



Kopperå

Shadow Flicker Assessment rev 1



To	Dorte Solvang / Rambøll Energi
From	Meventus AS
Date	09.10.2013
Report title	Kopperå Shadow Flicker Assessment rev 1
Report no	2012-007
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Revision 1:

This revision reflects an update to the neighbor buildings within the planning. After consultation with the landowner, the two buildings depicted within the planning area in the original report were removed as one did not exist and the other was a boat house, and not a residence or cabin.

Summary

The shadow flicker of a planned layout consisting of 50 Vestas V112 turbines at the Kopperå wind park was assessed in order to determine the impact on local neighbors. As Norway currently has no official guidelines regarding shadow flicker limits, the Danish guidelines of 10 hours/year of shadow flicker based on sunshine probability and expected turbine operational hours were used for the evaluation.

Using sunshine data from the nearest reference station and available wind data to estimate the operational hours of the turbines, the shadow flicker generated with the given layout at Kopperå is expected to marginally exceed the limits for at least one neighbor location, with three additional neighbors just below the threshold. All four of these neighbors are located outside the planning area and are within 1.5 hours of the 10 hour limit. When evaluating the impact, one should consider whether the neighbor location is a primary residence or a seasonal cabin. While the shadow flicker is not considered problematic for this project, measures such as turbine curtailment should be considered for the location expected to be in exceedance.

Table of Contents

Summary	2
1 Introduction and Background	4
2 Shadow Flicker Description and Guidelines	5
3 Shadow Flicker Methodology	5
3.1 General assumptions	5
3.2 Sunshine probability data	6
3.3 Turbine information and expected operational hours	6
4 Shadow Flicker Results	7



1 Introduction and Background

The Kopperå wind project is located in Norway along the Swedish border, approximately 90 km east of Trondheim. The shadow flicker generated from a layout consisting of 50 Vestas V112 turbines was assessed in order to determine the impact on local neighbors. The project planning area, layout and neighbors are depicted in Figure 1 below.

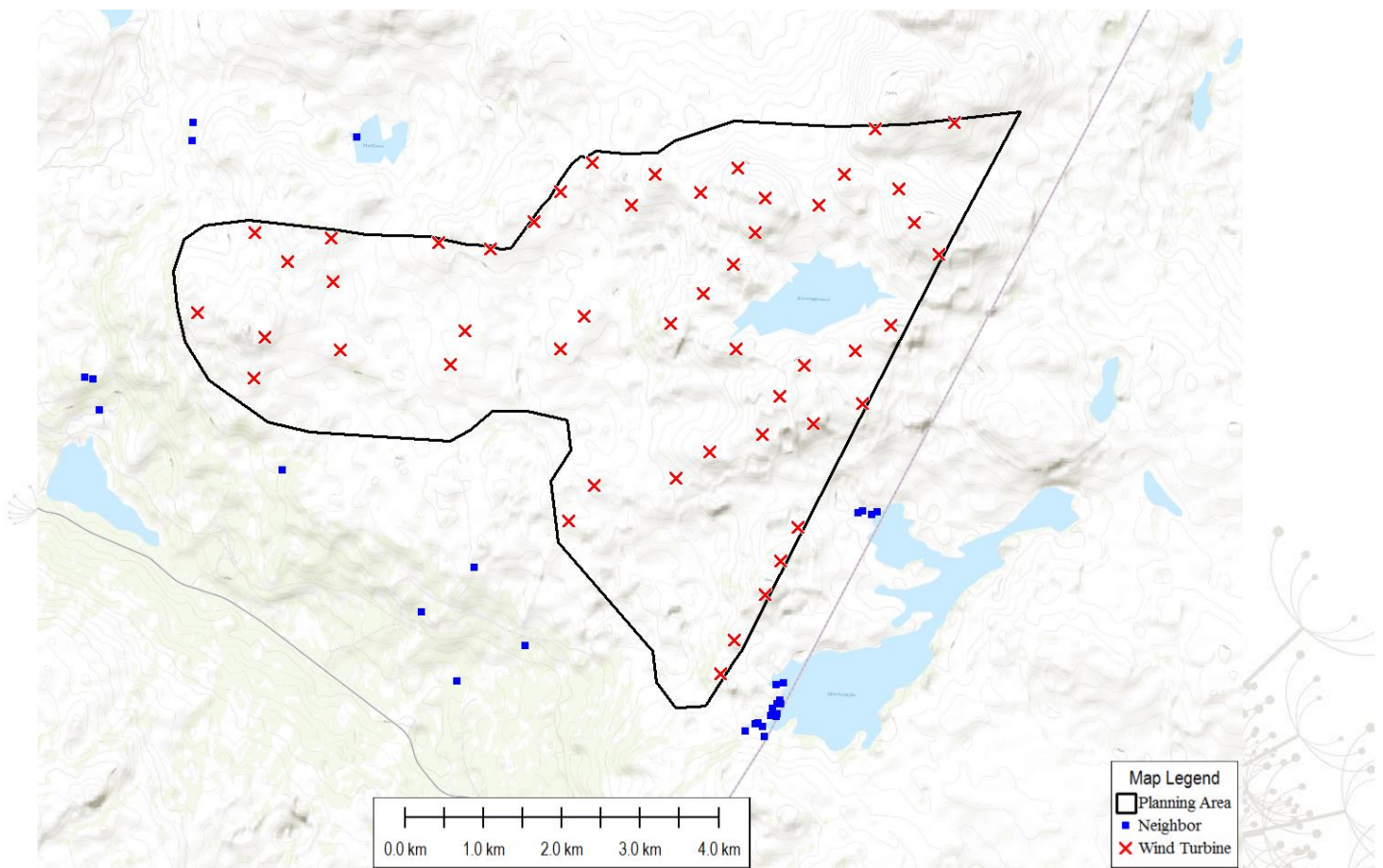


Figure 1 – Kopperå planning area, turbine positions and neighbors

The line starting in the top right corner down to the bottom middle of the picture is the Swedish border. No neighbor information for Sweden was provided, but an inspection with Google satellite maps indicated there were no buildings within a few kilometers of the nearest turbine positions.

2 Shadow Flicker Description and Guidelines

Shadow flicker is the flickering effect caused when rotating wind turbine blades, when located directly between the sun and an observer (such as a neighbor house), cast shadows onto the observer. The following conditions must be present for shadow flicker to occur:

- The turbine must be running (high enough wind speed)
- The sun must be shining (no cloud cover)
- The turbine must be directly between the observer and the sun without obstruction such as terrain, trees, or fog
- The observer has to be close enough to the object to be in its shadow

There are currently no official guidelines/regulations in Norway regarding the amount of shadow flicker generated from wind turbines, although some are currently under revision.

The limits in Denmark and Sweden are a total of 10 and 8 hours over the course of a year, respectively, based on statistics (sunshine probability and expected turbine operation hours). The guidelines for Denmark are used for the maximum values for this analysis, but the Swedish limits were also considered due to the project's close proximity to Sweden.

3 Shadow Flicker Methodology

The shadow flicker calculations were conducted using the program WindPRO. This software calculates how often and in which intervals a specific neighbor or area will be affected by turbine-generated shadow flicker. These calculations can be either worst-case or real-case scenarios based on sunshine probability data and expected turbine operational hours. Worst-case scenarios, or astronomical maximum shadow, are calculations based solely on the sun positions relative to the turbine where it is assumed the sun is always shining and the turbines are always running.

The software also accounts for the influence of terrain on visibility, but does not directly account for the influence of forest or trees. Results are provided either as a sum of the amount of shadow flicker at a specific neighbor location, or as an iso-line map depicting areas of expected shadow flicker.

3.1 General assumptions

The following general assumptions were included as part of the calculation:

- ZVI (zone of visual influence) based on the available height contours were determined to ensure only shadow flicker from visible turbines were included in the estimates

- Minimum sun height over horizon considered to influence shadow is 3 degrees
- Time step for calculation 1 minute
- Maximum distance from the turbine that shadow is expected to impact an area/neighbor is the distance where the rotor blade width covers at least 20% of the sun, or 2km limit (whichever is less).
- Wind speed cut in for turbine operation is based on the turbine power curve
- All neighbor houses were modeled as shadow receptors in 'Green house mode' to measure maximum possible shadow flicker at the location. This means the window is assumed perpendicular to all turbines, the following parameters were used to define the window/house
 - o Height and width of 10m
 - o Bottom of window is 1.5m above the ground
 - o Window slope is 0 (assumed to be a flat area on the ground)

3.2 Sunshine probability data

For the real-case calculations, sunshine probability data from the nearest weather station (Trondheim, approximately 90 km) was used for the Kopperå wind park. The average daily sunshine hours by month is presented in Table 1 below (source: Meteorologisk institutt).

Table 1 – Average Daily Sunshine Hours, Trondheim weather station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Daily Sunshine Hours	0.75	2.33	3.83	5.28	6.94	6.58	5.74	5.68	3.72	1.99	1.06	0.30

3.3 Turbine information and expected operational hours

The expected operational hours of the wind park is determined using the turbine properties (primarily the cut-in wind speed) and wind data expected to be representative of the long term climate of the site. The characteristics of turbines used in the layout are provided in Table 2 below.

Table 2 – Turbine Information, Vestas V112

Turbine Manufacturer & Model	Rotor Diameter (m)	Hub height (m)	Rated power (MW)	Cut-in wind speed (m/s)
Vestas V112	112	94	3.0	3.0

Detailed wind measurement data for the project was not available, so the wind distribution for the site was derived from 23 years of ERA-Interim reanalyzed data from ECMWF (European Center of Medium Range Forecasting). This 3 hour resolution data is available at equally spaced grid points (at a resolution of 0.7°) and interpolated to a desired location from the four closest grid points. The expected operational hours derived from this wind distribution is provided in Table 3 below.

Table 3 – Expected operational hours for turbines

	N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
Turbine Operational Hours	222	120	118	192	528	1255	1168	622	656	1171	1322	712	8084

While the ERA data is expected to be representative of the site, the expected wind speed levels may require scaling to match the long term climate of the site. This uncertainty could impact the expected operational hours.

4 Shadow Flicker Results

The calculated shadow flicker map for the given layout is provided in Figure 2 below. Green (or unshaded) areas depict locations where less than 8 hours of shadow flicker per year can be expected. Areas exceeding 8 hours of expected shadow flicker (Swedish guidelines) are marked in yellow, while orange depicts areas exceeding 10 hours (Danish guidelines). The red areas depict areas exceeding 50 hours (with some locations expecting over 200 hours/year of shadow flicker).

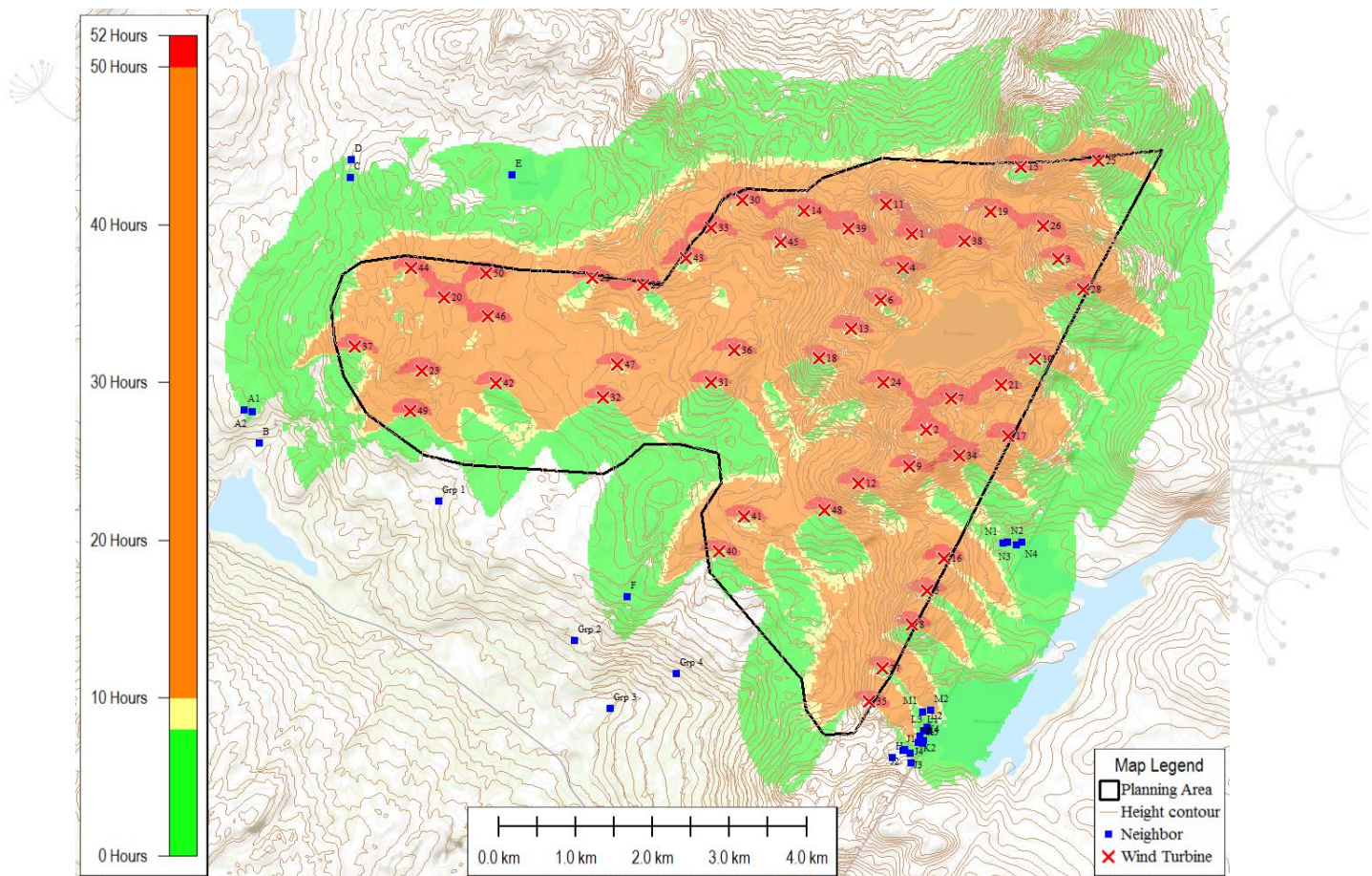


Figure 2 – Kopperå expected shadow flicker map (real-case) with turbines and neighbors

As seen above, the shadow flicker levels at only one neighbor located southeast of the planning area (M2) exceeds the 10 hours/year limit, with several others in the area just below the threshold. No impact is expected for any potential neighbors in Sweden. Table 4 below provides additional details about from which turbines and during what time periods shadow flicker are expected at the most affected neighbors.

Table 4 – Shadow flicker statistics for most affected neighbors by turbine/season

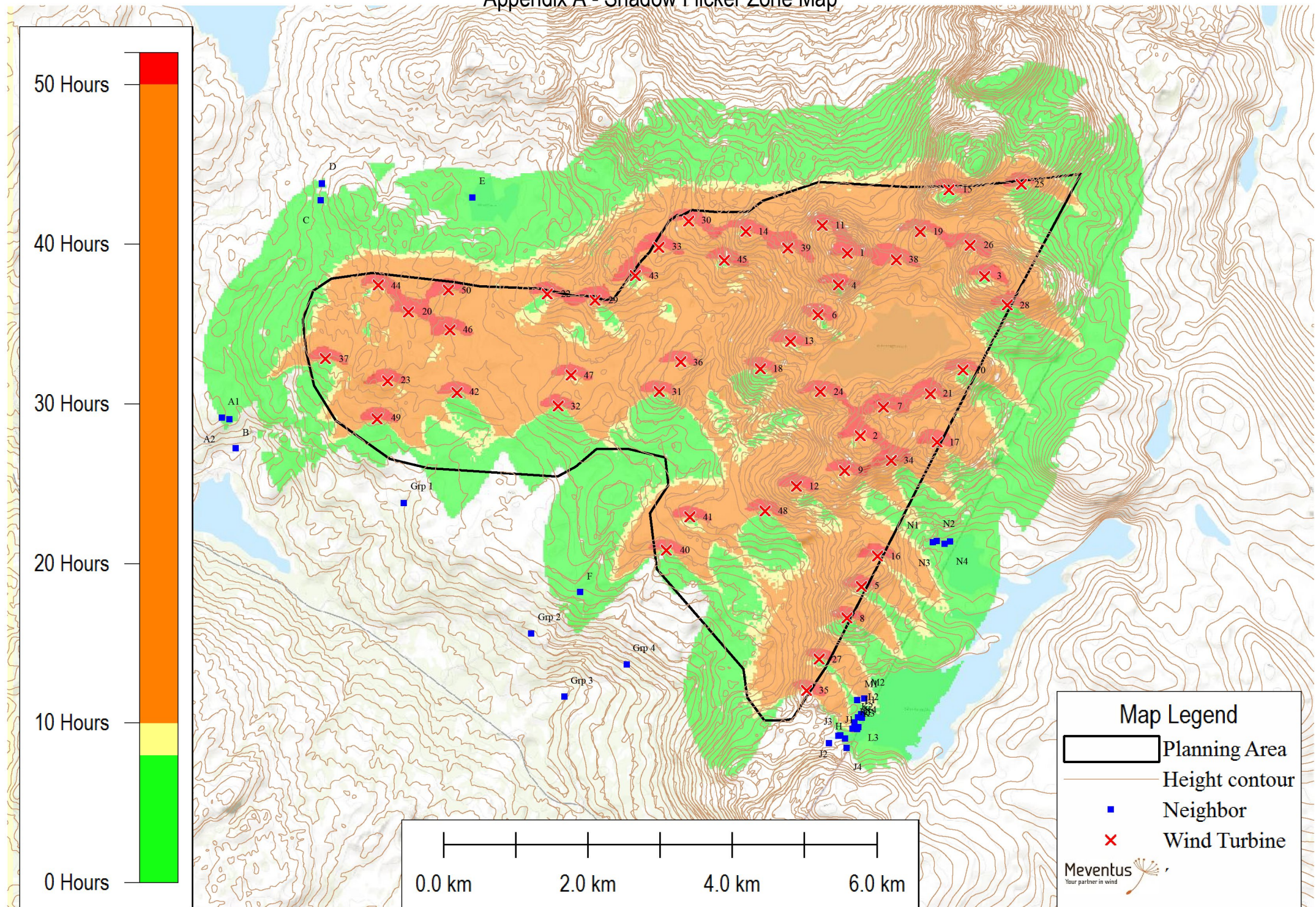
Neighbor	Worst-Case flicker (hours/year)	Real-Case flicker (hours/year)	Primary Turbine(s) causing flicker	Primary Season flicker occurs
M2	53.5	11.5	27	Summer
K1	42	9.5	35	Summer
M1	41.5	9	27	Summer
N1	48	8.5	9	Summer
N2	46.5	8	9	Summer

The neighbor experiencing the most flicker, M2 at 11.5 hours, only marginally exceeds the 10 hour limit. The other four neighbors depicted are slightly below the flicker limits. All of these neighbor locations experience flicker primarily during the summer and from one of three turbines located southeast in the park. Whether all neighbor buildings are primary residences or seasonal cabins should be considered when evaluating the respective impact.

It is also important to consider the actual location, orientation and size of the windows on each of the structures as the estimates will most likely be reduced with more detailed information. Turbine curtailment should be considered for those locations are considered problematic.

Refer to Appendix A for a larger shadow-flicker map and Appendix B for graphical calendars depicting the time of year and time of day each neighbor experiences shadow from each respective turbine.

Appendix A - Shadow Flicker Zone Map



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Kopperå

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02.10.2013 11:44/2.9.250

SHADOW - Main Result**Calculation:** 201310 Real Case (statistical based)**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

Sunshine probability S (Average daily sunshine hours) []

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.75	2.32	3.83	5.28	6.93	6.58	5.74	5.67	3.71	1.98	1.05	0.30	

Operational hours are calculated from WTGs in calculation and wind distribution:

ERA Data

Operational time

	N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
	222	120	118	192	528	1,255	1,168	622	656	1,171	1,322	712	8,084

Idle start wind speed: Cut in wind speed from power curve

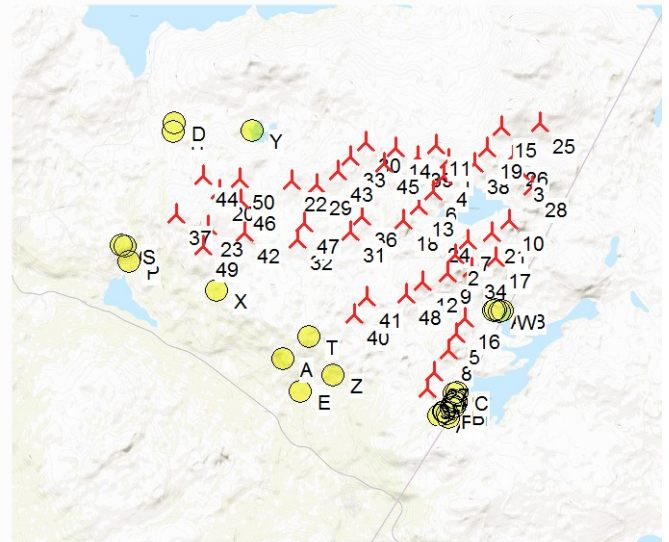
A ZVI (Zones of Visual Influence) calculation is performed before flicker calculation so non visible WTG do not contribute to calculated flicker values. A WTG will be visible if it is visible from any part of the receiver window. The ZVI calculation is based on the following assumptions:

Height contours used: Height Contours: Kopperå_height_contours.wpo (1)

Obstacles used in calculation

Eye height: 1.5 m

Grid resolution: 10.0 m



Scale 1:200,000

New WTG

Shadow receptor

WTGs

UTM (north)-WGS84 Zone: 33

	East	North	Z	Row data/Description
--	------	-------	---	----------------------

WTG type

Valid Manufact.

Type-generator

Power,

rated

[kW]

Rotor

diameter

[m]

Hub

height

[m]

Shadow data

Calculation RPM

distance

[m]

[RPM]

	East	North	Z	Row data/Description	Valid	Manufact.	Type-generator	Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Calculation distance [m]	RPM
			[m]									
1	354,152	7,035,461	980.0	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
2	354,334	7,032,936	900.0	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
3	356,052	7,035,144	1,000.0	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
4	354,029	7,035,021	951.0	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
5	354,351	7,030,846	800.0	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
6	353,749	7,034,612	900.0	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
7	354,653	7,033,331	890.7	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
8	354,147	7,030,413	780.0	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
9	354,116	7,032,451	846.6	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
10	355,752	7,033,847	906.4	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
11	353,808	7,035,846	935.2	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
12	353,450	7,032,238	806.9	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
13	353,366	7,034,242	870.1	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
14	352,751	7,035,764	880.0	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
15	355,556	7,036,338	987.5	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
16	354,571	7,031,269	774.2	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
17	355,395	7,032,850	860.0	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
18	352,951	7,033,861	840.0	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
19	355,165	7,035,759	940.0	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
20	348,081	7,034,648	681.8	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
21	355,303	7,033,514	880.0	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
22	350,001	7,034,896	721.9	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
23	347,793	7,033,692	668.9	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
24	353,780	7,033,546	858.3	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
25	356,562	7,036,415	956.8	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
26	355,854	7,035,572	940.0	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
27	353,765	7,029,844	720.0	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
28	356,366	7,034,747	940.0	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
29	350,661	7,034,809	735.9	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
30	351,955	7,035,909	795.6	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8

To be continued on next page...

Project:

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02.10.2013 11:44/2.9.250

SHADOW - Main Result**Calculation:** 201310 Real Case (statistical based)

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UTM (north)-WGS84 Zone: 33				WTG type				Shadow data				
	East	North	Z	Row data/Description	Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	Calculation distance	RPM
			[m]					[kW]	[m]	[m]	[m]	[RPM]
31	351,551	7,033,546	720.0	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
32	350,151	7,033,346	674.4	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
33	351,546	7,035,546	760.0	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
34	354,764	7,032,592	840.0	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
35	353,588	7,029,411	686.2	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
36	351,850	7,033,959	735.8	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
37	346,930	7,034,003	657.4	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
38	354,833	7,035,369	896.9	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
39	353,327	7,035,533	876.2	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
40	351,651	7,031,354	639.2	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
41	351,973	7,031,810	680.0	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
42	348,754	7,033,532	640.0	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
43	351,219	7,035,155	751.0	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
44	347,661	7,035,021	640.0	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
45	352,452	7,035,363	794.4	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
46	348,656	7,034,399	643.5	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
47	350,331	7,033,778	679.9	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
48	353,016	7,031,895	711.0	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
49	347,649	7,033,171	608.8	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8
50	348,632	7,034,951	666.8	VESTAS V112 3000 112.0 !O! ...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	1,711	12.8

Shadow receptor-Input

UTM (north)-WGS84 Zone: 33				Width	Height	Height a.g.l.	Degrees from south cw	Slope of window	Direction mode
No.	Name	East	North						
				[m]	[m]	[m]	[°]	[°]	
A Grp 2	349,780	7,030,199	492.7	10.0	10.0	1.5	0.0	0.0	"Green house mode"
B K4	354,305	7,028,903	700.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"
C M2	354,387	7,029,295	700.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"
D D	346,883	7,036,425	580.6	10.0	10.0	1.5	0.0	0.0	"Green house mode"
E Grp 3	350,237	7,029,321	420.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"
F J1	354,028	7,028,781	695.8	10.0	10.0	1.5	0.0	0.0	"Green house mode"
G J2	354,056	7,028,788	698.1	10.0	10.0	1.5	0.0	0.0	"Green house mode"
H C	346,867	7,036,192	577.5	10.0	10.0	1.5	0.0	0.0	"Green house mode"
I L3	354,354	7,029,030	700.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"
J J3	354,123	7,028,745	700.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"
K K2	354,250	7,028,967	700.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"
L L1	354,301	7,029,036	700.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"
M K3	354,290	7,028,871	700.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"
N M1	354,292	7,029,274	700.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"
O L2	354,342	7,029,081	700.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"
P B	345,687	7,032,761	392.3	10.0	10.0	1.5	0.0	0.0	"Green house mode"
Q A1	345,500	7,033,187	480.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"
R N2	355,388	7,031,478	700.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"
S A2	345,602	7,033,165	470.3	10.0	10.0	1.5	0.0	0.0	"Green house mode"
T F	350,456	7,030,769	587.6	10.0	10.0	1.5	0.0	0.0	"Green house mode"
U J4	354,143	7,028,611	711.4	10.0	10.0	1.5	0.0	0.0	"Green house mode"
V K1	354,226	7,028,880	700.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"
W N3	355,501	7,031,436	700.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"
X Grp 1	348,016	7,032,005	518.3	10.0	10.0	1.5	0.0	0.0	"Green house mode"
Y E	348,963	7,036,233	626.3	10.0	10.0	1.5	0.0	0.0	"Green house mode"
Z Grp 4	351,099	7,029,768	500.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"
AA N1	355,334	7,031,458	700.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"
AB N4	355,573	7,031,472	700.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"
AC H	353,898	7,028,679	689.4	10.0	10.0	1.5	0.0	0.0	"Green house mode"

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02.10.2013 11:44/2.9.250

SHADOW - Main Result**Calculation:** 201310 Real Case (statistical based)**Calculation Results**

Shadow receptor

No.	Name	Shadow, worst case		Max shadow hours per day [h/day]	Shadow, expected values
		Shadow hours per year [h/year]	Shadow days per year [days/year]		Shadow hours per year [h/year]
A	Grp 2	0:00	0	0:00	0:00
B	K4	26:03	67	0:34	6:08
C	M2	53:37	113	0:37	11:43
D	D	6:56	28	0:18	0:48
E	Grp 3	0:00	0	0:00	0:00
F	J1	4:20	27	0:14	0:54
G	J2	11:15	40	0:25	2:21
H	C	7:53	30	0:20	1:08
I	L3	20:51	61	0:34	5:06
J	J3	17:40	49	0:32	3:43
K	K2	32:59	76	0:37	7:47
L	L1	24:28	58	0:36	5:59
M	K3	30:21	83	0:34	6:56
N	M1	41:40	93	0:39	9:09
O	L2	24:07	69	0:35	5:48
P	B	0:00	0	0:00	0:00
Q	A1	15:50	60	0:18	2:41
R	N2	46:42	151	0:33	8:14
S	A2	9:41	40	0:18	1:35
T	F	11:34	41	0:22	2:15
U	J4	3:40	29	0:11	0:46
V	K1	41:45	87	0:36	9:19
W	N3	25:41	84	0:29	4:07
X	Grp 1	0:00	0	0:00	0:00
Y	E	19:58	74	0:22	1:44
Z	Grp 4	0:00	0	0:00	0:00
AA	N1	47:57	147	0:35	8:18
AB	N4	18:09	58	0:27	3:02
AC	H	0:00	0	0:00	0:00

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

No.	Name	Worst case [h/year]	Expected [h/year]
1	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (51)	0:00	0:00
2	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (52)	0:00	0:00
3	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (53)	0:00	0:00
4	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (54)	0:00	0:00
5	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (55)	17:01	2:24
6	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (56)	0:00	0:00
7	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (57)	0:00	0:00
8	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (58)	11:07	1:19
9	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (59)	21:00	4:35
10	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (60)	0:00	0:00
11	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (61)	0:00	0:00
12	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (62)	0:00	0:00
13	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (63)	0:00	0:00
14	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (64)	0:00	0:00
15	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (65)	0:00	0:00
16	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (66)	29:27	5:16
17	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (67)	0:00	0:00
18	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (68)	0:00	0:00
19	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (69)	0:00	0:00
20	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (70)	0:00	0:00
21	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (71)	0:00	0:00
22	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (72)	5:14	0:47
23	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (73)	0:00	0:00
24	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (74)	0:00	0:00

To be continued on next page...

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SHADOW - Main Result**Calculation:** 201310 Real Case (statistical based)

...continued from previous page

No.	Name	Worst case [h/year]	Expected [h/year]
25	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (75)	0:00	0:00
26	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (76)	0:00	0:00
27	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (77)	51:12	11:05
28	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (78)	0:00	0:00
29	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (79)	0:00	0:00
30	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (80)	0:00	0:00
31	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (81)	0:00	0:00
32	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (82)	0:00	0:00
33	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (83)	0:00	0:00
34	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (84)	0:00	0:00
35	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (85)	143:52	32:55
36	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (86)	0:00	0:00
37	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (87)	20:27	3:26
38	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (88)	0:00	0:00
39	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (89)	0:00	0:00
40	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (90)	11:34	2:15
41	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (91)	0:00	0:00
42	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (92)	0:00	0:00
43	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (93)	0:00	0:00
44	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (94)	14:49	1:56
45	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (95)	0:00	0:00
46	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (96)	0:00	0:00
47	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (97)	0:00	0:00
48	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (98)	0:00	0:00
49	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (99)	0:00	0:00
50	VESTAS V112 3000 112.0 !O! hub: 94.0 m (TOT: 150.0 m) (100)	14:44	1:00

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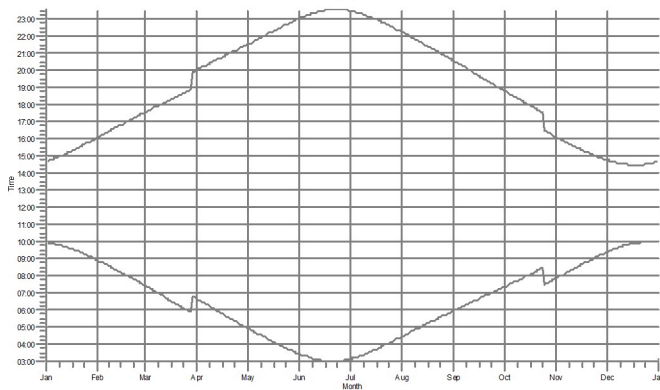
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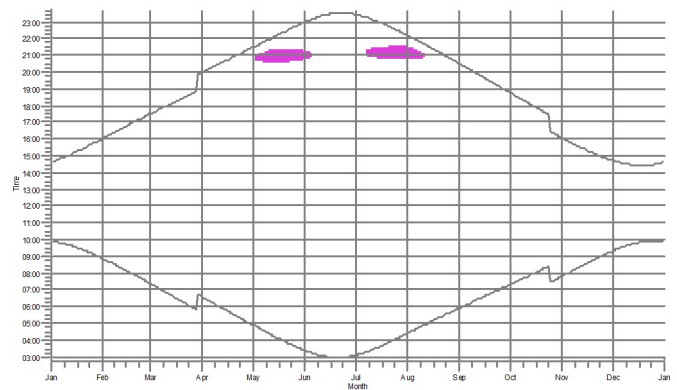
SHADOW - Calendar, graphical

Calculation: 201310 Real Case (statistical based)

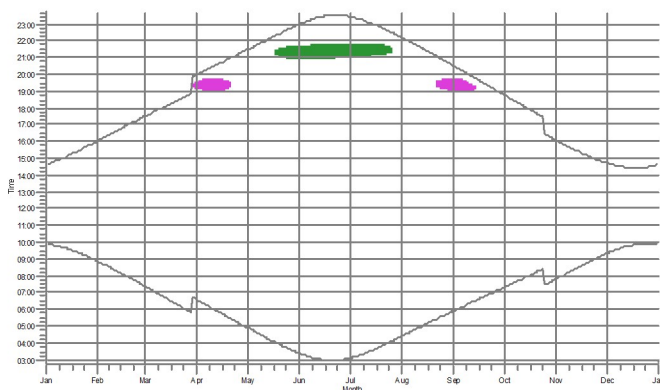
A: Grp 2



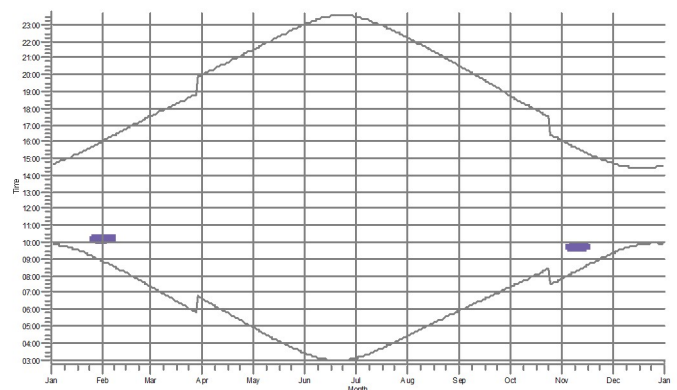
B: K4



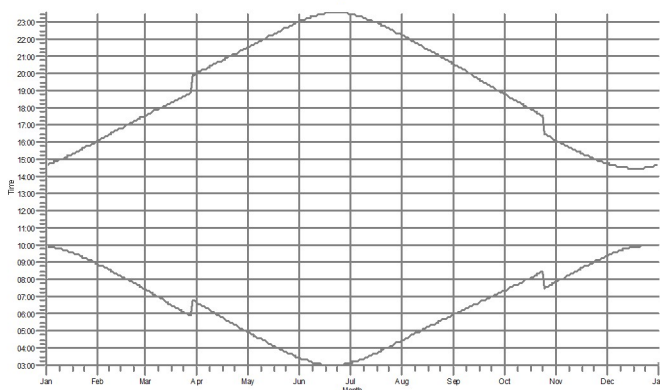
C: M2



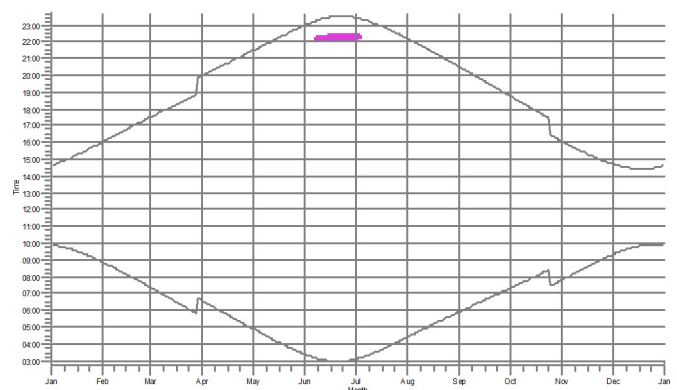
D: D



E: Grp 3



F: J1



WTGs

27: VESTAS V112 3000 112.0 'IOI' hub: 94.0 m (TOT: 150.0 m) (77)

35: VESTAS V112 3000 112.0 'IOI' hub: 94.0 m (TOT: 150.0 m) (85)

44: VESTAS V112 3000 112.0 'IOI' hub: 94.0 m (TOT: 150.0 m) (94)

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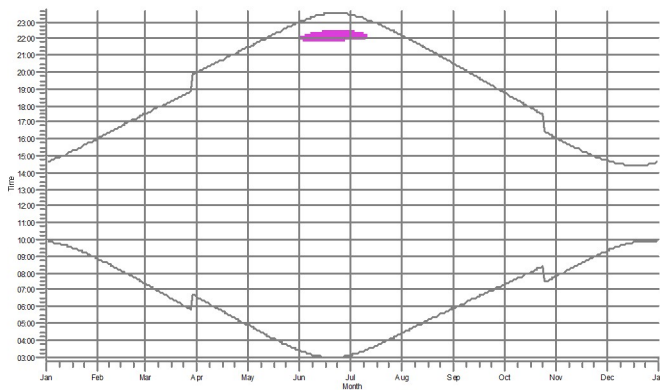
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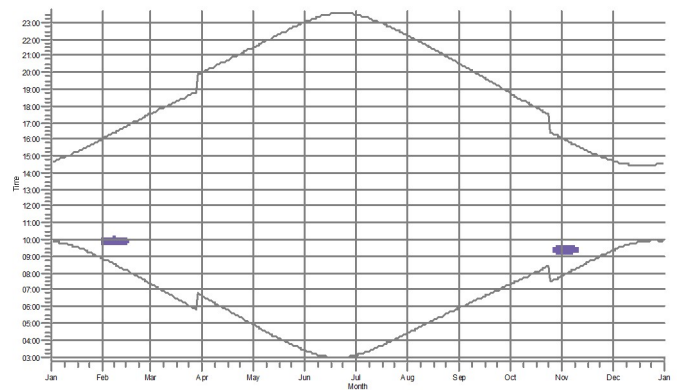
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SHADOW - Calendar, graphical**Calculation: 201310 Real Case (statistical based)**

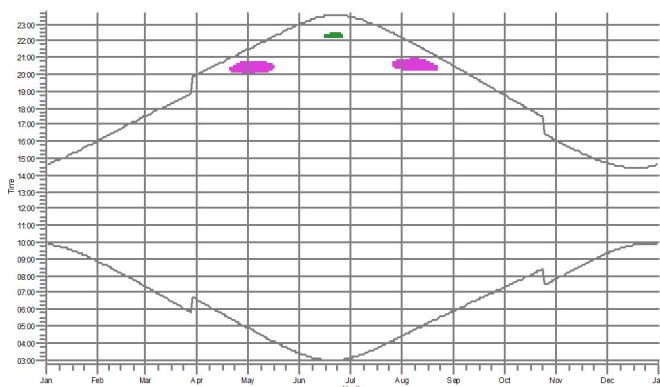
G: J2



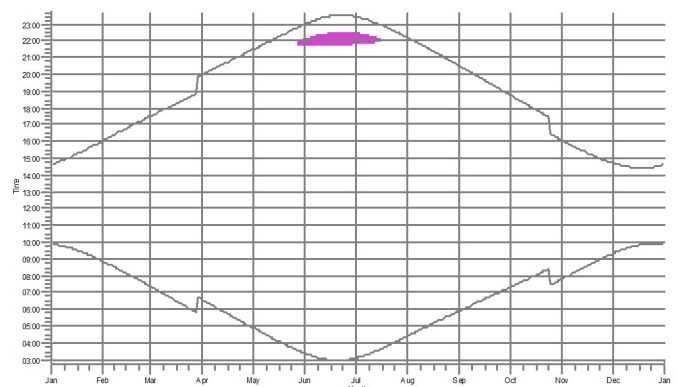
H: C



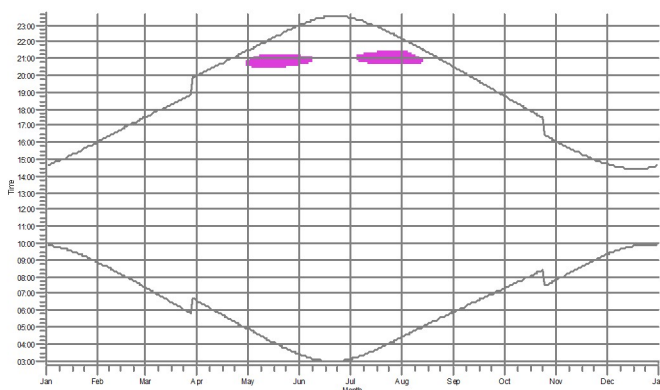
I: L3



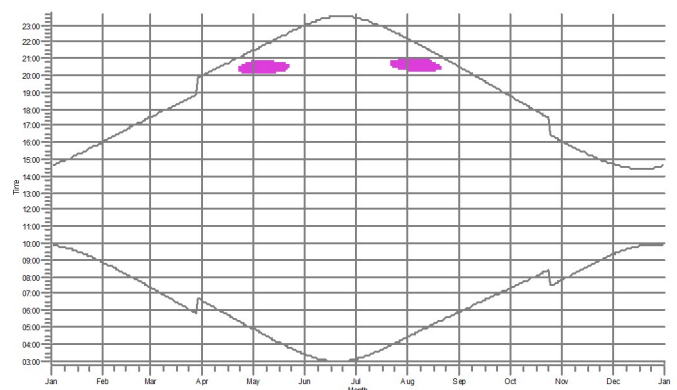
J: J3



K: K2



L: L1



WTGs

27: VESTAS V112 3000 112.0 'IO' hub: 94.0 m (TOT: 150.0 m) (77)

35: VESTAS V112 3000 112.0 'IO' hub: 94.0 m (TOT: 150.0 m) (85)

44: VESTAS V112 3000 112.0 'IO' hub: 94.0 m (TOT: 150.0 m) (94)

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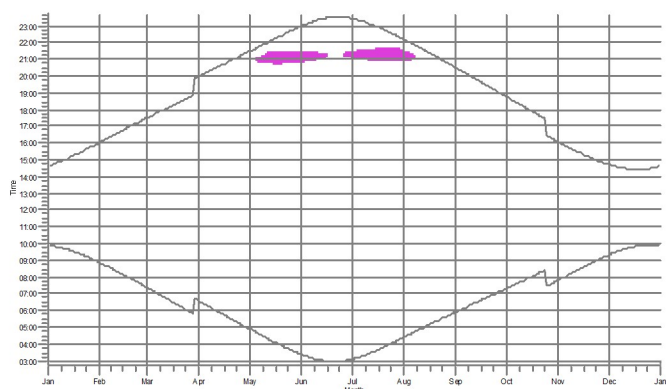
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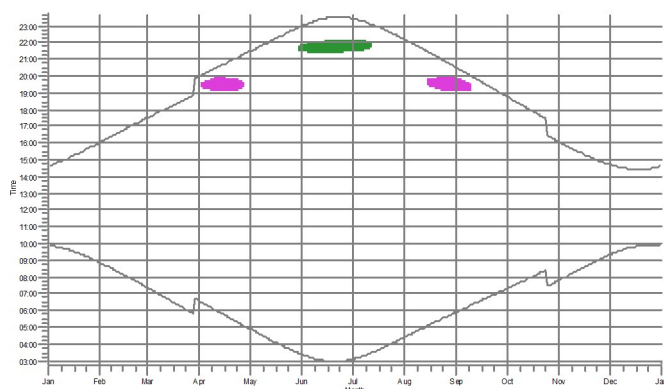
SHADOW - Calendar, graphical

Calculation: 201310 Real Case (statistical based)

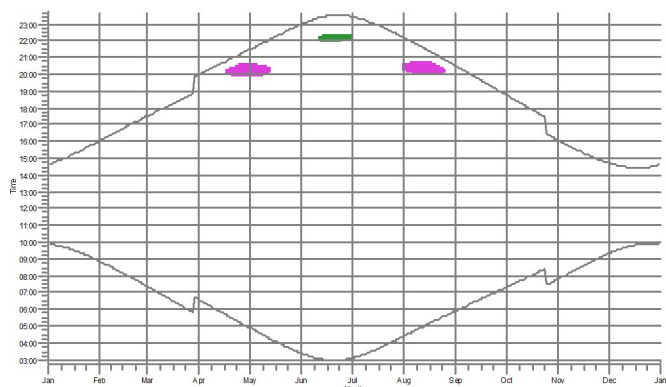
M: K3



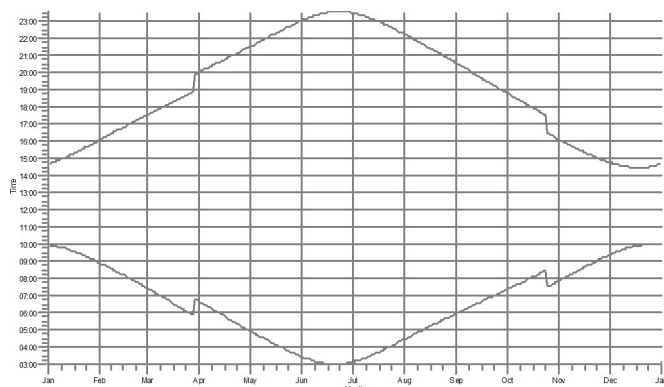
N: M1



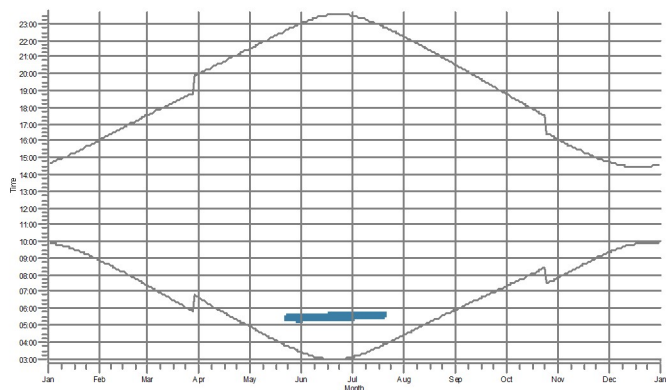
O: L2



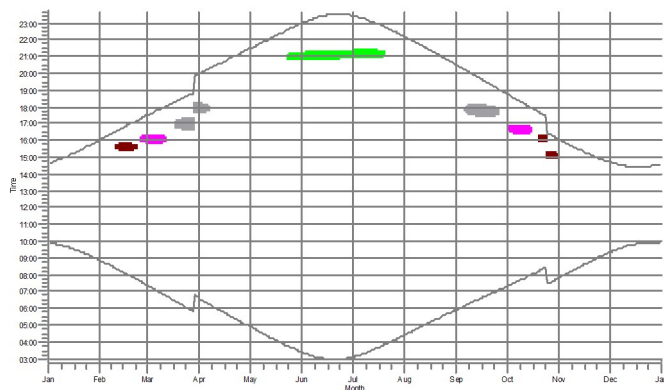
P: B



Q: A1



R: N2



WTGs

5: VESTAS V112 3000 112.0 IOI hub: 94.0 m (TOT: 150.0 m) (55)
 8: VESTAS V112 3000 112.0 IOI hub: 94.0 m (TOT: 150.0 m) (58)

9: VESTAS V112 3000 112.0 IOI hub: 94.0 m (TOT: 150.0 m) (59)
 16: VESTAS V112 3000 112.0 IOI hub: 94.0 m (TOT: 150.0 m) (66)

27: VESTAS V112 3000 112.0 IOI hub: 94.0 m (TOT: 150.0 m) (77)
 35: VESTAS V112 3000 112.0 IOI hub: 94.0 m (TOT: 150.0 m) (85)

37: VESTAS V112 3000 112.0 IOI hub: 94.0 m (TOT: 150.0 m) (87)

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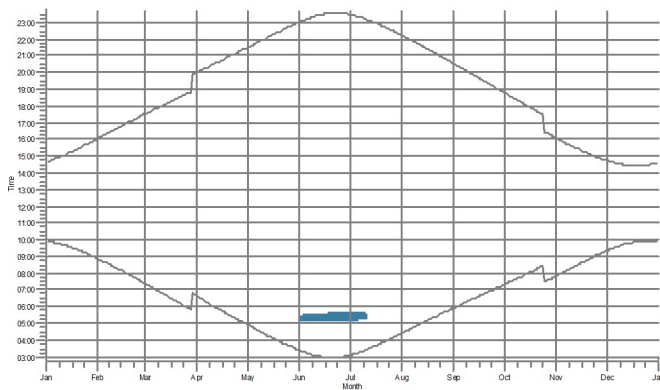
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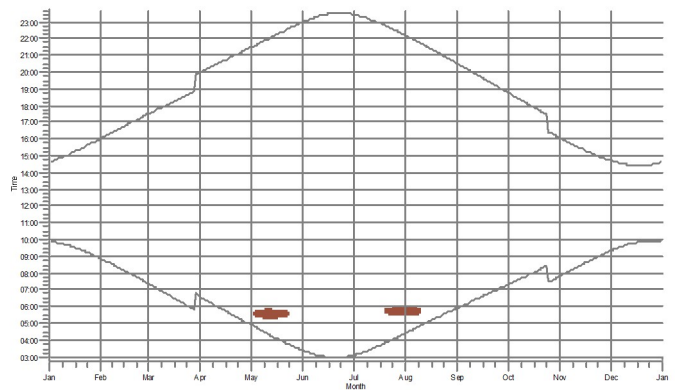
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SHADOW - Calendar, graphical**Calculation: 201310 Real Case (statistical based)**

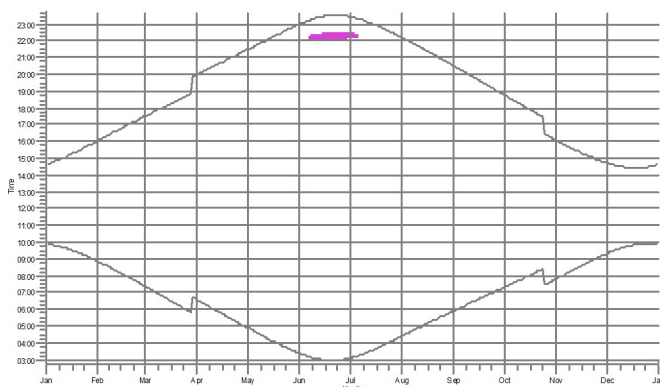
S: A2



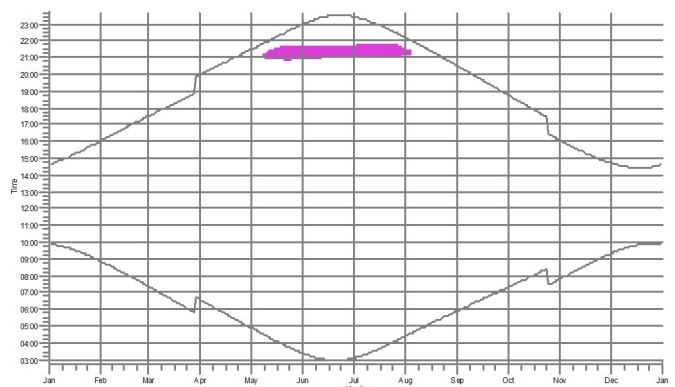
T: F



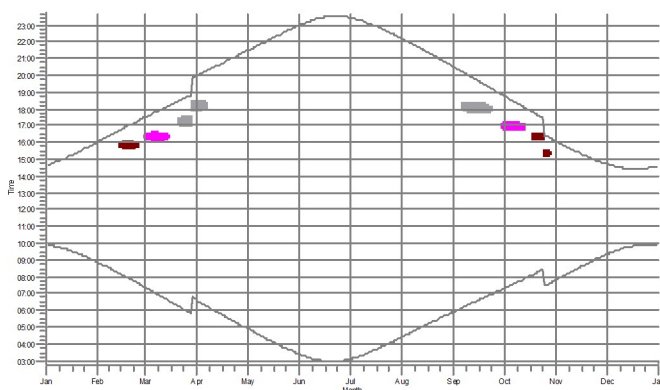
U: J4



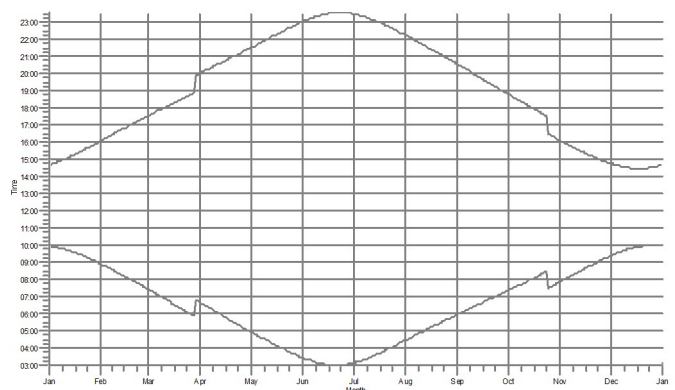
V: K1



W: N3



X: Grp 1



WTGs

5: VESTAS V112 3000 112.0 IOI hub: 94.0 m (TOT: 150.0 m) (55)
 8: VESTAS V112 3000 112.0 IOI hub: 94.0 m (TOT: 150.0 m) (58)

16: VESTAS V112 3000 112.0 IOI hub: 94.0 m (TOT: 150.0 m) (56)
 35: VESTAS V112 3000 112.0 IOI hub: 94.0 m (TOT: 150.0 m) (85)

37: VESTAS V112 3000 112.0 IOI hub: 94.0 m (TOT: 150.0 m) (87)
 40: VESTAS V112 3000 112.0 IOI hub: 94.0 m (TOT: 150.0 m) (90)

Project:

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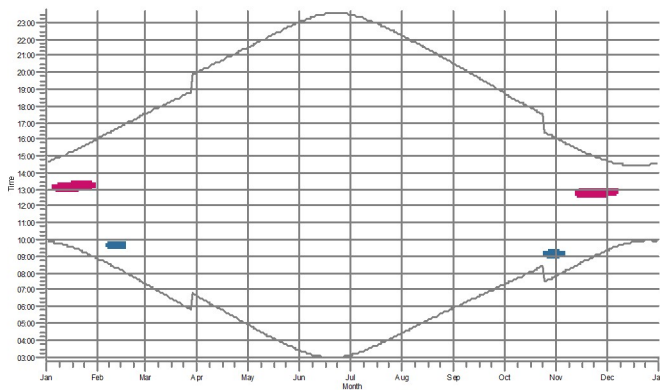
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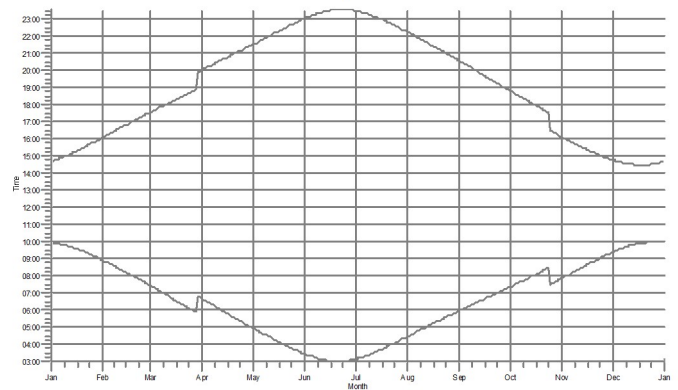
SHADOW - Calendar, graphical

Calculation: 201310 Real Case (statistical based)

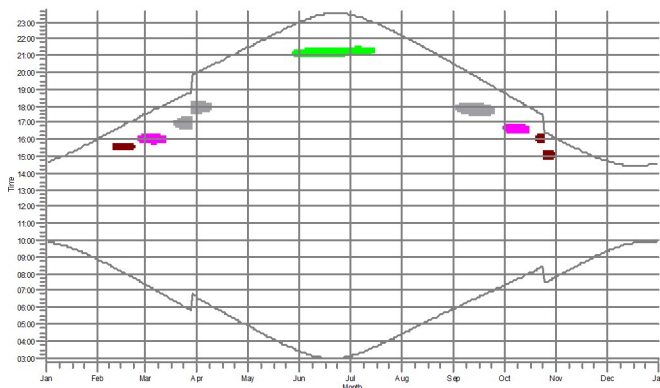
Y: E



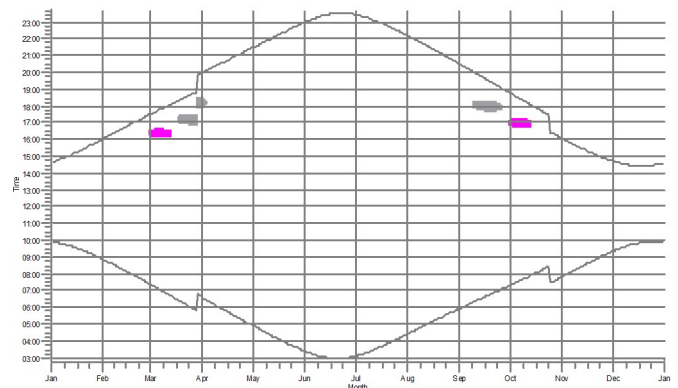
Z: Grp 4



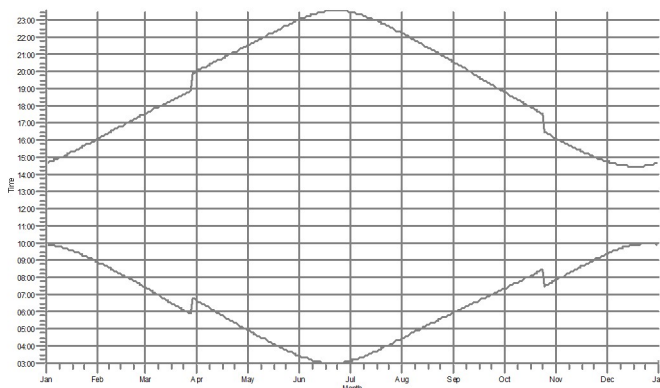
AA: N1



AB: N4



AC: H



WTGs

5: VESTAS V112 3000 112.0 IOI hub: 94.0 m (TOT: 150.0 m) (55)
 8: VESTAS V112 3000 112.0 IOI hub: 94.0 m (TOT: 150.0 m) (58)

9: VESTAS V112 3000 112.0 IOI hub: 94.0 m (TOT: 150.0 m) (59)
 16: VESTAS V112 3000 112.0 IOI hub: 94.0 m (TOT: 150.0 m) (66)

22: VESTAS V112 3000 112.0 IOI hub: 94.0 m (TOT: 150.0 m) (72)
 50: VESTAS V112 3000 112.0 IOI hub: 94.0 m (TOT: 150.0 m) (100)