

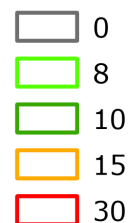
**RAMBOLL**

Suur-Savon Sähkö Oy  
Luhangan tuulivoimapaisto

Välkemallinnus  
(WindPro 3.5)

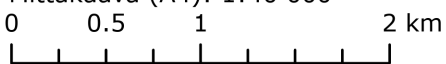
Layout 7WTG  
VESTAS V172-7.2  
Napakorkeus (HH) 200 m  
Roottorin halkaisija (RD) 200 m

Välketuntia vuodessa  
Real Case -mallinnus



- Tuulivoimala
- Asuinrakennus
- Lomarakennus
- Reseptori

Mittakaava (A4): 1:40 000



17.10.2022 MN

## SHADOW - Main Result

Calculation: res\_Luhanka\_HH200\_RD200\_17102022

### 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

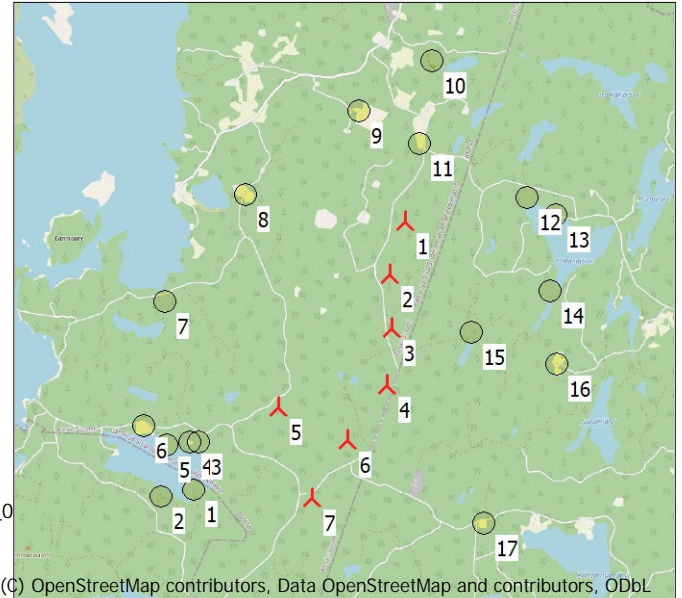
Minimum sun height over horizon for influence 3 °  
Day step for calculation 1 days  
Time step for calculation 1 minutes

Sunshine probability S (Average daily sunshine hours) []  
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec  
0.81 2.25 4.39 5.97 8.13 8.13 8.42 6.71 4.10 1.90 0.67 0.32

Operational time  
N NNE ENE E ESE SSE S SSW WSW W WNW NNW Sum  
605 373 376 455 514 623 765 1 146 1 185 980 719 683 8 424

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: Elevation Grid Data Object: Luhanka\_Valke\_EMDGrid\_0  
Obstacles used in calculation  
Receptor grid resolution: 1.0 m

All coordinates are in  
Finish TM ETRS-TM35FIN-ETRS89



### WTGs

	East	North	Z	Row data/Description	WTG type			Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Shadow data	
					Valid	Manufact.	Type-generator				Calculation distance [m]	RPM [RPM]
1	436 481	6 845 421	179.0	VESTAS V172-7.2 USER 7200 ...	Yes	VESTAS	V172-7.2 USER-7 200	7 200	200.0	200.0	2 274	0.0
2	436 272	6 844 716	196.4	VESTAS V172-7.2 USER 7200 ...	Yes	VESTAS	V172-7.2 USER-7 200	7 200	200.0	200.0	2 274	0.0
3	436 278	6 844 015	203.3	VESTAS V172-7.2 USER 7200 ...	Yes	VESTAS	V172-7.2 USER-7 200	7 200	200.0	200.0	2 274	0.0
4	436 192	6 843 265	159.0	VESTAS V172-7.2 USER 7200 ...	Yes	VESTAS	V172-7.2 USER-7 200	7 200	200.0	200.0	2 274	0.0
5	434 755	6 842 991	171.6	VESTAS V172-7.2 USER 7200 ...	Yes	VESTAS	V172-7.2 USER-7 200	7 200	200.0	200.0	2 274	0.0
6	435 657	6 842 541	164.0	VESTAS V172-7.2 USER 7200 ...	Yes	VESTAS	V172-7.2 USER-7 200	7 200	200.0	200.0	2 274	0.0
7	435 183	6 841 775	153.0	VESTAS V172-7.2 USER 7200 ...	Yes	VESTAS	V172-7.2 USER-7 200	7 200	200.0	200.0	2 274	0.0

### Shadow receptor-Input

No.	East	North	Z	Width	Height	Elevation a.g.l.	Slope of window	Direction mode	Eye height (ZVI) a.g.l.
	[m]	[m]	[m]	[m]	[m]	[m]	[°]		[m]
1	433 611	6 841 910	94.1	1.0	1.0	1.0	90.0	"Green house mode"	2.0
2	433 171	6 841 840	95.7	1.0	1.0	1.0	90.0	"Green house mode"	2.0
3	433 691	6 842 557	94.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
4	433 567	6 842 547	95.9	1.0	1.0	1.0	90.0	"Green house mode"	2.0
5	433 260	6 842 523	95.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
6	432 953	6 842 784	100.9	1.0	1.0	1.0	90.0	"Green house mode"	2.0
7	433 280	6 844 424	96.5	1.0	1.0	1.0	90.0	"Green house mode"	2.0
8	434 376	6 845 815	93.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
9	435 902	6 846 895	117.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
10	436 871	6 847 534	124.9	1.0	1.0	1.0	90.0	"Green house mode"	2.0
11	436 690	6 846 436	156.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
12	438 097	6 845 710	120.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
13	438 485	6 845 467	123.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
14	438 399	6 844 463	125.2	1.0	1.0	1.0	90.0	"Green house mode"	2.0
15	437 335	6 843 940	152.0	1.0	1.0	1.0	90.0	"Green house mode"	2.0
16	438 462	6 843 494	160.2	1.0	1.0	1.0	90.0	"Green house mode"	2.0
17	437 459	6 841 399	123.2	1.0	1.0	1.0	90.0	"Green house mode"	2.0

## SHADOW - Main Result

Calculation: res\_Luhanka\_HH200\_RD200\_17102022

### Calculation Results

Shadow receptor

No.	Shadow, worst case		Shadow, expected values	
	Shadow hours per year [h/year]	Shadow days per year [days/year]	Max shadow hours per day [h/day]	Shadow hours per year [h/year]
1	24:41	73	0:29	5:51
2	28:09	84	0:26	7:11
3	72:35	147	0:43	18:12
4	69:58	155	0:38	17:40
5	30:27	84	0:31	7:32
6	12:09	38	0:26	3:03
7	9:30	32	0:23	1:12
8	15:00	54	0:21	2:46
9	36:23	91	0:41	2:49
10	21:32	72	0:23	1:16
11	56:18	105	0:46	5:11
12	20:59	62	0:28	4:05
13	9:02	30	0:23	1:57
14	15:44	56	0:22	3:31
15	90:31	193	0:44	20:24
16	8:04	29	0:21	1:56
17	16:31	57	0:23	4:28

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

No.	Name	Worst case [h/year]	Expected [h/year]
1	VESTAS V172-7.2 USER 7200 200.0 !O! hub: 200.0 m (TOT: 300.0 m) (7)	108:00	13:12
2	VESTAS V172-7.2 USER 7200 200.0 !O! hub: 200.0 m (TOT: 300.0 m) (1)	88:39	13:34
3	VESTAS V172-7.2 USER 7200 200.0 !O! hub: 200.0 m (TOT: 300.0 m) (2)	52:18	12:53
4	VESTAS V172-7.2 USER 7200 200.0 !O! hub: 200.0 m (TOT: 300.0 m) (3)	20:05	3:22
5	VESTAS V172-7.2 USER 7200 200.0 !O! hub: 200.0 m (TOT: 300.0 m) (6)	108:52	28:05
6	VESTAS V172-7.2 USER 7200 200.0 !O! hub: 200.0 m (TOT: 300.0 m) (4)	45:34	10:35
7	VESTAS V172-7.2 USER 7200 200.0 !O! hub: 200.0 m (TOT: 300.0 m) (5)	42:49	8:32

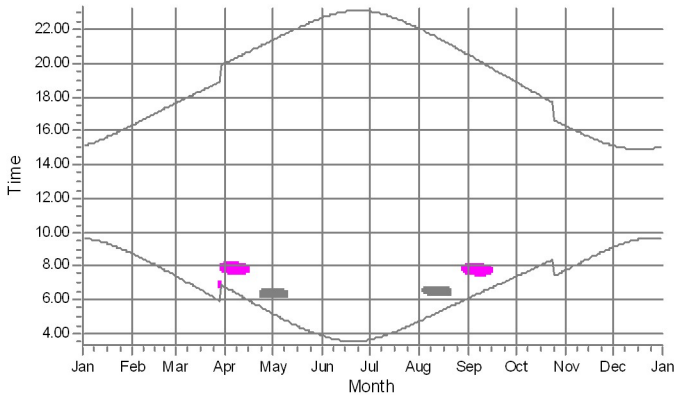
Total times in Receptor wise and WTG wise tables can differ, as a WTG can lead to flicker at 2 or more receptors simultaneously and/or receptors may receive flicker from 2 or more WTGs simultaneously.

The calculation of the total expected values for a given receptor assumes a weighted average directional reduction for all WTGs contributing to shadow flicker within the same day. In the case where shadow flicker from different WTGs is not concurrent within the day, the total expected time at a given receptor may deviate marginally from the individual flicker time caused by each turbine separately.

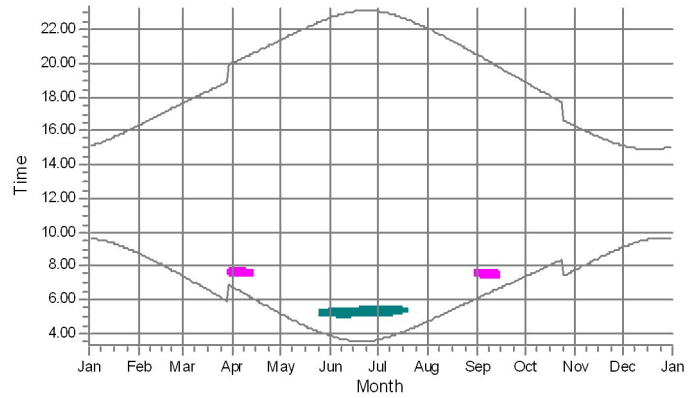
## SHADOW - Calendar, graphical

Calculation: res\_Luhanka\_HH200\_RD200\_17102022

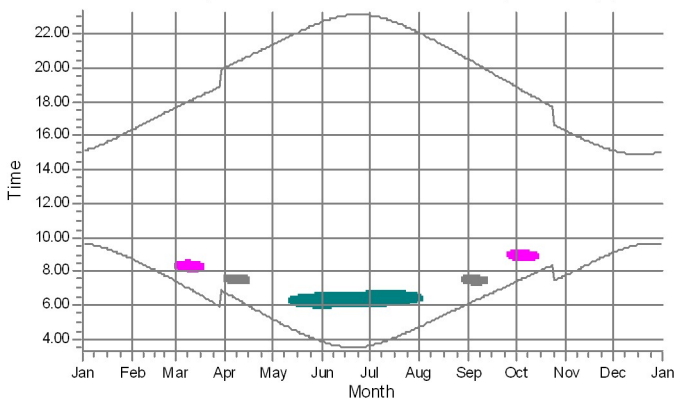
1: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (10)



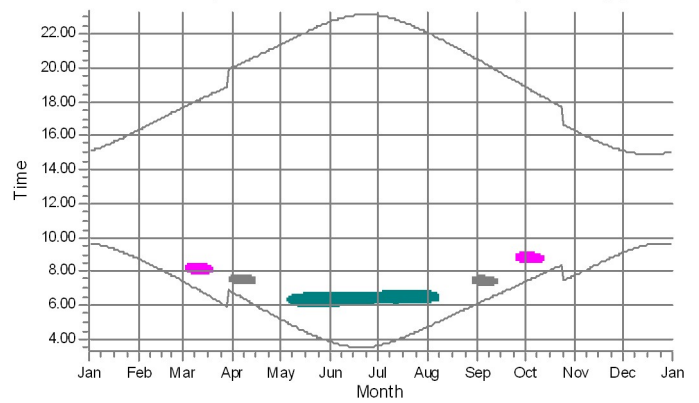
2: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (11)



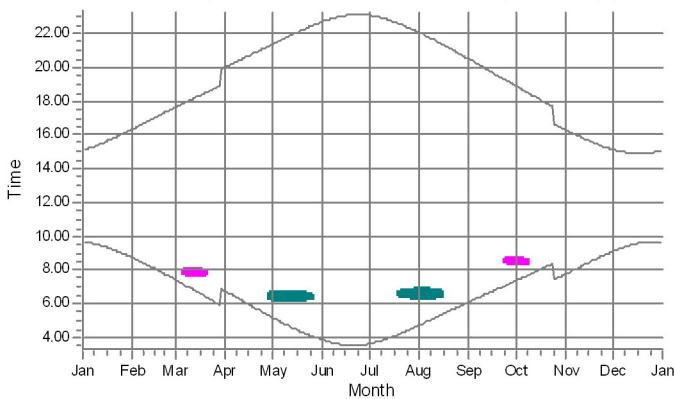
3: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (9)



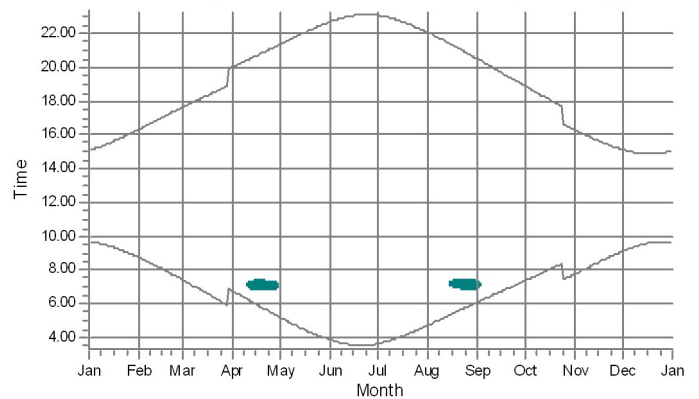
4: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (7)






5: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (8)



6: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (6)



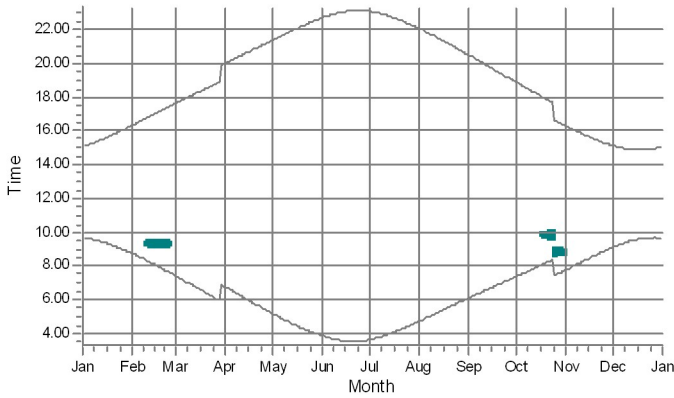
### WTGs

-  6: VESTAS V172-7.2 USER 7200 200.0 !O! hub: 200.0 m (TOT: 300.0 m) (4)
-  7: VESTAS V172-7.2 USER 7200 200.0 !O! hub: 200.0 m (TOT: 300.0 m) (5)
-  5: VESTAS V172-7.2 USER 7200 200.0 !O! hub: 200.0 m (TOT: 300.0 m) (6)

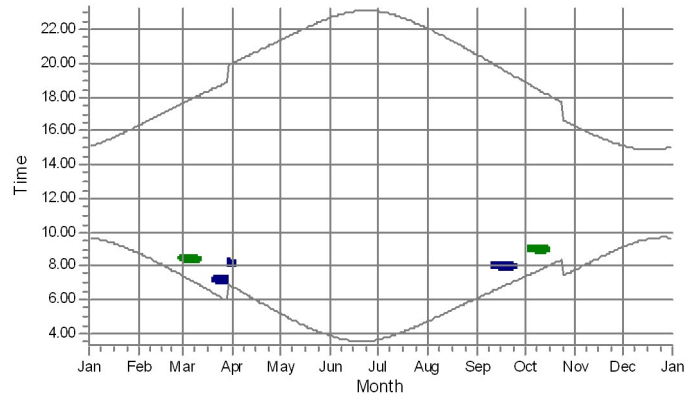
## SHADOW - Calendar, graphical

Calculation: res\_Luhanka\_HH200\_RD200\_17102022

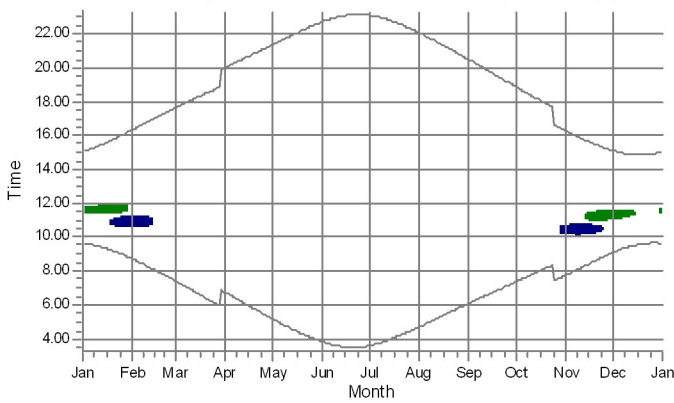
7: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (5)



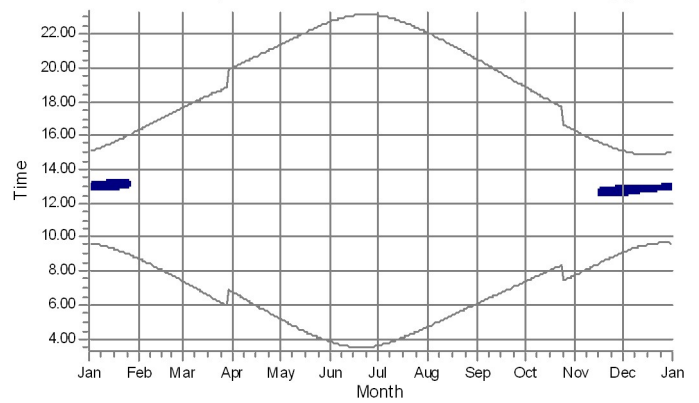
8: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (4)



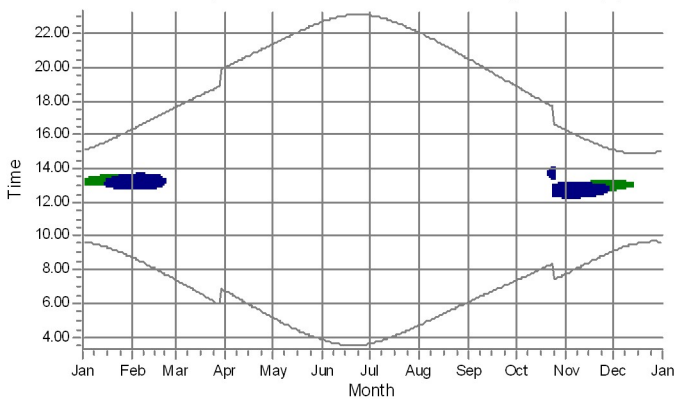
9: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (1)



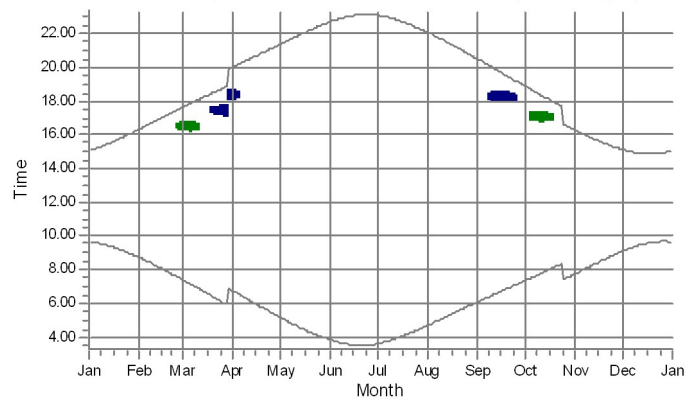
10: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (3)



11: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (2)



12: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (12)



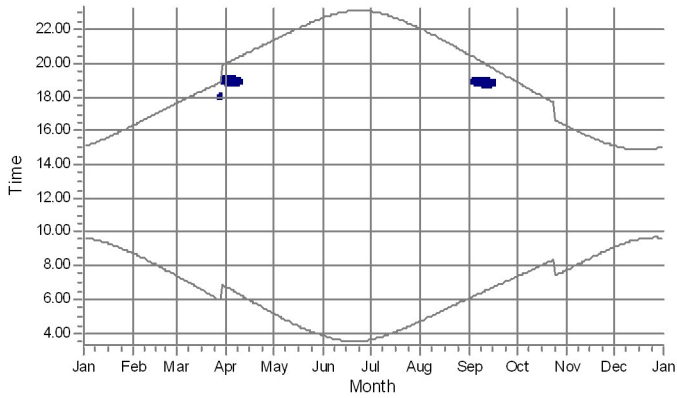
### WTGs

- 2: VESTAS V172-7.2 USER 7200 200.0 !O! hub: 200.0 m (TOT: 300.0 m) (1)
- 5: VESTAS V172-7.2 USER 7200 200.0 !O! hub: 200.0 m (TOT: 300.0 m) (6)
- 1: VESTAS V172-7.2 USER 7200 200.0 !O! hub: 200.0 m (TOT: 300.0 m) (7)

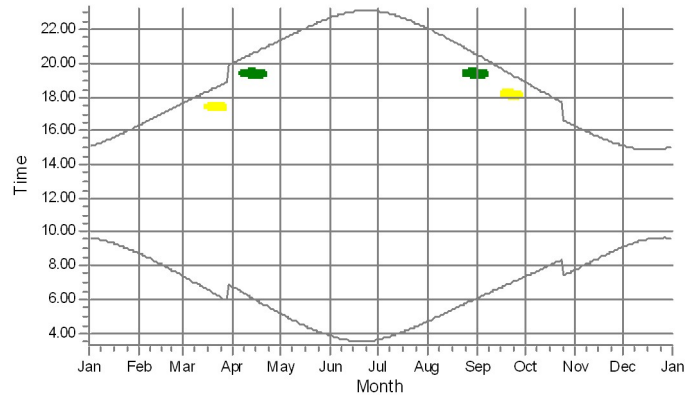
## SHADOW - Calendar, graphical

Calculation: res\_Luhanka\_HH200\_RD200\_17102022

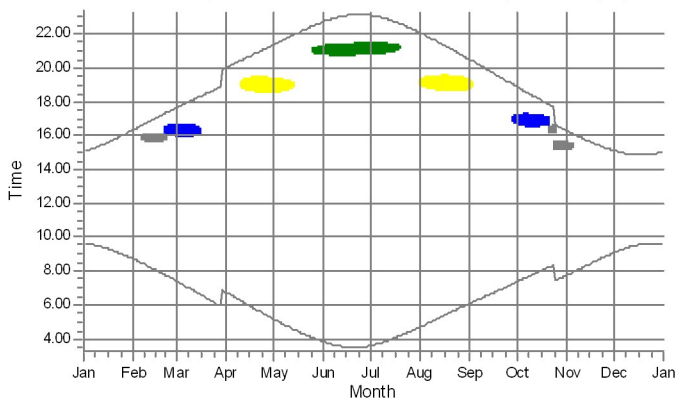
13: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (13)



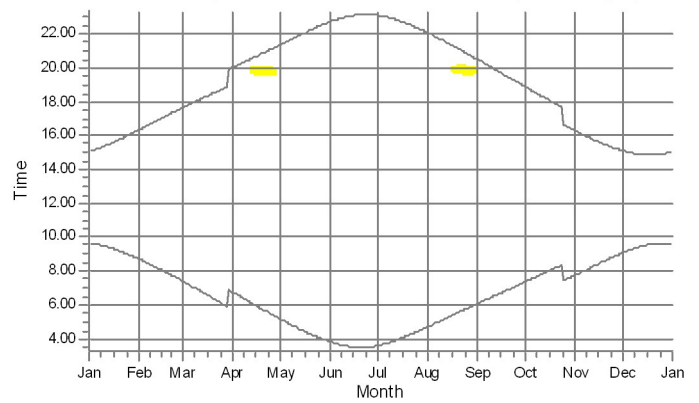
14: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (14)



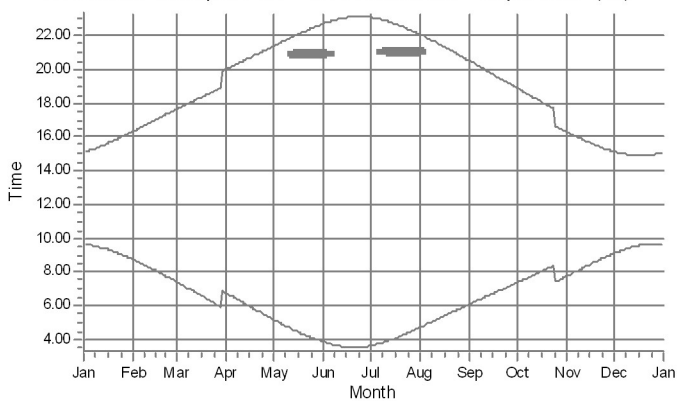
15: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (16)



16: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (15)



17: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (17)



### WTGs

- 2: VESTAS V172-7.2 USER 7200 200.0 !O! hub: 200.0 m (TOT: 300.0 m) (1)
- 3: VESTAS V172-7.2 USER 7200 200.0 !O! hub: 200.0 m (TOT: 300.0 m) (2)
- 4: VESTAS V172-7.2 USER 7200 200.0 !O! hub: 200.0 m (TOT: 300.0 m) (3)
- 6: VESTAS V172-7.2 USER 7200 200.0 !O! hub: 200.0 m (TOT: 300.0 m) (4)
- 1: VESTAS V172-7.2 USER 7200 200.0 !O! hub: 200.0 m (TOT: 300.0 m) (7)