



Brungfjellet

Shadow Flicker Assessment



To	Linn-Mari Valaker Høgalmen / Rambøll Energi
From	Meventus AS
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Summary

The shadow flicker of a planned layout consisting of 65 Siemens SWT 93 turbines at the Brungfjellet 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 Brungfjellet is expected to exceed the limits for at least 8 neighbor locations. Two of these neighbors exceed the limits significantly at between 20-53 hours.

It is important to note that a portion of the neighbor areas appear to be forested, which was not accounted for in the calculations. This could significantly reduce estimates. When evaluating the impact, one should consider whether the neighbor location is a primary residence or a seasonal cabin. Turbine curtailment should be considered for those locations are considered problematic.

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1 Introduction and Background

The Brungfjellet wind project is located in Norway's Sør-Trøndelag county, approximately 25 km south of Trondheim. The shadow flicker generated from a layout consisting of 65 Siemens SWT93 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.

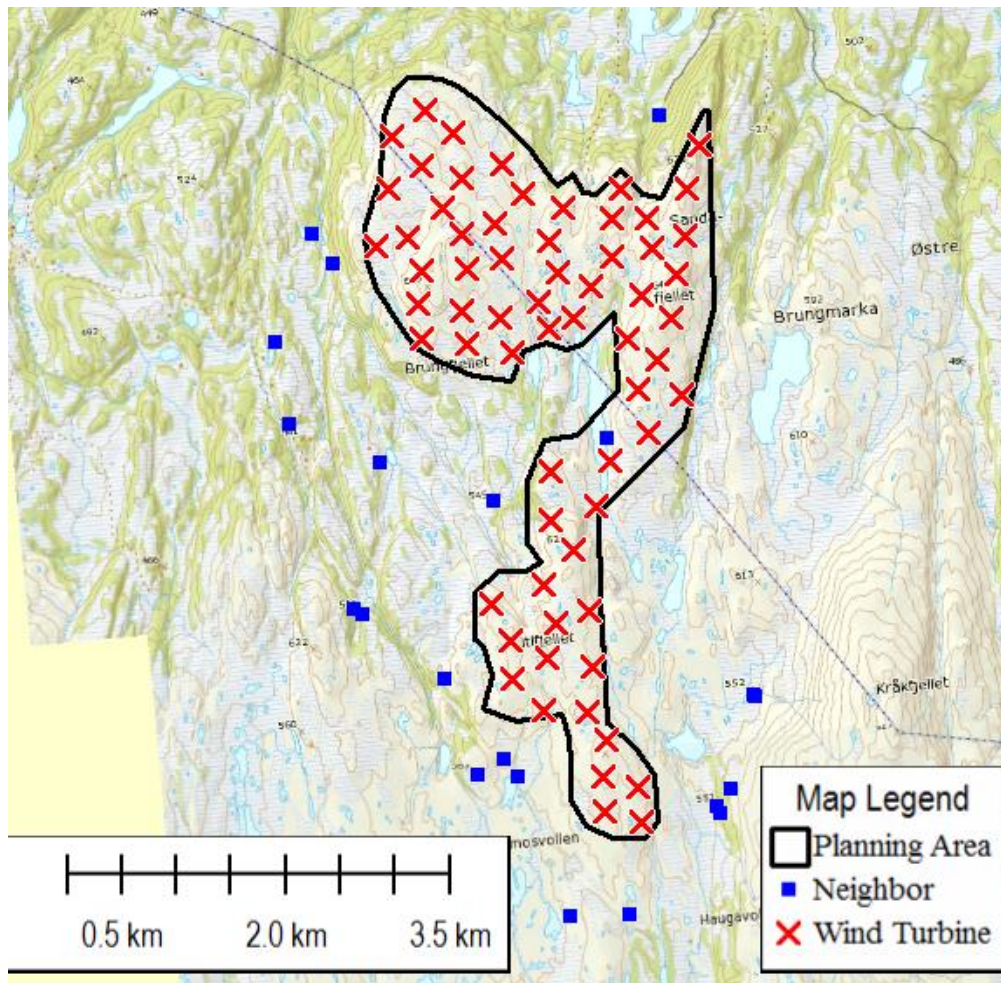


Figure 1 – Brungfjellet planning area, turbine positions and neighbors

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.

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

- Height and width of 10m
- Bottom of window is 1.5m above the ground
- 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 25 km) was used for the Brungfjellet 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, Siemens SWT 93

Turbine Manufacturer & Model	Rotor Diameter (m)	Hub height (m)	Rated power (MW)	Cut-in wind speed (m/s)
Siemens SWT 93	92.6	90	2.3	4.0

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	249	151	126	156	382	1,112	1,140	574	701	1,042	962	576	7,173

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).

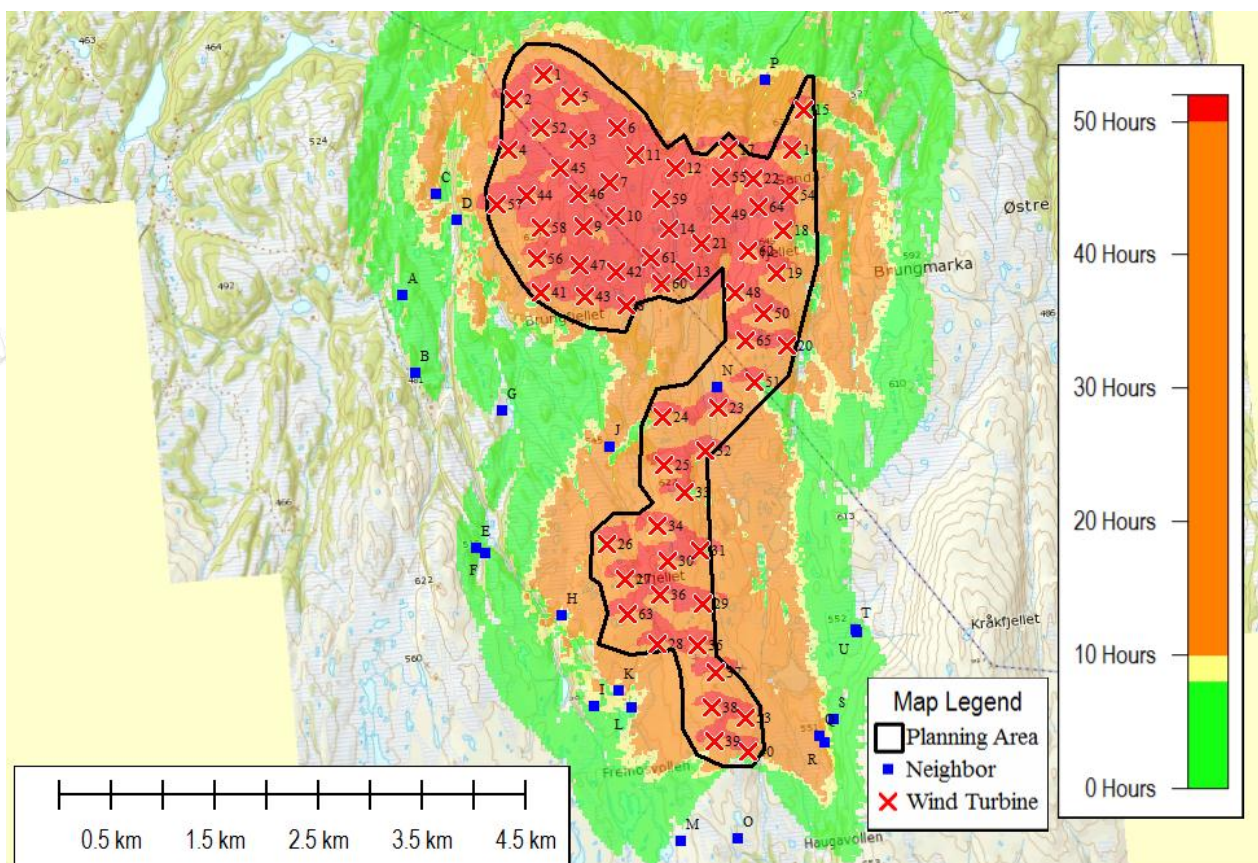


Figure 2 – Brungfjellet expected shadow flicker map (real-case) with turbines and neighbors

As seen above, the shadow flicker levels at 8 neighbors exceed the 10 hours/year limit, some of them significantly, while 1 additional neighbor is just below the limits. 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

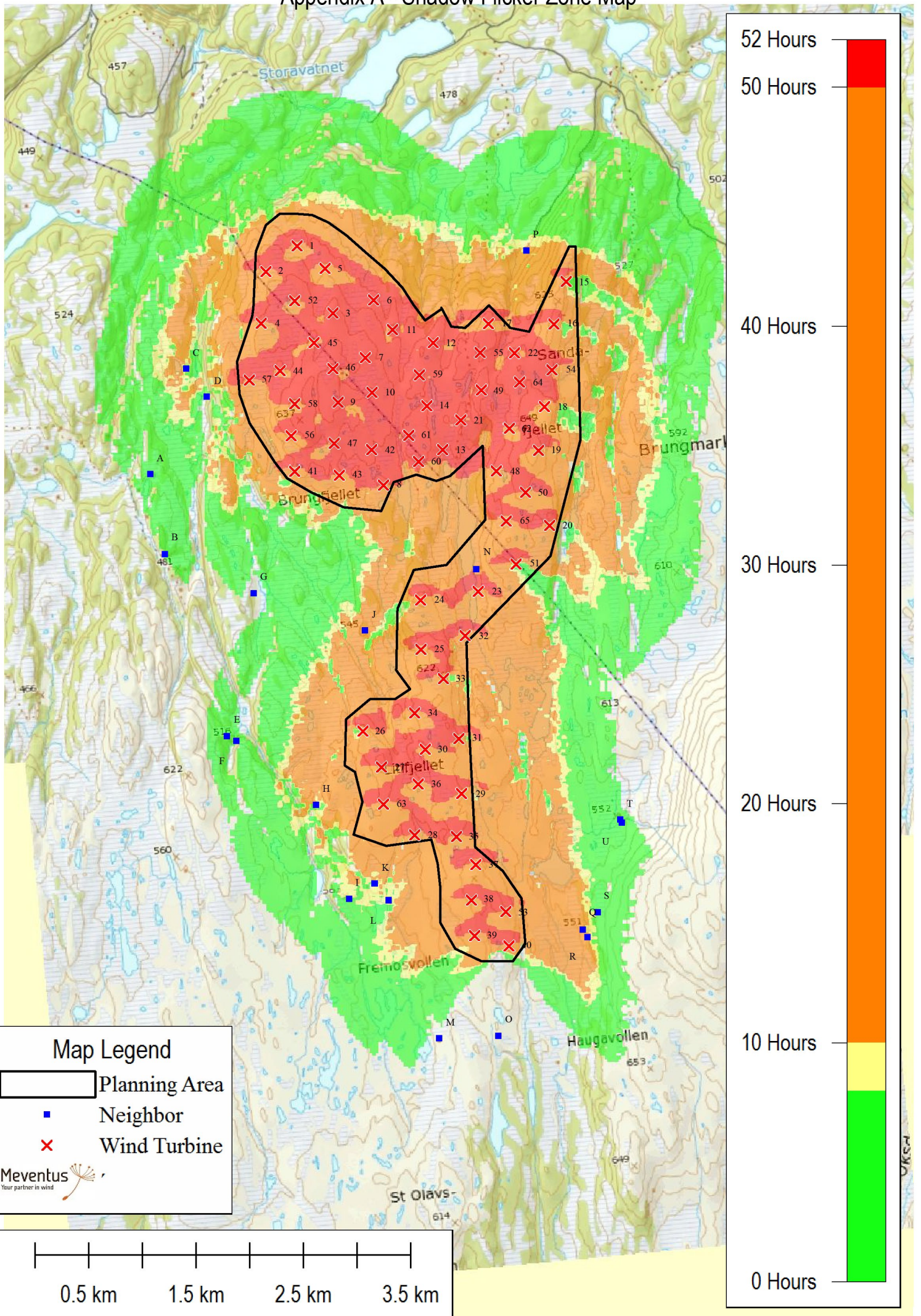
Neighbor	Worst-Case flicker (hours/year)	Real-Case flicker (hours/year)	Primary Turbine(s) causing flicker	Primary Season flicker occurs
N	368.4	53.03	51/8 23	Summer Spring/Fall
J	143.47	20.42	At least 7 turbines	All year
P	103.36	14.33	At least 7 turbines	Spring/Fall
Q	70.2	13.01	37 53	Spring through Fall Spring/Fall
K	72.54	11.55	28	Summer
R	61.3	11.39	37 53	Spring through Fall Spring/Fall
H	66.01	11.18	27	Summer
C	63.48	10.5	4/52	Summer
L	56.43	9.57	37	Spring/Fall

There are a large number of neighbors located inside the planning area or surrounded by turbines, making them suspect able to shadow flicker from multiple directions. Two neighbors (N and J) experience the most flicker, with each experiencing approximately 20 or more hours. Shadow flicker occurs at these neighbors throughout the year, but is minimal during winter months. The most problematic locations experience flicker in the spring and fall months, some of them include summer months as well.

It is important to note that portions of the areas where neighbors are located appear to be forested. This was not accounted for in the calculations, and could reduce the amounts significantly depending on the forest heights and proximity to neighbors. Whether all neighbor buildings are primary residences or seasonal cabins should also be considered when evaluating the respective impact. Taking into account the actual location, orientation and size of the windows on each of the structures will also most likely reduce the estimates. 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



SHADOW - Main Result

Calculation: Brungfjellet Real Case

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
249	151	126	156	382	1,112	1,140	574	701	1,042	962	576	7,173

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: Brungfjellet.wpo (1)

Obstacles used in calculation

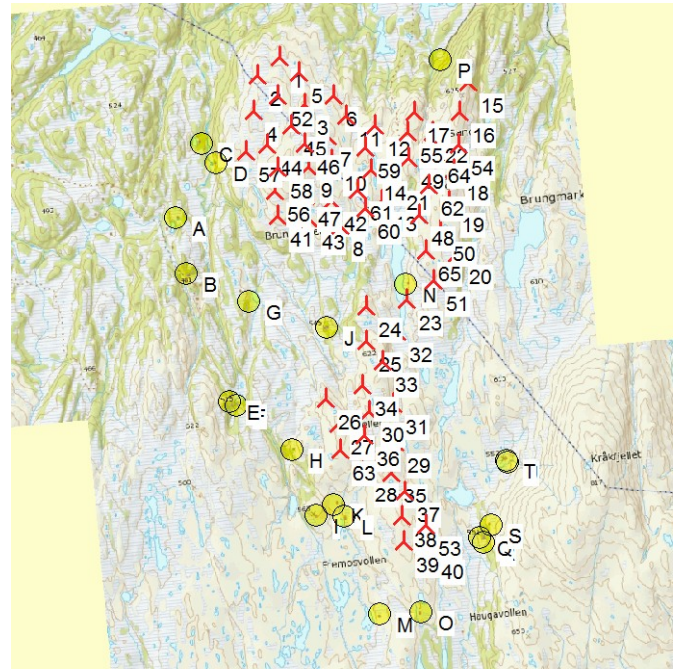
Eye height: 1.5 m

Grid resolution: 10.0 m

WTGs

	UTM (north)-WGS84 Zone: 32				WTG type				Shadow data				
	East	North	Z	Row data/Description	Valid	Manufact.	Type-generator	Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Calculation distance [m]	RPM	
			[m]									[RPM]	
1	577,875	7,010,526	545.0	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
2	577,585	7,010,287	570.0	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
3	578,209	7,009,899	595.0	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
4	577,543	7,009,805	582.7	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
5	578,136	7,010,315	558.4	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
6	578,587	7,010,020	543.9	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
7	578,512	7,009,486	600.0	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
8	578,680	7,008,299	575.0	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
9	578,257	7,009,069	620.3	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
10	578,574	7,009,161	600.0	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
11	578,765	7,009,748	555.0	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
12	579,142	7,009,626	580.0	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
13	579,232	7,008,631	560.0	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
14	579,084	7,009,036	578.1	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
15	580,381	7,010,193	617.7	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
16	580,265	7,009,796	620.0	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
17	579,657	7,009,800	612.5	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
18	580,179	7,009,030	638.4	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
19	580,122	7,008,621	635.0	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
20	580,225	7,007,924	600.0	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
21	579,400	7,008,905	585.0	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
22	579,899	7,009,528	606.0	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
23	579,561	7,007,313	548.2	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
24	579,026	7,007,230	604.3	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
25	579,030	7,006,774	611.7	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
26	578,488	7,006,011	600.0	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
27	578,661	7,005,677	620.0	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
28	578,971	7,005,045	582.3	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
29	579,408	7,005,432	607.5	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	
30	579,067	7,005,842	618.5	Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0	

To be continued on next page...



 New WTG

Scale 1:100,000

Shadow receptor

Project:

Brungfjellet

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Calculated:

20.12.2012 19:57/2.8.563

SHADOW - Main Result**Calculation:** Brungfjellet Real Case

...continued from previous page

UTM (north)-WGS84 Zone: 32				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	579,380	7,005,942	604.7 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
32	579,438	7,006,901	558.0 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
33	579,236	7,006,502	620.0 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
34	578,971	7,006,180	600.0 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
35	579,358	7,005,032	604.7 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
36	579,003	7,005,522	603.7 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
37	579,537	7,004,772	602.6 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
38	579,498	7,004,442	600.6 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
39	579,526	7,004,110	590.0 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
40	579,848	7,004,016	584.7 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
41	577,853	7,008,430	580.0 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
42	578,569	7,008,629	586.0 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
43	578,269	7,008,390	578.0 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
44	577,718	7,009,363	580.0 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
45	578,033	7,009,626	602.8 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
46	578,210	7,009,384	621.2 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
47	578,222	7,008,690	603.4 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
48	579,728	7,008,431	608.0 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
49	579,589	7,009,184	604.0 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
50	580,000	7,008,235	622.1 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
51	579,913	7,007,566	601.9 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
52	577,852	7,010,016	583.1 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
53	579,816	7,004,333	600.0 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
54	580,249	7,009,370	598.5 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
55	579,579	7,009,535	600.0 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
56	577,819	7,008,759	607.4 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
57	577,431	7,009,277	570.0 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
58	577,855	7,009,057	622.5 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
59	579,014	7,009,323	580.0 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
60	579,008	7,008,521	585.0 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
61	578,913	7,008,763	581.8 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
62	579,849	7,008,829	604.0 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
63	578,681	7,005,334	600.0 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
64	579,945	7,009,258	614.3 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0
65	579,820	7,007,966	603.1 Siemens SWT-2.3-93 2300 92...	Yes	Siemens	SWT-2.3-93-2,300	2,300	92.6	90.0	1,462	16.0

Shadow receptor-Input

UTM (north)-WGS84 Zone: 32										
No.	Name	East	North	Z	Width	Height	Height a.g.l.	Degrees from south cw	Slope of window	Direction mode
				[m]	[m]	[m]	[m]	[°]	[°]	
A	A	576,510	7,008,403	485.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"
B	B	576,646	7,007,657	510.4	10.0	10.0	1.5	0.0	0.0	"Green house mode"
C	C	576,844	7,009,382	468.9	10.0	10.0	1.5	0.0	0.0	"Green house mode"
D	D	577,036	7,009,122	462.1	10.0	10.0	1.5	0.0	0.0	"Green house mode"
E	E	577,223	7,005,965	530.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"
F	F	577,309	7,005,920	517.6	10.0	10.0	1.5	0.0	0.0	"Green house mode"
G	G	577,473	7,007,295	515.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"
H	H	578,050	7,005,326	545.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"
I	I	578,361	7,004,451	560.2	10.0	10.0	1.5	0.0	0.0	"Green house mode"
J	J	578,506	7,006,949	545.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"
K	K	578,597	7,004,594	550.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"
L	L	578,727	7,004,439	536.8	10.0	10.0	1.5	0.0	0.0	"Green house mode"
M	M	579,199	7,003,154	546.6	10.0	10.0	1.5	0.0	0.0	"Green house mode"
N	N	579,544	7,007,519	545.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"
O	O	579,748	7,003,178	555.7	10.0	10.0	1.5	0.0	0.0	"Green house mode"
P	P	580,009	7,010,479	463.3	10.0	10.0	1.5	0.0	0.0	"Green house mode"
Q	Q	580,532	7,004,167	545.0	10.0	10.0	1.5	0.0	0.0	"Green house mode"

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Kjøita 19

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+47 3860 7115

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Calculated:

20.12.2012 19:57/2.8.563

SHADOW - Main Result**Calculation:** Brungfjellet Real Case

...continued from previous page

UTM (north)-WGS84 Zone: 32

No.	Name	East	North	Z	Width	Height	Height a.g.l.	Degrees from south cw	Slope of window	Direction mode
				[m]	[m]	[m]	[m]	[°]	[°]	
R	R	580,579	7,004,095	553.3	10.0	10.0	1.5	0.0	0.0	"Green house mode"
S	S	580,675	7,004,327	591.9	10.0	10.0	1.5	0.0	0.0	"Green house mode"
T	T	580,881	7,005,190	552.6	10.0	10.0	1.5	0.0	0.0	"Green house mode"
U	U	580,896	7,005,162	551.9	10.0	10.0	1.5	0.0	0.0	"Green house mode"

Calculation Results

Shadow receptor

No.	Name	Shadow, worst case			Shadow, expected values	
		Shadow hours per year	Shadow days per year	Max shadow hours per day	Shadow hours per year	
		[h/year]	[days/year]	[h/day]	[h/year]	
A	A	16:41	77	0:18	2:43	
B	B	7:55	35	0:18	1:17	
C	C	63:48	164	0:38	10:50	
D	D	0:00	0	0:00	0:00	
E	E	5:36	24	0:18	0:58	
F	F	6:34	26	0:19	1:10	
G	G	0:00	0	0:00	0:00	
H	H	66:01	141	0:37	11:18	
I	I	50:41	170	0:27	8:05	
J	J	143:47	251	1:05	20:42	
K	K	72:54	189	0:33	11:55	
L	L	56:43	155	0:33	9:57	
M	M	0:00	0	0:00	0:00	
N	N	368:40	279	2:23	53:03	
O	O	0:00	0	0:00	0:00	
P	P	103:36	141	1:26	14:33	
Q	Q	70:20	146	0:55	13:01	
R	R	61:30	134	0:54	11:39	
S	S	40:09	110	0:45	6:47	
T	T	9:33	43	0:18	1:11	
U	U	9:25	43	0:18	1:11	

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

No.	Name	Worst case [h/year]	Expected [h/year]
1	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (1)	0:00	0:00
2	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (2)	0:00	0:00
3	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (3)	0:00	0:00
4	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (4)	11:02	1:41
5	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (5)	0:00	0:00
6	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (6)	0:00	0:00
7	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (7)	0:00	0:00
8	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (8)	16:19	2:48
9	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (9)	0:00	0:00
10	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (10)	0:00	0:00
11	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (11)	4:13	0:33
12	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (12)	6:07	0:42
13	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (13)	0:00	0:00
14	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (14)	0:00	0:00
15	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (15)	32:31	6:26
16	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (16)	14:57	1:52
17	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (17)	13:42	1:44
18	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (18)	0:00	0:00
19	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (19)	0:00	0:00
20	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (20)	0:00	0:00
21	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (21)	0:00	0:00

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Project:

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Calculated:

20.12.2012 19:57/2.8.563

SHADOW - Main Result**Calculation:** Brungfjellet Real Case

...continued from previous page

No.	Name	Worst case [h/year]	Expected [h/year]
22	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (22)	10:36	1:10
23	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (23)	177:41	25:24
24	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (24)	59:43	9:19
25	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (25)	39:01	6:17
26	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (26)	25:21	3:04
27	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (27)	38:04	5:09
28	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (28)	26:28	4:01
29	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (29)	17:38	2:34
30	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (30)	7:54	0:47
31	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (31)	6:06	0:45
32	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (32)	42:32	4:29
33	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (33)	22:13	2:47
34	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (34)	19:55	2:06
35	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (35)	40:49	6:36
36	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (36)	0:00	0:00
37	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (37)	71:02	12:54
38	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (38)	53:09	9:54
39	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (39)	45:13	7:24
40	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (40)	52:26	8:15
41	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (41)	17:49	2:49
42	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (42)	0:00	0:00
43	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (43)	0:00	0:00
44	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (44)	0:00	0:00
45	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (45)	0:00	0:00
46	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (46)	0:00	0:00
47	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (47)	0:00	0:00
48	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (48)	0:00	0:00
49	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (49)	6:03	0:36
50	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (50)	0:00	0:00
51	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (51)	97:29	17:19
52	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (52)	19:55	3:06
53	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (53)	68:44	12:36
54	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (54)	0:00	0:00
55	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (55)	8:54	1:00
56	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (56)	12:13	2:01
57	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (57)	30:57	5:43
58	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (58)	0:00	0:00
59	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (59)	0:00	0:00
60	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (60)	0:00	0:00
61	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (61)	0:00	0:00
62	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (62)	0:00	0:00
63	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (63)	24:03	4:33
64	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (64)	7:28	0:45
65	Siemens SWT-2.3-93 2300 92.6 !O! hub: 90.0 m (TOT: 136.3 m) (65)	0:00	0:00

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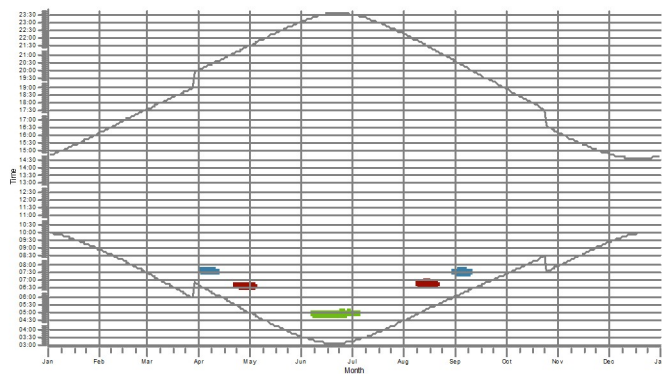
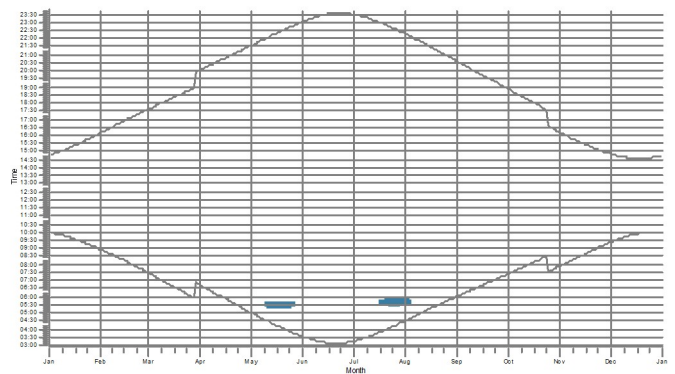
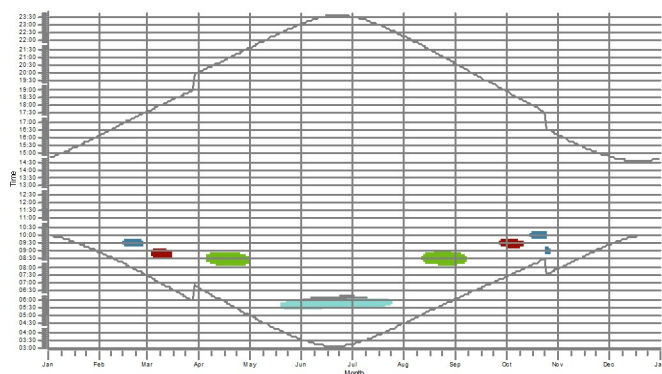
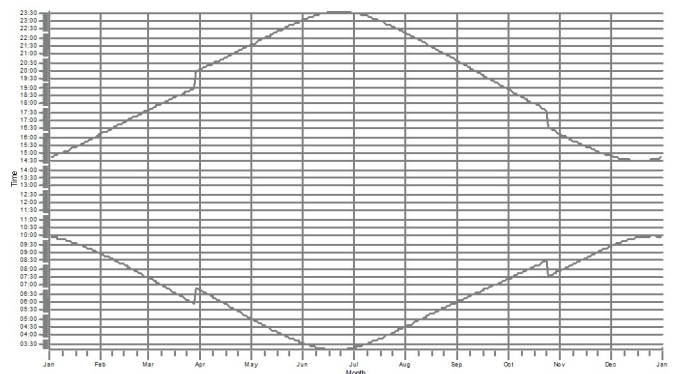
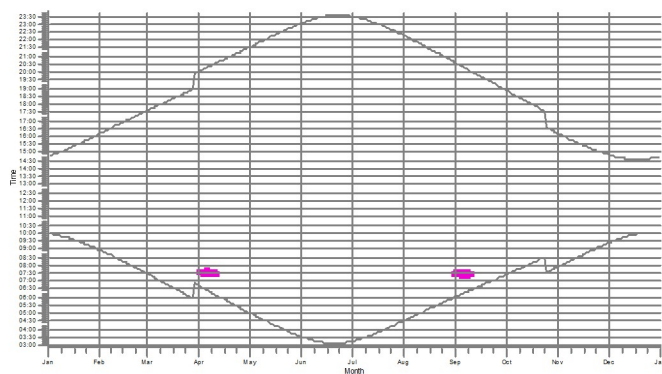
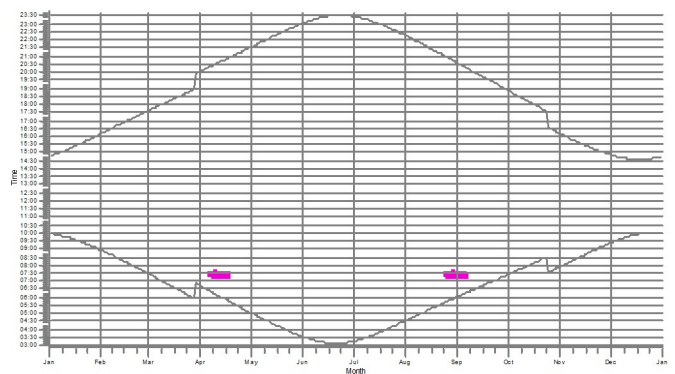
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SHADOW - Calendar, graphical**Calculation: Brungfjellet Real Case****A: A****B: B****C: C****D: D****E: E****F: F**

WTGs

4: Siemens SWT-2.3-93 2300 92.6 IOI hub: 90.0 m (TOT: 136.3 m) (4)

41: Siemens SWT-2.3-93 2300 92.6 IOI hub: 90.0 m (TOT: 136.3 m) (41)

56: Siemens SWT-2.3-93 2300 92.6 IOI hub: 90.0 m (TOT: 136.3 m) (56)

26: Siemens SWT-2.3-93 2300 92.6 IOI hub: 90.0 m (TOT: 136.3 m) (26)

52: Siemens SWT-2.3-93 2300 92.6 IOI hub: 90.0 m (TOT: 136.3 m) (52)

57: Siemens SWT-2.3-93 2300 92.6 IOI hub: 90.0 m (TOT: 136.3 m) (57)

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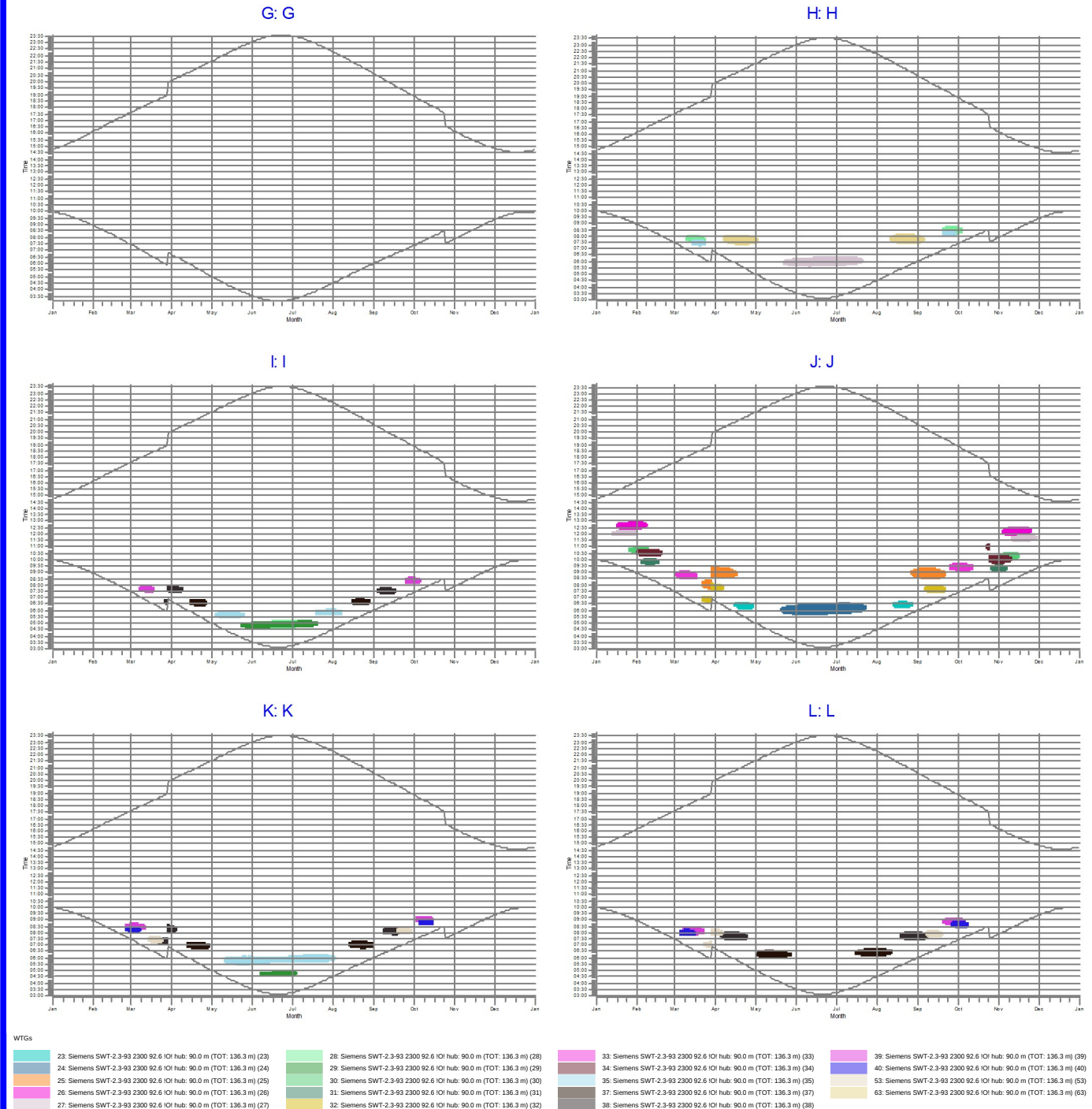
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SHADOW - Calendar, graphical**Calculation: Brungfjellet Real Case**

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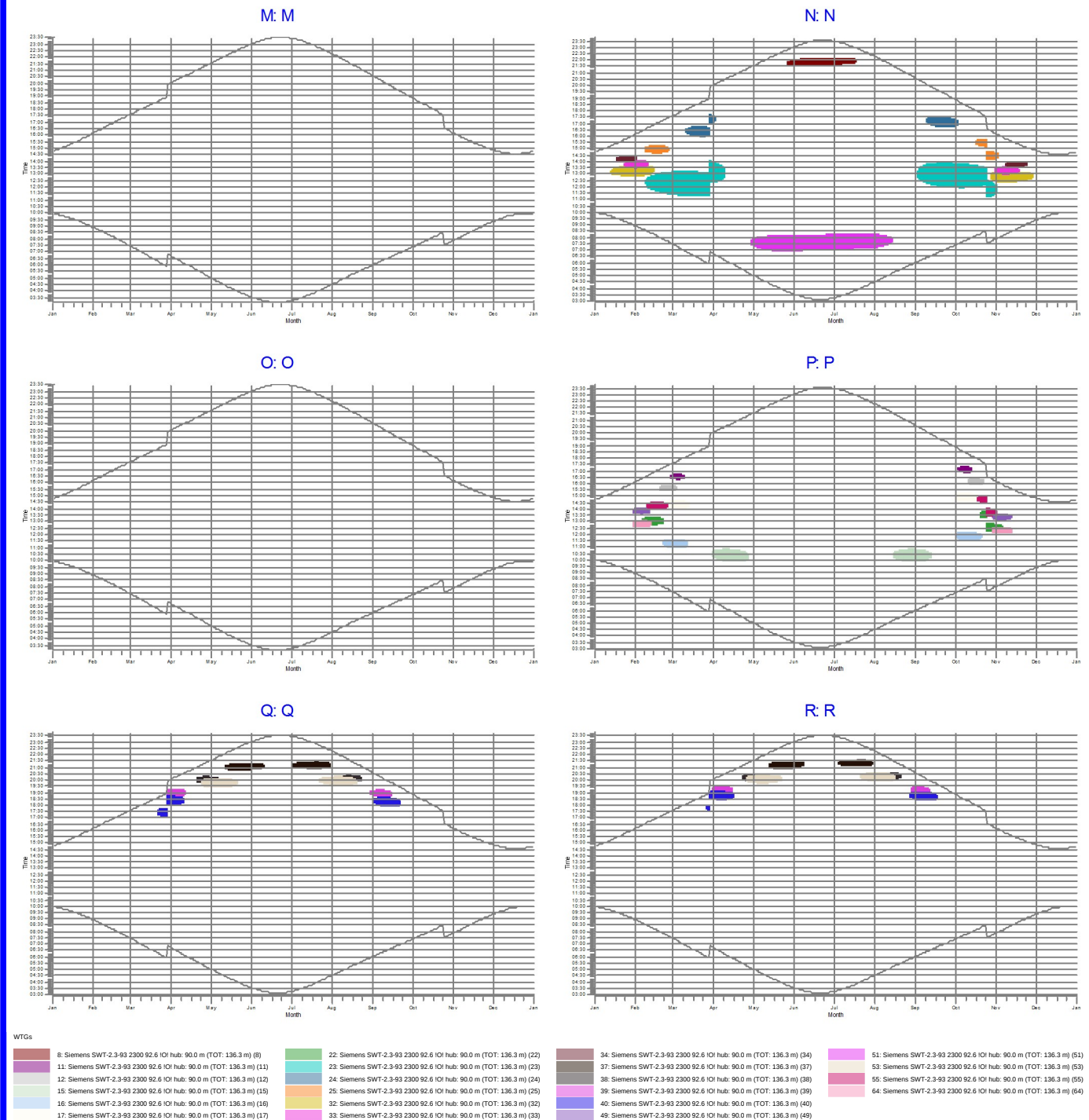
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SHADOW - Calendar, graphical

Calculation: Brungfjellet Real Case



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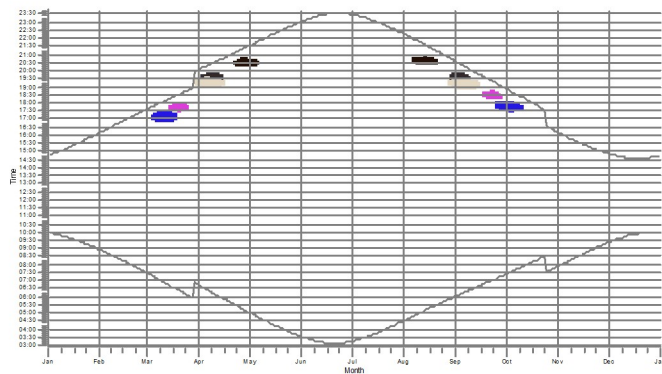
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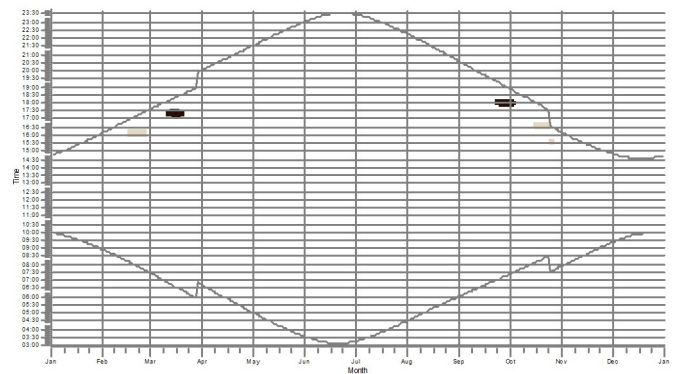
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SHADOW - Calendar, graphical**Calculation: Brungfjellet Real Case**

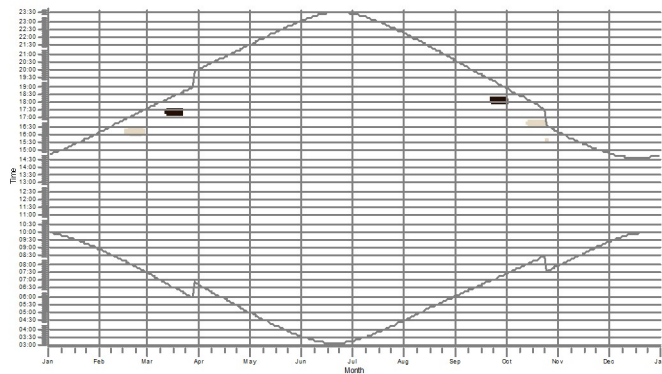
S: S



T: T



U: U



WTGs

37: Siemens SWT-2.3-93 2300 92.6 lOI hub: 90.0 m (TOT: 136.3 m) (37)

38: Siemens SWT-2.3-93 2300 92.6 lOI hub: 90.0 m (TOT: 136.3 m) (38)

39: Siemens SWT-2.3-93 2300 92.6 lOI hub: 90.0 m (TOT: 136.3 m) (39)

40: Siemens SWT-2.3-93 2300 92.6 lOI hub: 90.0 m (TOT: 136.3 m) (40)

53: Siemens SWT-2.3-93 2300 92.6 lOI hub: 90.0 m (TOT: 136.3 m) (53)