

EDF Luminus
Markiesstraat 1
1000 Brussel

COGEN Energy BVBA
Boelare 52
BE-9900 EEKLO

Frederik De Smet / fds@cogen-energy.be
Calculated:
25-10-2017 16:50/3.1.617

SHADOW - Main Result

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) [UCCLE]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1,73	3,04	3,77	5,42	6,72	6,47	6,55	6,53	5,25	3,96	2,43	1,56

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
261	393	465	559	645	475	572	869	1.140	1.059	606	326	7.370

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: CONTOURLINE_ONLINEDATA_19.wpo
Obstacles used in calculation

Eye height: 1,5 m

Grid resolution: 10,0 m

Topographic shadow included in calculation

All coordinates are in

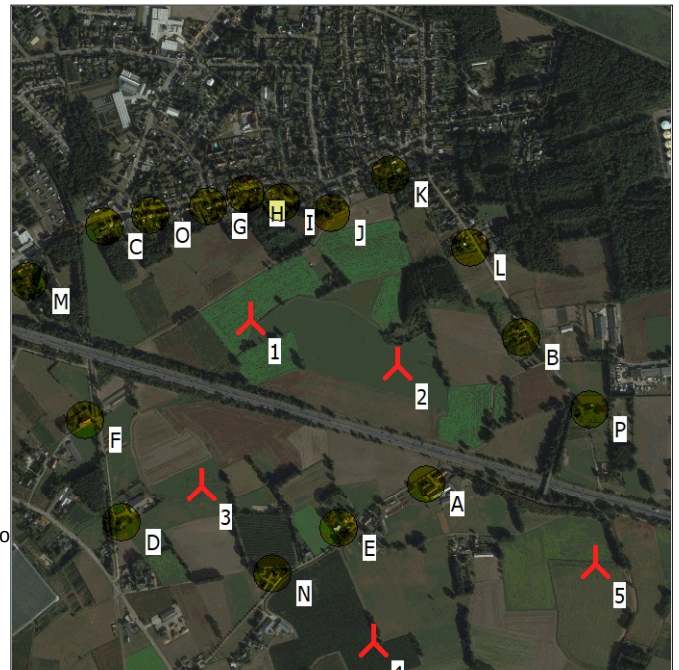
Belgian Lambert72-BD72 (BE 2001 <±1m)

WTGs

	X	Y	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]
			[m]									
1	181.978	205.416	10,0	Siemens SWT-2.3-120 2300 120.0 !O!... Yes	Yes	Siemens	SWT-2.3-120-2.300	2.300	120,0	92,0	1.633	13,0
2	182.369	205.299	10,0	Siemens SWT-2.3-120 2300 120.0 !O!... Yes	Yes	Siemens	SWT-2.3-120-2.300	2.300	120,0	92,0	1.633	13,0
3	181.851	204.974	10,0	Siemens SWT-2.3-120 2300 120.0 !O!... Yes	Yes	Siemens	SWT-2.3-120-2.300	2.300	120,0	80,0	1.633	13,0
4	182.308	204.566	10,9	Siemens SWT-2.3-120 2300 120.0 !O!... Yes	Yes	Siemens	SWT-2.3-120-2.300	2.300	120,0	80,0	1.633	13,0
5	182.895	204.774	15,5	Siemens SWT-2.3-120 2300 120.0 !O!... Yes	Yes	Siemens	SWT-2.3-120-2.300	2.300	120,0	80,0	1.633	13,0
6	184.217	205.481	13,7	ENERCON E-92 2,3 MW 2300 92.0 !-! ... No	No	ENERCON	E-92 2,3 MW-2.300	2.300	92,0	108,4	1.516	16,0
7	184.563	205.378	20,0	ENERCON E-92 2,3 MW 2300 92.0 !-! ... No	No	ENERCON	E-92 2,3 MW-2.300	2.300	92,0	108,4	1.516	16,0

Shadow receptor-Input

No.	X	Y	Z	Width	Height	Height a.g.l.	Degrees from south cw	Slope of window	Direction mode
			[m]	[m]	[m]	[m]	[°]	[°]	
A	182.446	204.982	10,0	5,0	2,0	1,0	0,0	90,0	"Green house mode"
B	182.697	205.374	12,1	5,0	2,0	1,0	0,0	90,0	"Green house mode"
C	181.588	205.659	14,9	5,0	2,0	1,0	0,0	90,0	"Green house mode"
D	181.639	204.876	10,0	5,0	2,0	1,0	0,0	90,0	"Green house mode"
E	182.214	204.865	10,0	5,0	2,0	1,0	0,0	90,0	"Green house mode"
F	181.541	205.149	10,0	5,0	2,0	1,0	0,0	90,0	"Green house mode"
G	181.864	205.714	10,4	5,0	2,0	1,0	0,0	90,0	"Green house mode"
H	181.963	205.747	10,7	5,0	2,0	1,0	0,0	90,0	"Green house mode"
I	182.058	205.724	12,3	5,0	2,0	1,0	0,0	90,0	"Green house mode"
J	182.190	205.699	12,4	5,0	2,0	1,0	0,0	90,0	"Green house mode"
K	182.346	205.800	13,9	5,0	2,0	1,0	0,0	90,0	"Green house mode"
L	182.561	205.609	15,7	5,0	2,0	1,0	0,0	90,0	"Green house mode"
M	181.389	205.512	18,0	5,0	2,0	1,0	0,0	90,0	"Green house mode"
N	182.040	204.744	10,0	5,0	2,0	1,0	0,0	90,0	"Green house mode"
O	181.711	205.689	12,9	5,0	2,0	1,0	0,0	90,0	"Green house mode"
P	182.878	205.185	15,7	5,0	2,0	1,0	0,0	90,0	"Green house mode"



Red arrow: New WTG

Yellow circle: Shadow receptor

Project:

CUMULATIEVE EFFECTEN SLAGSCHADUW HERENTALS

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SHADOW - Main Result

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]
A	155:01	209	1:06	25:06
B	152:56	148	1:56	34:19
C	83:19	95	1:24	13:44
D	208:04	183	2:10	49:32
E	329:41	294	1:38	53:31
F	190:11	256	1:35	36:26
G	217:39	120	2:13	25:18
H	207:56	101	2:21	22:45
I	243:13	112	2:44	28:00
J	245:56	137	2:21	32:22
K	103:04	114	1:13	13:49
L	203:22	181	1:54	30:20
M	86:32	141	0:51	12:01
N	153:16	165	1:28	26:09
O	171:41	144	1:54	22:01
P	170:54	201	1:36	28:39

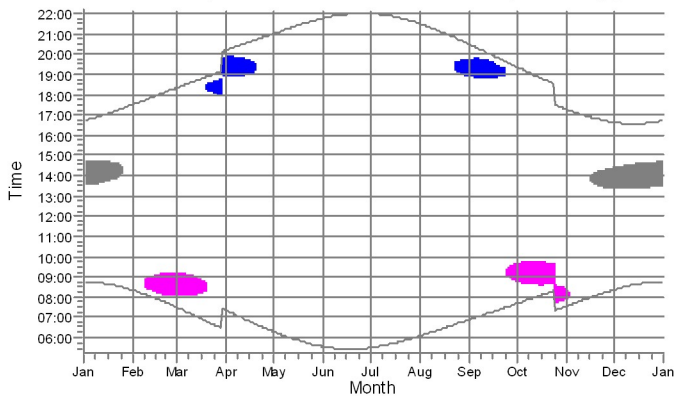
Total amount of flickering on the shadow receptors caused by each WTG

No.	Name	Worst case [h/year]	Expected [h/year]
1	Siemens SWT-2.3-120 2300 120.0 !O! hub: 92,0 m (TOT: 152,0 m) (1)	970:08	139:53
2	Siemens SWT-2.3-120 2300 120.0 !O! hub: 92,0 m (TOT: 152,0 m) (2)	676:06	110:12
3	Siemens SWT-2.3-120 2300 120.0 !O! hub: 80,0 m (TOT: 140,0 m) (7)	547:42	112:00
4	Siemens SWT-2.3-120 2300 120.0 !O! hub: 80,0 m (TOT: 140,0 m) (8)	421:47	54:48
5	Siemens SWT-2.3-120 2300 120.0 !O! hub: 80,0 m (TOT: 140,0 m) (9)	191:09	29:05
6	ENERCON E-92 2,3 MW 2300 92.0 !-! hub: 108,4 m (TOT: 154,4 m) (10)	4:31	1:06
7	ENERCON E-92 2,3 MW 2300 92.0 !-! hub: 108,4 m (TOT: 154,4 m) (11)	0:00	0:00

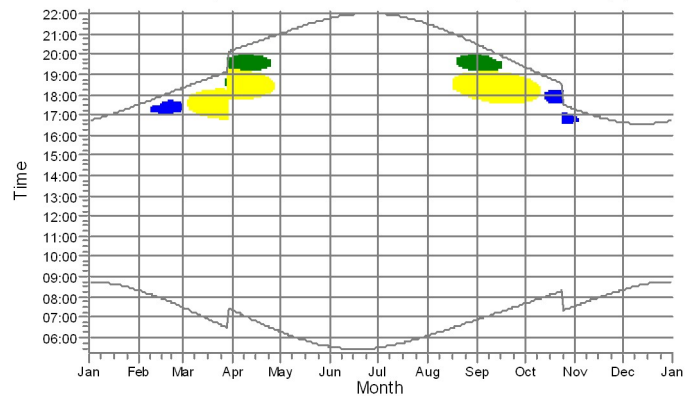
Total times in Receptor wise and WTG wise tables can differ, as a WTG can lead to flicker at 2 or more receptors simultaneously and/or receptors may receive flicker from 2 or more WTGs simultaneously.

SHADOW - Calendar, graphical

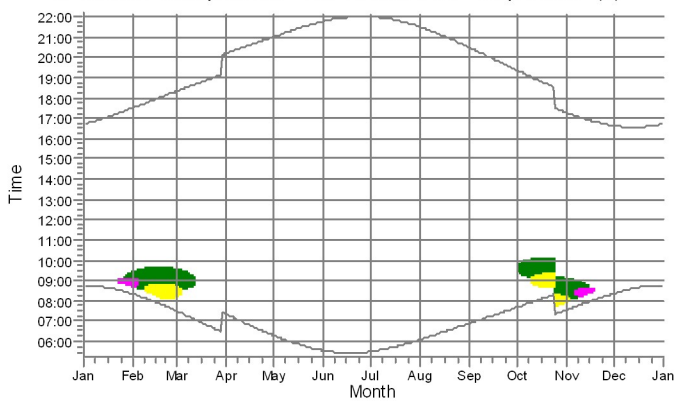
A: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (1)



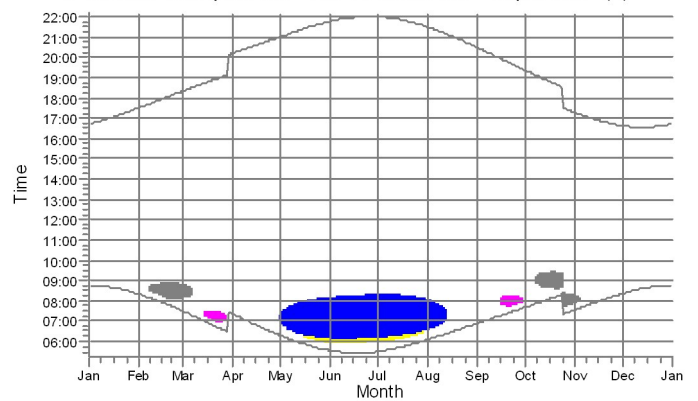
B: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (2)



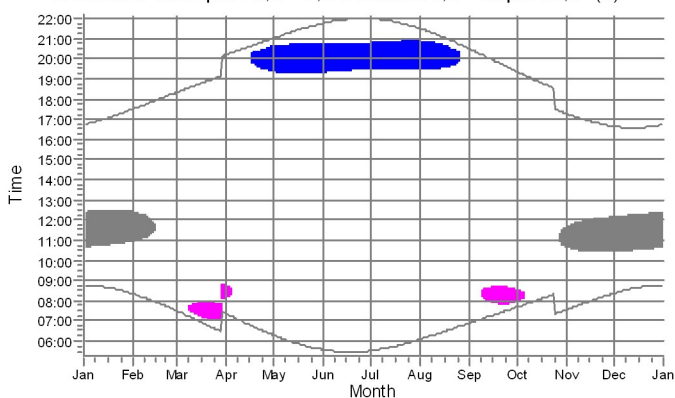
C: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (3)



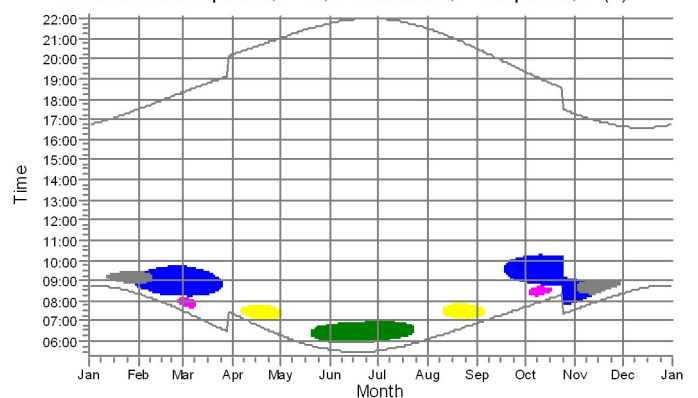
D: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (4)



E: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (5)



F: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (6)

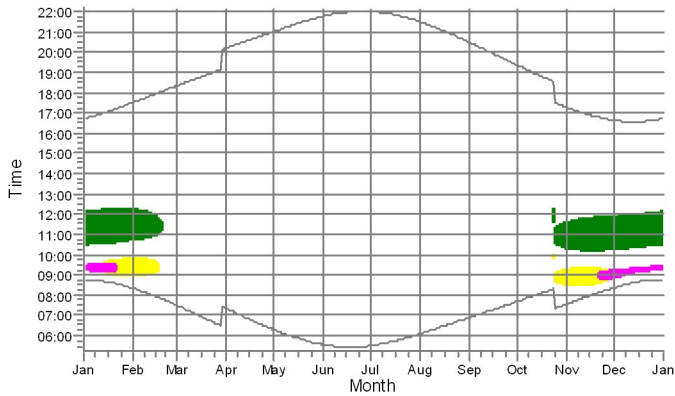


WTGs

- | | |
|--|--|
| | 1: Siemens SWT-2.3-120 2300 120.0 !O! hub: 92,0 m (TOT: 152,0 m) (1) |
| | 2: Siemens SWT-2.3-120 2300 120.0 !O! hub: 92,0 m (TOT: 152,0 m) (2) |
| | 3: Siemens SWT-2.3-120 2300 120.0 !O! hub: 80,0 m (TOT: 140,0 m) (7) |
| | 4: Siemens SWT-2.3-120 2300 120.0 !O! hub: 80,0 m (TOT: 140,0 m) (8) |
| | 5: Siemens SWT-2.3-120 2300 120.0 !O! hub: 80,0 m (TOT: 140,0 m) (9) |

SHADOW - Calendar, graphical

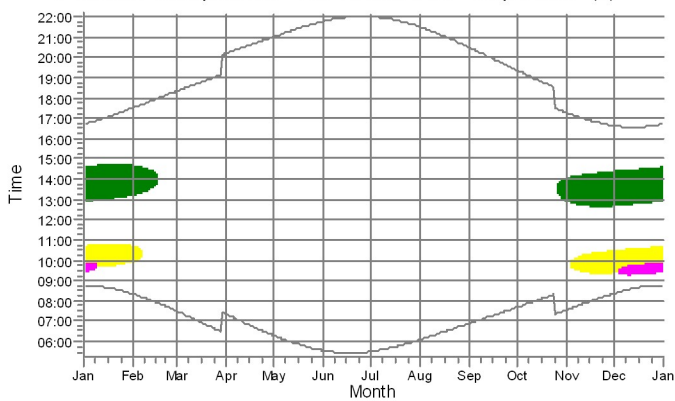
G: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (7)



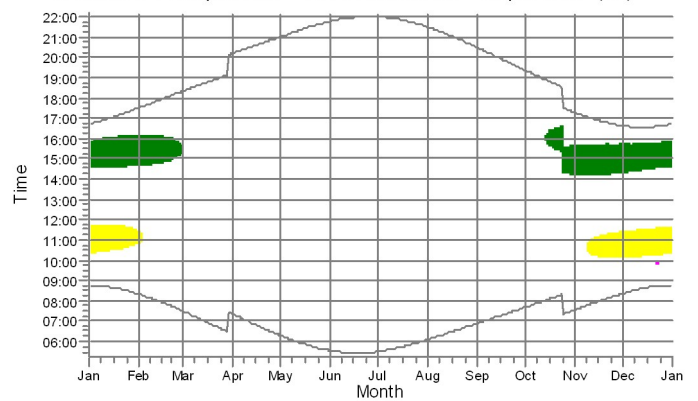
H: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (8)



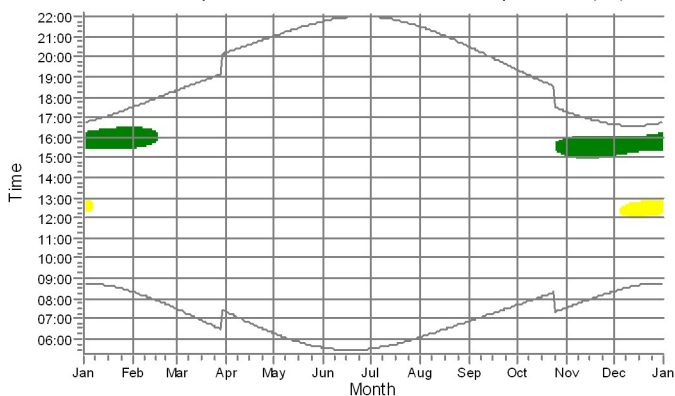
I: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (9)



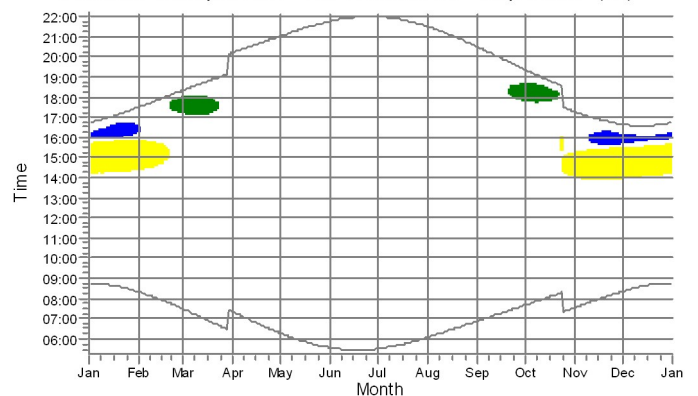
J: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (10)



K: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (11)



L: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (12)



WTGs

- 1: Siemens SWT-2.3-120 2300 120.0 !O! hub: 92,0 m (TOT: 152,0 m) (1)
- 2: Siemens SWT-2.3-120 2300 120.0 !O! hub: 92,0 m (TOT: 152,0 m) (2)
- 3: Siemens SWT-2.3-120 2300 120.0 !O! hub: 80,0 m (TOT: 140,0 m) (7)
- 5: Siemens SWT-2.3-120 2300 120.0 !O! hub: 80,0 m (TOT: 140,0 m) (9)

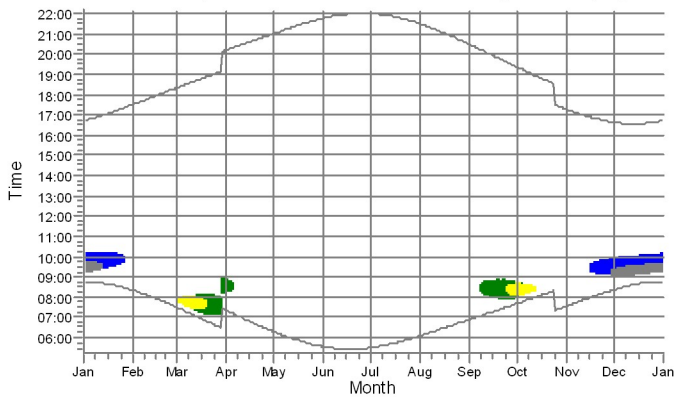
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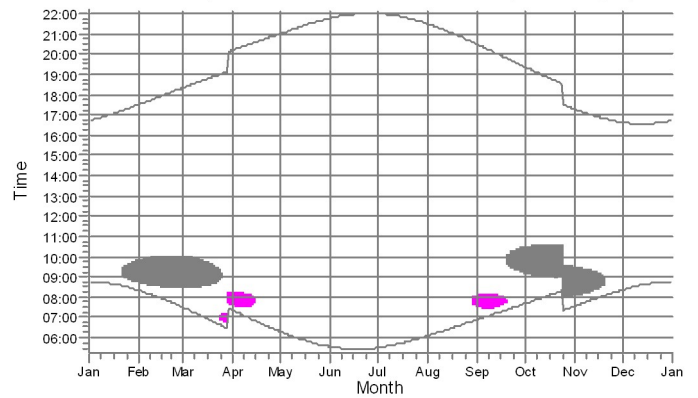
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SHADOW - Calendar, graphical

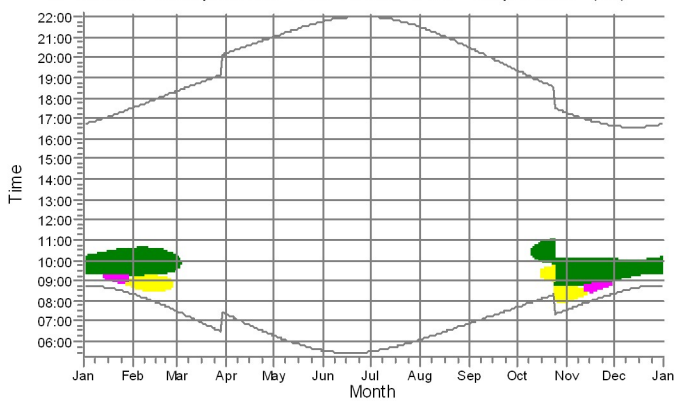
M: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (13)



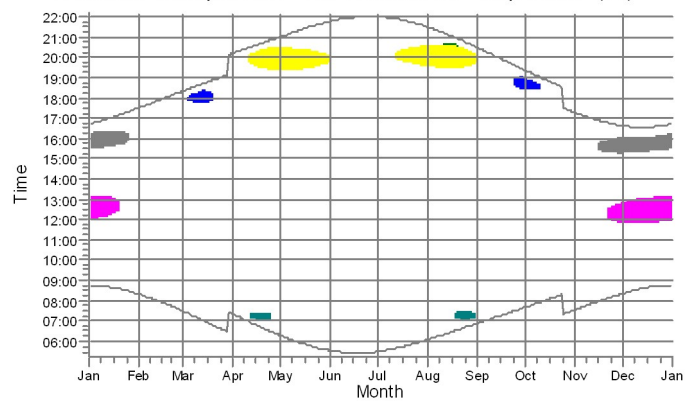
N: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (14)



O: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (15)



P: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (17)

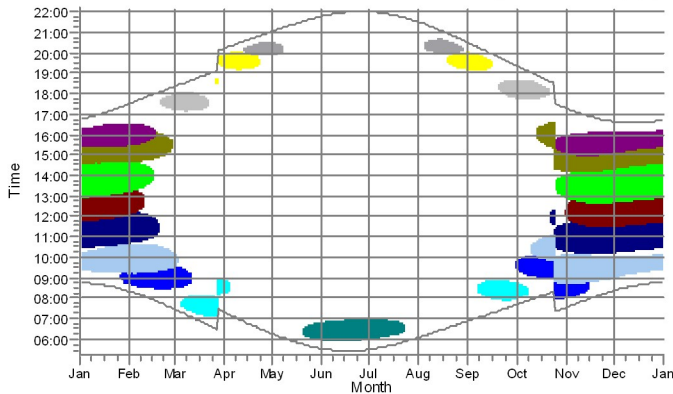


WTGs

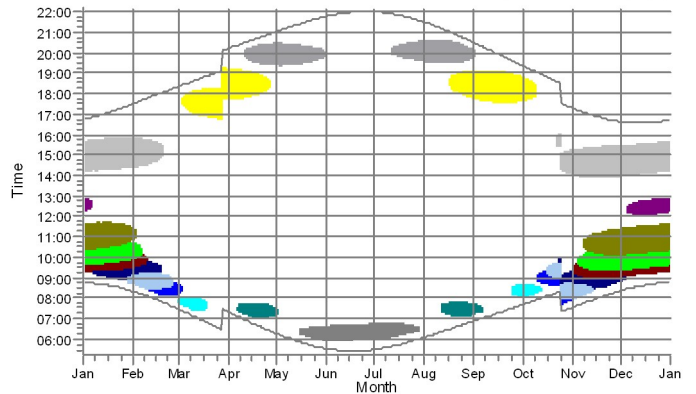
- | | |
|--|---|
| | 1: Siemens SWT-2.3-120 2300 120.0 !O! hub: 92,0 m (TOT: 152,0 m) (1) |
| | 2: Siemens SWT-2.3-120 2300 120.0 !O! hub: 92,0 m (TOT: 152,0 m) (2) |
| | 3: Siemens SWT-2.3-120 2300 120.0 !O! hub: 80,0 m (TOT: 140,0 m) (7) |
| | 4: Siemens SWT-2.3-120 2300 120.0 !O! hub: 80,0 m (TOT: 140,0 m) (8) |
| | 5: Siemens SWT-2.3-120 2300 120.0 !O! hub: 80,0 m (TOT: 140,0 m) (9) |
| | 6: ENERCON E-92 2,3 MW 2300 92.0 !-! hub: 108,4 m (TOT: 154,4 m) (10) |

SHADOW - Calendar per WTG, graphical

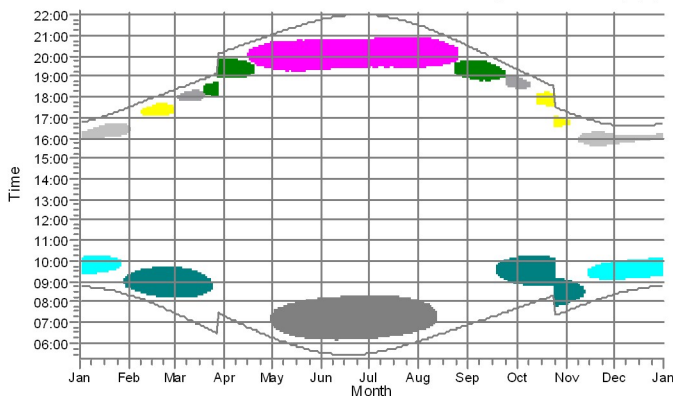
1: Siemens SWT-2.3-120 2300 120.0 !O! hub: 92,0 m (TOT: 152,0 m) (1)



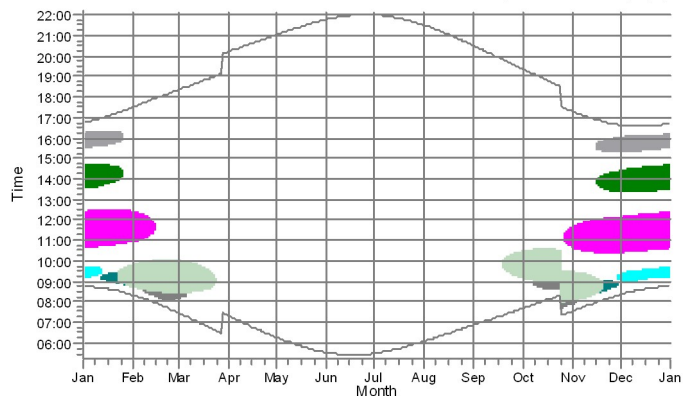
2: Siemens SWT-2.3-120 2300 120.0 !O! hub: 92,0 m (TOT: 152,0 m) (2)



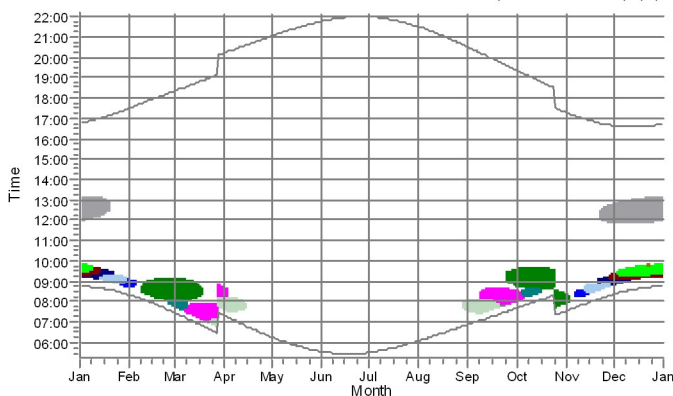
3: Siemens SWT-2.3-120 2300 120.0 !O! hub: 80,0 m (TOT: 140,0 m) (7)



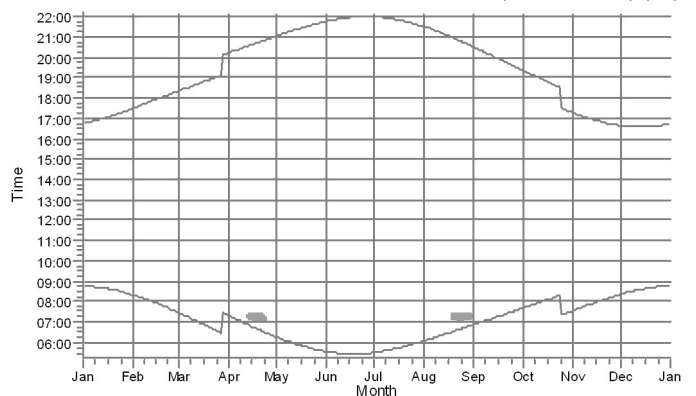
4: Siemens SWT-2.3-120 2300 120.0 !O! hub: 80,0 m (TOT: 140,0 m) (8)



5: Siemens SWT-2.3-120 2300 120.0 !O! hub: 80,0 m (TOT: 140,0 m) (9)



6: ENERCON E-92 2,3 MW 2300 92.0 !-! hub: 108,4 m (TOT: 154,4 m) (10)



Shadow receptors

	A: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (1)
	B: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (2)
	C: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (3)
	D: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (4)
	E: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (5)
	F: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (6)
	G: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (7)
	H: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (8)

	I: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (9)
	J: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (10)
	K: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (11)
	L: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (12)
	M: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (13)
	N: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (14)
	O: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (15)
	P: Shadow Receptor: 5,0 × 2,0 Azimuth: 0,0° Slope: 90,0° (17)

Project:

CUMULATIEVE EFFECTEN SLAGSCHADUW HERENTALS

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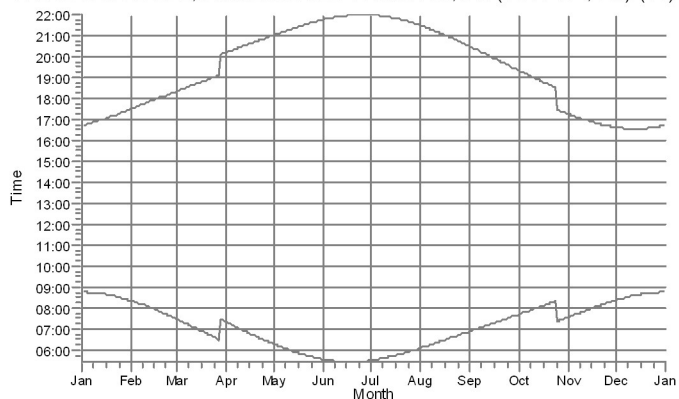
Frederik De Smet / fds@cogen-energy.be

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25-10-2017 16:50/3.1.617

SHADOW - Calendar per WTG, graphical

7: ENERCON E-92 2,3 MW 2300 92.0 ! hub: 108,4 m (TOT: 154,4 m) (11)



Shadow receptors

SHADOW - Map



Map: HERENTALS2 , Print scale 1:20.000, Map center Belgian Lambert72-BD72 (BE 2001 <±1m) East: 182.195 North: 205.344
 New WTG Shadow receptor
 Flicker map level: Height Contours: CONTOURLINE_ONLINEDATA_19.wpo (1)