12.8
58	351,471	5,076,116	341.1	VESTAS V126-3.45_HighTor_TA 3450 12...	Yes	VESTAS	V126-3.45_HighTor_TA-3,450	3,450	126.0	117.0	1,716	12.8
59	350,539	5,075,645	370.6	VESTAS V126-3.45_HighTor_TA 3450 12...	Yes	VESTAS	V126-3.45_HighTor_TA-3,450	3,450	126.0	117.0	1,716	12.8

Shadow receptor-Input

No.	Name	X(East)	Y(North)	Z	Width	Height	Height a.g.l.	Degrees from south cw	Slope of window	Direction mode
				[m]	[m]	[m]	[m]	[°]	[°]	
A	A	349,201	5,073,382	361.8	1.0	1.0	1.5	0.0	90.0	"Green house mode"
B	B	354,278	5,078,419	234.8	1.0	1.0	1.5	0.0	90.0	"Green house mode"
C	C	354,661	5,078,971	208.9	1.0	1.0	1.5	0.0	90.0	"Green house mode"
D	D	354,804	5,079,023	197.3	1.0	1.0	1.5	0.0	90.0	"Green house mode"
E	E	354,883	5,079,043	192.5	1.0	1.0	1.5	0.0	90.0	"Green house mode"
F	F	355,883	5,078,781	247.1	1.0	1.0	1.5	0.0	90.0	"Green house mode"
G	G	356,334	5,079,133	167.8	1.0	1.0	1.5	0.0	90.0	"Green house mode"
H	H	358,266	5,075,232	333.4	1.0	1.0	1.5	0.0	90.0	"Green house mode"
I	I	346,339	5,067,869	361.0	1.0	1.0	1.5	0.0	90.0	"Green house mode"
J	J	345,965	5,069,817	326.3	1.0	1.0	1.5	0.0	90.0	"Green house mode"
K	K	346,017	5,072,016	167.2	1.0	1.0	1.5	0.0	90.0	"Green house mode"
L	L	349,552	5,076,449	157.0	1.0	1.0	1.5	0.0	90.0	"Green house mode"
M	M	349,512	5,076,949	145.4	1.0	1.0	1.5	0.0	90.0	"Green house mode"
N	N	349,743	5,077,245	155.9	1.0	1.0	1.5	0.0	90.0	"Green house mode"
O	O	347,674	5,066,138	364.4	1.0	1.0	1.5	0.0	90.0	"Green house mode"

Calculation Results

Shadow receptor

No.	Name	Shadow, worst case: Shadow hours per year [h/year]	Shadow days per year [days/year]	Max shadow hours per day [h/day]
A	A	0:00	0	0:00
B	B	4:05	20	0:16
C	C	0:00	0	0:00
D	D	0:00	0	0:00
E	E	0:00	0	0:00
F	F	0:00	0	0:00
G	G	0:00	0	0:00
H	H	0:00	0	0:00
I	I	11:11	39	0:23
J	J	7:19	30	0:20
K	K	0:00	0	0:00

To be continued on next page...

Project:
Kent_Hills_3

Simon Belanger
P.Eng., Design Renewables
TransAlta
Box 1900, Station "M"

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+1 (403) 267-2000
Simon Belanger / simon_belanger@transalta.com
Calculated:
2017/08/22 7:42 PM/3.1.617

SHADOW - Main Result

Calculation: KH3 (9WTG) Cumulative with KH1-2

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No.	Name	Shadow, worst case Shadow hours per year [h/year]	Shadow days per year [days/year]	Max shadow hours per day [h/day]
L	L	18:13	64	0:23
M	M	22:06	82	0:20
N	N	9:10	34	0:21
O	O	0:00	0	0:00

Total amount of flickering on the shadow receptors caused by each WTG

No.	Name	Worst case [h/year]
1	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2705)	0:00
2	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2719)	0:00
3	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2720)	0:00
4	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2721)	0:00
5	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2722)	4:05
6	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2723)	0:00
7	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2724)	0:00
8	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2725)	0:00
9	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2726)	0:00
10	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2727)	0:00
11	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2728)	0:00
12	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2729)	0:00
13	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2730)	0:00
14	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2731)	0:00
15	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2732)	0:00
16	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2733)	0:00
17	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2734)	0:00
18	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2735)	0:00
19	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2736)	0:00
20	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2737)	0:00
21	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2738)	0:00
22	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2739)	0:00
23	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2740)	0:00
24	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2741)	0:00
25	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2742)	0:00
26	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2743)	0:00
27	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2744)	0:00
28	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2745)	0:00
29	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2746)	0:00
30	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2747)	0:00
31	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2748)	0:00
32	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2749)	0:00
33	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2750)	0:00
34	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2751)	0:00
35	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2752)	0:00
36	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2753)	0:00
37	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2754)	0:00
38	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2755)	0:00
39	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2756)	0:00
40	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2757)	0:00
41	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2758)	0:00
42	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2759)	0:00
43	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2760)	0:00
44	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2761)	0:00
45	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2762)	0:00
46	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2763)	0:00
47	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2764)	0:00
48	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2765)	0:00
49	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2766)	0:00
50	VESTAS V90_1.21 3000 90.0 !O! hub: 80.0 m (TOT: 125.0 m) (2767)	0:00
51	VESTAS V126-3.45_HighTor_TA 3450 126.0 !O! hub: 117.0 m (TOT: 180.0 m) (2975)	0:00
52	VESTAS V126-3.45_HighTor_TA 3450 126.0 !O! hub: 117.0 m (TOT: 180.0 m) (2976)	0:00
53	VESTAS V126-3.45_HighTor_TA 3450 126.0 !O! hub: 117.0 m (TOT: 180.0 m) (2977)	0:00
54	VESTAS V126-3.45_HighTor_TA 3450 126.0 !O! hub: 117.0 m (TOT: 180.0 m) (2978)	11:11

To be continued on next page...

Project:
Kent_Hills_3

Simon Belanger
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Simon Belanger / simon_belanger@transalta.com
Calculated:
2017/08/22 7:42 PM/3.1.617

SHADOW - Main Result

Calculation: KH3 (9WTG) Cumulative with KH1-2

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No.	Name	Worst case [h/year]
55	VESTAS V126-3.45_HighTor_TA 3450 126.0 !O! hub: 117.0 m (TOT: 180.0 m) (2979)	7:19
56	VESTAS V126-3.45_HighTor_TA 3450 126.0 !O! hub: 117.0 m (TOT: 180.0 m) (2980)	0:00
57	VESTAS V126-3.45_HighTor_TA 3450 126.0 !O! hub: 117.0 m (TOT: 180.0 m) (2981)	24:07
58	VESTAS V126-3.45_HighTor_TA 3450 126.0 !O! hub: 117.0 m (TOT: 180.0 m) (2982)	0:00
59	VESTAS V126-3.45_HighTor_TA 3450 126.0 !O! hub: 117.0 m (TOT: 180.0 m) (2983)	25:22

Total times in Receptor view and WTG view tables can differ, as a WTG can lead to flicker at 2 or more receptors simultaneously and/or receptors may receive flicker from 2 or more WTGs simultaneously.