



VCC Energia Licata Srl

REGIONE SICILIANA

**PROVINCIA DI AGRIGENTO
COMUNE DI LICATA**



**PROVINCIA DI CALTANISSETTA
COMUNE DI BUTERA**



**PROGETTO PER LA REALIZZAZIONE DI UN IMPIANTO EOLICO DELLA
POTENZA DI 93,5 MW**

"AGRABONA"

**REL.AMB.
09**

RELAZIONE SUGLI EFFETTI DI SHADOW FLICKERING

Committente:
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Il Rappresentante Legale

PROGETTO DEFINITIVO

Data: 10/11/2021

Rev. 01

PROGETTO REDATTO DA: VCC Trapani Srl

Il progettista:
Ing. Giuseppe Morgante



1 INTRODUZIONE

La presente relazione redatta dal prof. Ing. Marco Trapanese iscritto all'ordine degli ingegneri della provincia di Palermo al n.6946 valuta e calcola dell'effetto dello shadow flicker per il parco eolico "Agrabona", iniziativa proposta dalla società "VCC Energia Licata SRL".

Per la localizzazione e la consistenza del parco si rimanda alla relazione tecnica generale (elaborato RS06REL001A0).

Lo "shadow flicker" (letteralmente ombreggiamento intermittente) è l'espressione comunemente impiegata per descrivere l'effetto stroboscopico delle ombre proiettate dalle pale rotanti degli aerogeneratori eolici allorquando il sole si trova alle loro spalle (Figura 1).

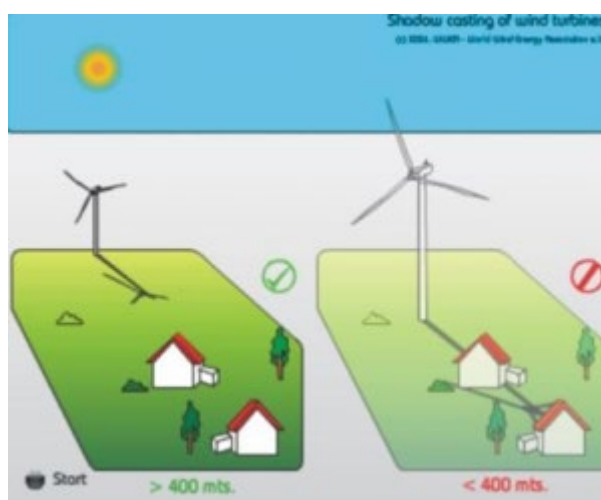


Fig.1 Effetto di shadow flickering

Il fenomeno si traduce in una variazione alternata di intensità luminosa che, a lungo andare, può provocare fastidio agli occupanti delle abitazioni le cui finestre risultano esposte al fenomeno stesso. Il fenomeno, ovviamente, risulta assente sia quando il sole è oscurato da nuvole o nebbia, sia quando, in assenza di vento, le pale del generatore non sono in rotazione. In particolare, le frequenze che possono provocare un senso di fastidio sono comprese tra i 2.5 ed i 20 Hz (Verkuijlen and Westra, 1984), e, l'effetto sugli individui è simile a quello che si sperimenterebbe in seguito alle variazioni di intensità luminosa di una lampada ad incandescenza a causa di continui sbalzi della tensione della rete di alimentazione elettrica.

I più recenti aerogeneratori tripala operano ad una velocità di rotazione inferiore ai 35 giri al minuto, corrispondente ad una frequenza di passaggio delle pale sulla verticale inferiore a 1.75 Hz, minore, quindi, della frequenza critica di 2.5 Hz. Inoltre, i generatori di grande potenza (dal MW in su) raramente superano la velocità di rotazione di 20 giri al minuto, corrispondente a frequenze di passaggio delle pale ampiamente minori di quelle ritenute fastidiose per la maggioranza degli individui. Le relazioni spaziali tra un aerogeneratore ed un ricettore (abitazione), così come la direzione del vento risultano essere fattori chiave per la durata del fenomeno di shadow flicker. Per distanze dell'ordine dei 300 m, il fenomeno in esame potrebbe verificarsi all'alba oppure al tramonto, ovvero in quelle ore in cui le ombre risultano molto lunghe per effetto della piccola elevazione solare. Al di là di una certa distanza l'ombra smette di essere un problema perché il rapporto tra lo spessore

della pala ed il diametro del sole diventa molto piccolo. Quindi, come è facile immaginare, la condizione più penalizzante corrisponde al caso in cui il piano del rotore risulta ortogonale alla congiungente ricevitore – sole; infatti, in tali condizioni, l'ombra proiettata darà origine ad un cerchio di diametro pari al rotore del generatore eolico. Sebbene il fenomeno possa essere percepito anche all'esterno, esso risulta evidente e fastidioso in quegli ambienti con finestrate rivolte verso le ombre. In generale, l'area soggetta a shadow flicker non si estende oltre i 500÷1000 m dall'aerogeneratore e le zone a maggiore impatto ricadono entro i 300 m di distanza dalle macchine con durata del fenomeno dell'ordine delle 200 ore all'anno; il flickering, se presente, non supera in genere i 20/30 minuti di durata nell'arco di una giornata. L'intensità del fenomeno è definita come la differenza di luminosità che si percepisce in presenza ed in assenza di flickering in una data posizione.

In generale, si può affermare che:

- Avendo le pale una forma rastremata con lo spessore che cresce verso il mozzo; il fenomeno risulterà tanto più intenso quanto maggiore sarà la porzione di disco solare coperta dalla pala stessa e quanto minore la distanza dal ricevitore.
- L'intensità del flickering sarà minima quando l'ombra prodotta è generata all'estremità delle pale.
- Maggiori distanze tra generatore e ricevitore determinano ombre meno nette; in tal caso l'effetto flickering risulterà meno intenso e distinto.

2 Modello di calcolo

L'analisi dell'impatto da shadow flickering prodotto da un campo eolico è realizzata, generalmente, attraverso l'impiego di specifici applicativi che modellano il fenomeno in esame. I pacchetti software impiegati per la progettazione di impianti eolici contengono moduli specifici per il calcolo e l'analisi del fenomeno di flickering. L'analisi si basa sull'impiego di un modello digitale del terreno dell'area oggetto di progettazione, sulle posizioni (E, N, quota) degli aerogeneratori e dei ricevitori sensibili, nonché sui dati che correlano la posizione del sole nell'arco dell'anno con le condizioni operative delle turbine nello stesso arco di tempo.

Al fine di calcolare la posizione relativa del sole nell'arco di un anno rispetto al parco eolico ed ai ricevitori è necessario definire la longitudine, la latitudine ed il fuso orario dell'area interessata dal progetto.

Nello specifico è stato impiegato il modulo shadow flickering del software WindFarm 4 (ReSoft Limited©). Esso consente di analizzare la posizione del sole nell'arco di un anno per identificare i tempi in cui ogni turbina può proiettare ombre sulle finestre delle abitazioni vicine.

In particolare, il modello permette di:

- calcolare il potenziale per le ombre intermittenti alle finestre delle abitazioni; – mostrare un calendario grafico degli eventi di flickering;
- mostrare un elenco dettagliato di ciascun evento di ombreggiamento (ora di inizio, di fine, durata del fenomeno, aerogeneratore/i coinvolti ecc...);
- creare mappe di impatto potenziale che mostrano le ore d'ombra intermittente per l'intero parco eolico o per le singole macchine (curve di isodurata) nell'arco dell'anno.

Al di là di una certa distanza l'ombra smette di essere un problema perché il rapporto tra lo spessore della pala e il diametro del sole diventa piccolo. Poiché non vi è un valore generalmente accettato per questa distanza massima, WindFarm permette di specificare il limite in metri o multipli del diametro della turbina o dell' altezza della pala stessa. In particolare, il modello numerico utilizzato, al pari degli altri presenti sul mercato, produce in output una mappa di impatto nel caso più penalizzante (WORST CASE), corrispondente alle ore in cui il sole permane al di sopra dell'orizzonte nell'arco dell'anno (ore di luce, ca. 4380 h/a), indipendentemente dalla presenza o meno di nubi, le quali inficerebbero il fenomeno stesso dello shadow flickering per l'impossibilità che si generino ombre. Quindi, allo scopo di pervenire a valori più realistici di impatto, prossimi al caso reale (REAL CASE), si è impiegato il valore di eliofania locale, ovvero il numero di ore di cielo libero da nubi durante il giorno. Per l'area in esame tale valore corrisponde a circa 2400 h/a^{1, 2}; quindi, i risultati del calcolo possono, ragionevolmente, essere abbattuti del 45.2 %, pari al complemento a 1 del rapporto $2400/4380 = 54.8 \%$. In altri termini, rispetto al WORST CASE, la probabilità di occorrenza del fenomeno di shadow flickering si riduce, per l'area in esame, al 54.8 % che corrisponde proprio alla probabilità che il disco solare risulti libero da nubi. A.9.c.

3 Risultati

La frequenza dello shadow flickering è correlata alla velocità di rotazione del rotore; le frequenze tipiche per le macchine considerate nel presente progetto sono dell'ordine di 0.7÷1.5 Hz (circa un passaggio al secondo). In termini di impatto sulla popolazione, tali frequenze sono innocue; basti pensare che le lampade stroboscopiche, largamente impiegate nelle discoteche, producono frequenze comprese tra 5 e 10 Hz. Inoltre, a livello internazionale, è universalmente accettato che frequenze inferiori a 10 Hz non hanno alcuna correlazione con attacchi di natura epilettica. Inoltre, alla luce di quanto descritto nel paragrafo precedente, nel caso in esame non è presente nessun impatto significativo da shadow flickering sui ricettori individuati. Le distanze reciproche tra generatori eolici e ricettori e le condizioni orografiche del sito considerato, determinano la pressoché totale assenza del fenomeno in esame.

Nella pagina successiva, è mostrata una carta con la distribuzione delle ombre sul territorio e i relativi elaborati di calcolo.

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) [GELA]
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
4,68 5,56 6,38 7,53 8,42 9,58 10,34 9,72 8,14 6,82 5,66 4,46

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

ERA5(T) Rectangular Grid_N37,25_E014,00

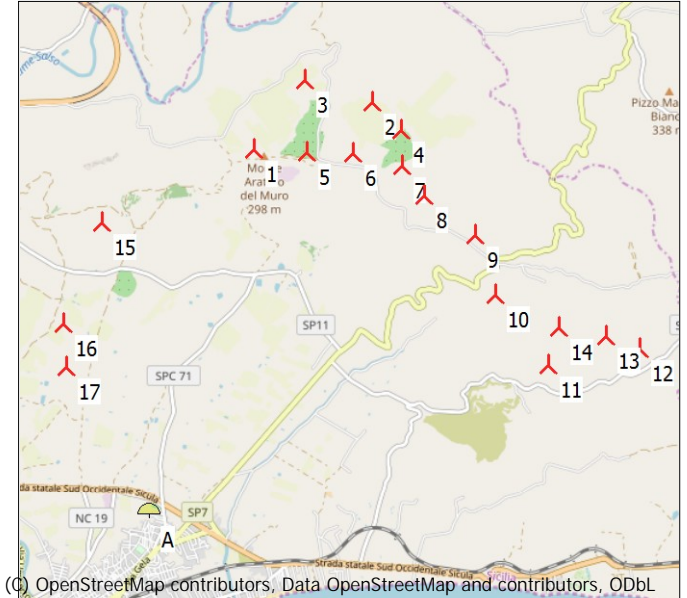
Operational time
N NNE ENE E ESE SSE S SSW WSW W WNW NNW Sum
659 545 576 641 455 349 343 472 625 1.007 1.049 654 7.375
Idle start wind speed: Cut in wind speed from power curve

Line-of-sight calculation has been deactivated. This means that sheltering from obstacles, areas or hills are not taken into account.

All coordinates are in
Geo [deg,min,sec]-WGS84

WTGs

No.	Longitude	Latitude	Z	Row data/Description	WTG type		Type-generator	Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Shadow data	
					Valid	Manufact.					Calculation distance [m]	RPM [RPM]
			[m]									
1	13°58'13,43" E	37°09'40,35" N	251,5	GE WIND ENERGY 5.3-....	No	GE WIND ENERGY	5.3-158 GT120-5.500	5.500	158,0	120,9	1.819	0,0
2	13°59'17,00" E	37°10'00,79" N	247,0	GE WIND ENERGY 5.5-....	Yes	GE WIND ENERGY	5.5-158 GT120-5.500	5.500	158,0	120,9	1.819	0,0
3	13°58'40,06" E	37°10'10,01" N	204,5	GE WIND ENERGY 5.5-....	Yes	GE WIND ENERGY	5.5-158 GT120-5.500	5.500	158,0	120,9	1.819	0,0
4	13°59'32,42" E	37°09'49,15" N	280,5	GE WIND ENERGY 5.5-....	Yes	GE WIND ENERGY	5.5-158 GT120-5.500	5.500	158,0	120,9	1.819	0,0
5	13°58'41,68" E	37°09'39,58" N	273,3	GE WIND ENERGY 5.5-....	Yes	GE WIND ENERGY	5.5-158 LT120-5.500	5.500	158,0	101,0	1.820	0,0
6	13°59'06,34" E	37°09'39,31" N	256,5	GE WIND ENERGY 5.5-....	Yes	GE WIND ENERGY	5.5-158 GT120-5.500	5.500	158,0	120,9	1.819	0,0
7	13°59'33,01" E	37°09'33,56" N	307,3	GE WIND ENERGY 5.5-....	Yes	GE WIND ENERGY	5.5-158 GT120-5.500	5.500	158,0	120,9	1.819	0,0
8	13°59'44,53" E	37°09'21,01" N	266,6	GE WIND ENERGY 5.5-....	Yes	GE WIND ENERGY	5.5-158 GT120-5.500	5.500	158,0	120,9	1.819	0,0
9	14°00'11,95" E	37°09'04,30" N	269,0	GE WIND ENERGY 5.5-....	Yes	GE WIND ENERGY	5.5-158 GT120-5.500	5.500	158,0	120,9	1.819	0,0
10	14°00'22,62" E	37°08'38,66" N	269,8	GE WIND ENERGY 5.5-....	Yes	GE WIND ENERGY	5.5-158 LT120-5.500	5.500	158,0	101,0	1.820	0,0
11	14°00'51,19" E	37°08'08,48" N	298,1	GE WIND ENERGY 5.5-....	Yes	GE WIND ENERGY	5.5-158 LT120-5.500	5.500	158,0	101,0	1.820	0,0
12	14°01'40,27" E	37°08'15,26" N	304,2	GE WIND ENERGY 5.5-....	Yes	GE WIND ENERGY	5.5-158 LT120-5.500	5.500	158,0	101,0	1.820	0,0
13	14°01'22,12" E	37°08'20,56" N	331,3	GE WIND ENERGY 5.5-....	Yes	GE WIND ENERGY	5.5-158 LT120-5.500	5.500	158,0	101,0	1.820	0,0
14	14°00'56,75" E	37°08'24,90" N	345,1	GE WIND ENERGY 5.5-....	Yes	GE WIND ENERGY	5.5-158 LT120-5.500	5.500	158,0	101,0	1.820	0,0
15	13°56'51,38" E	37°09'09,32" N	62,8	GE WIND ENERGY 5.5-....	Yes	GE WIND ENERGY	5.5-158 LT120-5.500	5.500	158,0	101,0	1.820	0,0
16	13°56'31,34" E	37°08'26,34" N	39,2	GE WIND ENERGY 5.5-....	Yes	GE WIND ENERGY	5.5-158 LT120-5.500	5.500	158,0	101,0	1.820	0,0
17	13°56'32,21" E	37°08'07,46" N	16,2	GE WIND ENERGY 5.5-....	Yes	GE WIND ENERGY	5.5-158 LT120-5.500	5.500	158,0	101,0	1.820	0,0



Shadow receptor-Input

No.	Longitude	Latitude	Z	Width	Height	Elevation a.g.l.	Degrees from south cw	Slope of window	Direction mode	Eye height (ZVI) a.g.l.
			[m]	[m]	[m]	[m]	[°]	[°]		[m]
A	13°57'16,60" E	37°07'04,67" N	25,4	1,0	1,0	1,0	0,0	90,0	Fixed direction	2,0

Calculation Results

Shadow receptor

Shadow, expected values

No.	Shadow hours per year [h/year]
A	0:00

SHADOW - Main Result

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

No.	Name	Expected [h/year]
1	GE WIND ENERGY 5.3-158 GT120 5500 158.0 !-! hub: 120,9 m (TOT: 199,9 m) (1)	0:00
2	GE WIND ENERGY 5.5-158 GT120 5500 158.0 !-! hub: 120,9 m (TOT: 199,9 m) (3)	0:00
3	GE WIND ENERGY 5.5-158 GT120 5500 158.0 !-! hub: 120,9 m (TOT: 199,9 m) (4)	0:00
4	GE WIND ENERGY 5.5-158 GT120 5500 158.0 !-! hub: 120,9 m (TOT: 199,9 m) (5)	0:00
5	GE WIND ENERGY 5.5-158 LT120 5500 158.0 !-! hub: 101,0 m (TOT: 180,0 m) (6)	0:00
6	GE WIND ENERGY 5.5-158 GT120 5500 158.0 !-! hub: 120,9 m (TOT: 199,9 m) (7)	0:00
7	GE WIND ENERGY 5.5-158 GT120 5500 158.0 !-! hub: 120,9 m (TOT: 199,9 m) (8)	0:00
8	GE WIND ENERGY 5.5-158 GT120 5500 158.0 !-! hub: 120,9 m (TOT: 199,9 m) (9)	0:00
9	GE WIND ENERGY 5.5-158 GT120 5500 158.0 !-! hub: 120,9 m (TOT: 199,9 m) (10)	0:00
10	GE WIND ENERGY 5.5-158 LT120 5500 158.0 !-! hub: 101,0 m (TOT: 180,0 m) (11)	0:00
11	GE WIND ENERGY 5.5-158 LT120 5500 158.0 !-! hub: 101,0 m (TOT: 180,0 m) (12)	0:00
12	GE WIND ENERGY 5.5-158 LT120 5500 158.0 !-! hub: 101,0 m (TOT: 180,0 m) (13)	0:00
13	GE WIND ENERGY 5.5-158 LT120 5500 158.0 !-! hub: 101,0 m (TOT: 180,0 m) (14)	0:00
14	GE WIND ENERGY 5.5-158 LT120 5500 158.0 !-! hub: 101,0 m (TOT: 180,0 m) (15)	0:00
15	GE WIND ENERGY 5.5-158 LT120 5500 158.0 !-! hub: 101,0 m (TOT: 180,0 m) (16)	0:00
16	GE WIND ENERGY 5.5-158 LT120 5500 158.0 !-! hub: 101,0 m (TOT: 180,0 m) (17)	0:00
17	GE WIND ENERGY 5.5-158 LT120 5500 158.0 !-! hub: 101,0 m (TOT: 180,0 m) (18)	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

Shadow receptor: A - Shadow Receptor: 1,0 × 1,0 Azimuth: 0,0° Slope: 90,0° (1)

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [GELA]

Reference year for calendar

2022

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
4,68 5,56 6,38 7,53 8,42 9,58 10,34 9,72 8,14 6,82 5,66 4,46

Operational time

N NNE ENE E ESE SSE S SSW WSW W WNW NNW Sum
659 545 576 641 455 349 343 472 625 1.007 1.049 654 7.375
Idle start wind speed: Cut in wind speed from power curve

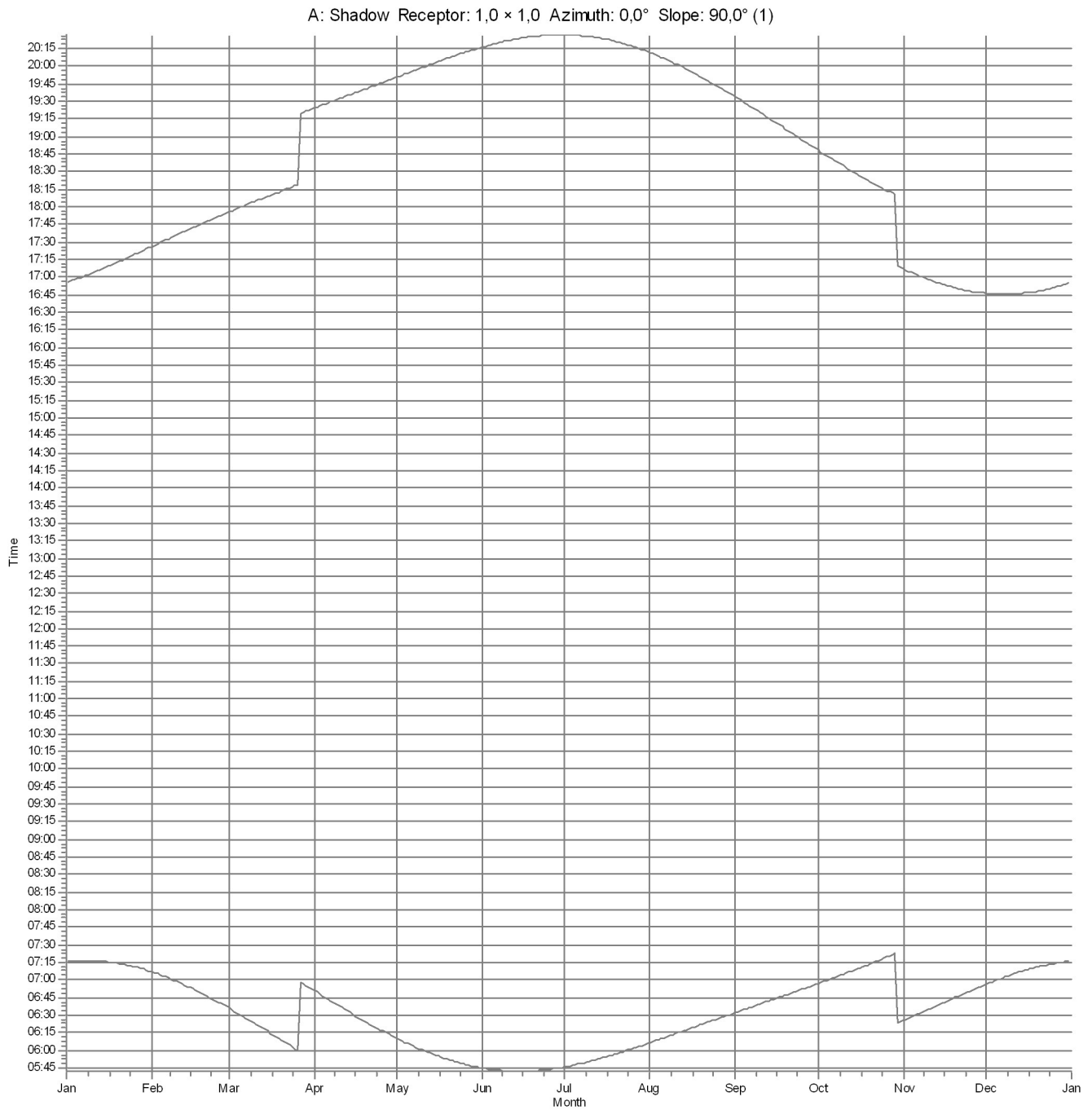
	January	February	March	April	May	June	July	August	September	October	November	December
1	07:16 16:55	07:06 17:26	06:36 17:55	06:50 19:24	06:10 19:50	05:45 20:16	05:45 20:26	06:06 20:11	06:32 19:33	06:57 18:48	06:25 17:06	06:56 16:46
2	07:16 16:56	07:06 17:27	06:34 17:56	06:49 19:25	06:09 19:51	05:44 20:17	05:46 20:26	06:07 20:10	06:33 19:32	06:57 18:46	06:26 17:05	06:57 16:46
3	07:16 16:57	07:05 17:28	06:33 17:57	06:47 19:25	06:07 19:52	05:44 20:17	05:46 20:26	06:08 20:09	06:34 19:30	06:58 18:45	06:27 17:04	06:58 16:45
4	07:16 16:57	07:04 17:29	06:31 17:58	06:46 19:26	06:06 19:53	05:44 20:18	05:47 20:26	06:09 20:08	06:34 19:29	06:59 18:44	06:28 17:03	06:59 16:45
5	07:16 16:58	07:03 17:30	06:30 17:59	06:45 19:27	06:05 19:54	05:43 20:18	05:43 20:26	06:09 20:07	06:35 19:27	07:00 18:42	06:29 17:02	07:00 16:45
6	07:16 16:59	07:02 17:31	06:29 18:00	06:43 19:28	06:04 19:55	05:43 20:19	05:48 20:26	06:10 20:06	06:36 19:26	07:01 18:41	06:30 17:01	07:00 16:45
7	07:17 17:00	07:01 17:32	06:27 18:01	06:42 19:29	06:03 19:56	05:43 20:20	05:48 20:26	06:11 20:05	06:37 19:24	07:02 18:39	06:31 17:00	07:01 16:45
8	07:17 17:01	07:00 17:33	06:26 18:02	06:40 19:30	06:02 19:57	05:43 20:20	05:49 20:25	06:12 20:04	06:38 19:23	07:03 18:38	06:32 16:59	07:02 16:45
9	07:16 17:02	06:59 17:34	06:24 18:03	06:39 19:31	06:01 19:57	05:42 20:21	05:50 20:25	06:13 20:03	06:38 19:21	07:03 18:36	06:33 16:58	07:03 16:45
10	07:16 17:03	06:58 17:36	06:23 18:04	06:37 19:32	06:00 19:58	05:42 20:21	05:50 20:25	06:14 20:02	06:39 19:20	07:04 18:35	06:34 16:58	07:04 16:45
11	07:16 17:04	06:57 17:37	06:22 18:05	06:36 19:33	05:59 19:59	05:42 20:22	05:51 20:25	06:14 20:01	06:40 19:18	07:05 18:33	06:35 16:57	07:05 16:45
12	07:16 17:05	06:56 17:38	06:20 18:06	06:34 19:33	05:58 20:00	05:42 20:22	05:51 20:24	06:15 20:00	06:41 19:17	07:06 18:32	06:37 16:56	07:05 16:45
13	07:16 17:06	06:55 17:39	06:19 18:07	06:33 19:34	05:57 20:01	05:42 20:23	05:52 20:24	06:16 19:58	06:42 19:15	07:07 18:30	06:38 16:55	07:06 16:46
14	07:16 17:07	06:54 17:40	06:17 18:07	06:32 19:35	05:56 20:02	05:42 20:23	05:53 20:23	06:17 19:57	06:42 19:14	07:08 18:29	06:39 16:54	07:07 16:46
15	07:15 17:08	06:53 17:41	06:16 18:08	06:30 19:36	05:55 20:03	05:42 20:24	05:53 20:23	06:18 19:56	06:43 19:12	07:09 18:28	06:40 16:54	07:08 16:46
16	07:15 17:09	06:52 17:42	06:14 18:09	06:29 19:37	05:55 20:04	05:42 20:24	05:54 20:22	06:19 19:55	06:44 19:11	07:10 18:26	06:41 16:53	07:08 16:46
17	07:15 17:10	06:51 17:43	06:13 18:10	06:27 19:38	05:54 20:04	05:42 20:24	05:55 20:22	06:19 19:54	06:45 19:09	07:11 18:25	06:42 16:52	07:09 16:47
18	07:15 17:11	06:49 17:44	06:11 18:11	06:26 19:39	05:53 20:05	05:42 20:25	05:55 20:21	06:20 19:52	06:46 19:08	07:12 18:24	06:43 16:51	07:10 16:47
19	07:14 17:12	06:48 17:45	06:10 18:12	06:25 19:40	05:52 20:06	05:42 20:25	05:56 20:21	06:21 19:51	06:47 19:06	07:13 18:22	06:44 16:51	07:10 16:47
20	07:14 17:13	06:47 17:46	06:08 18:13	06:23 19:41	05:51 20:07	05:42 20:25	05:57 20:20	06:22 19:50	06:47 19:05	07:13 18:21	06:45 16:50	07:11 16:48
21	07:13 17:14	06:46 17:47	06:07 18:14	06:22 19:41	05:51 20:08	05:42 20:25	05:58 20:20	06:23 19:48	06:48 19:03	07:14 18:20	06:46 16:50	07:11 16:48
22	07:13 17:15	06:45 17:48	06:05 18:15	06:21 19:42	05:50 20:08	05:43 20:26	05:58 20:19	06:24 19:47	06:49 19:02	07:15 18:18	06:47 16:49	07:12 16:49
23	07:12 17:16	06:43 17:49	06:04 18:16	06:19 19:43	05:49 20:09	05:43 20:26	05:59 20:18	06:24 19:46	06:50 19:00	07:16 18:17	06:48 16:49	07:13 16:49
24	07:12 17:17	06:42 17:50	06:02 18:17	06:18 19:44	05:49 20:10	05:43 20:26	06:00 20:18	06:25 19:44	06:51 18:59	07:17 18:16	06:49 16:48	07:13 16:50
25	07:11 17:18	06:41 17:51	06:01 18:17	06:17 19:45	05:48 20:11	05:43 20:26	06:01 20:17	06:26 19:43	06:51 18:57	07:18 18:15	06:50 16:48	07:13 16:50
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30	07:08 17:24		06:53 19:22	06:11 19:49	05:45 20:14	05:45 20:26	06:05 20:13	06:30 19:36	06:56 18:49	06:23 17:09	06:55 16:46	07:15 16:53
31	07:07 17:25		06:52 19:23		05:45 20:15		06:05 20:12	06:31 19:35		06:24 17:08		07:16 16:54
Potential sun hours	308	302	369	393	438	440	448	421	374	350	307	300
Total, worst case												
Sun reduction												
Oper. time red.												
Wind dir. red.												
Total reduction												
Total, real												

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)	First time (hh:mm) with flicker	(WTG causing flicker first time)
	Sun set (hh:mm)	Last time (hh:mm) with flicker	(WTG causing flicker last time)
	Minutes with flicker		

SHADOW - Calendar, graphical

Shadow receptor: A - Shadow Receptor: 1,0 × 1,0 Azimuth: 0,0° Slope: 90,0° (1)



WTGs

SHADOW - Calendar per WTG

WTG: 1 - GE WIND ENERGY 5.3-158 GT120 5500 158.0 !-! hub: 120,9 m (TOT: 199,9 m) (1)

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [GELA]

Reference year for calendar

2022

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
4,68 5,56 6,38 7,53 8,42 9,58 10,34 9,72 8,14 6,82 5,66 4,46

Operational time

N NNE ENE E ESE SSE S SSW WSW W WNW NNW Sum
659 545 576 641 455 349 343 472 625 1.007 1.049 654 7.375
Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:16 16:55	07:06 17:26	06:35 17:55	06:50 19:24	06:10 19:50	05:44 20:16	05:45 20:27	06:06 20:11	06:32 19:33	06:56 18:48	06:25 17:06	06:56 16:46
2	07:16 16:56	07:06 17:27	06:34 17:56	06:49 19:25	06:08 19:51	05:44 20:17	05:46 20:26	06:07 20:10	06:33 19:32	06:57 18:46	06:26 17:05	06:57 16:45
3	07:16 16:56	07:05 17:28	06:33 17:57	06:47 19:25	06:07 19:52	05:44 20:17	05:46 20:26	06:08 20:09	06:33 19:30	06:58 18:45	06:27 17:04	06:58 16:45
4	07:16 16:57	07:04 17:29	06:31 17:58	06:46 19:26	06:06 19:53	05:43 20:18	05:47 20:26	06:08 20:08	06:34 19:29	06:59 18:43	06:28 17:03	06:59 16:45
5	07:16 16:58	07:03 17:30	06:30 17:59	06:44 19:27	06:05 19:54	05:43 20:19	05:47 20:26	06:09 20:07	06:35 19:27	07:00 18:42	06:29 17:02	07:00 16:45
6	07:17 16:59	07:02 17:31	06:29 18:00	06:43 19:28	06:04 19:55	05:43 20:19	05:48 20:26	06:10 20:06	06:36 19:26	07:01 18:40	06:30 17:01	07:01 16:45
7	07:17 17:00	07:01 17:32	06:27 18:01	06:42 19:29	06:03 19:56	05:43 20:20	05:48 20:26	06:11 20:05	06:37 19:24	07:02 18:39	06:31 17:00	07:01 16:45
8	07:17 17:01	07:00 17:33	06:26 18:02	06:40 19:30	06:02 19:57	05:42 20:20	05:49 20:26	06:12 20:04	06:37 19:23	07:03 18:38	06:32 16:59	07:02 16:45
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Potential sun hours	307	302	369	393	438	440	448	421	374	350	307	300
Sum of minutes with flicker	0	0	0	0	0	0	0	0	0	0	0	0

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)	First time (hh:mm) with flicker	Last time (hh:mm) with flicker	Minutes with flicker
	Sun set (hh:mm)	First time (hh:mm) with flicker	Last time (hh:mm) with flicker	Minutes with flicker

SHADOW - Calendar per WTG

WTG: 2 - GE WIND ENERGY 5.5-158 GT120 5500 158.0 !-! hub: 120,9 m (TOT: 199,9 m) (3)

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [GELA]

Reference year for calendar

2022

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
4,68 5,56 6,38 7,53 8,42 9,58 10,34 9,72 8,14 6,82 5,66 4,46

Operational time

N NNE ENE E ESE SSE S SSW WSW W WNW NNW Sum
659 545 576 641 455 349 343 472 625 1.007 1.049 654 7.375
Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:16 16:55	07:06 17:25	06:35 17:55	06:50 19:24	06:09 19:50	05:44 20:16	05:45 20:26	06:06 20:11	06:32 19:33	06:56 18:48	06:25 17:06	06:56 16:46
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Potential sun hours	307	302	369	393	438	440	448	421	374	350	307	300
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Table layout: For each day in each month the following matrix apply

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	Sun set (hh:mm)	First time (hh:mm) with flicker	Last time (hh:mm) with flicker	Minutes with flicker

SHADOW - Calendar per WTG

WTG: 3 - GE WIND ENERGY 5.5-158 GT120 5500 158.0 !-! hub: 120,9 m (TOT: 199,9 m) (4)

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [GELA]

Reference year for calendar

2022

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
4,68 5,56 6,38 7,53 8,42 9,58 10,34 9,72 8,14 6,82 5,66 4,46

Operational time

N NNE ENE E ESE SSE S SSW WSW W WNW NNW Sum
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Idle start wind speed: Cut in wind speed from power curve

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Potential sun hours	307	302	369	393	438	440	448	421	374	350	307	300
Sum of minutes with flicker	0	0	0	0	0	0	0	0	0	0	0	0

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)	First time (hh:mm) with flicker	Last time (hh:mm) with flicker	Minutes with flicker
	Sun set (hh:mm)	First time (hh:mm) with flicker	Last time (hh:mm) with flicker	Minutes with flicker

SHADOW - Calendar per WTG

WTG: 4 - GE WIND ENERGY 5.5-158 GT120 5500 158.0 !-! hub: 120,9 m (TOT: 199,9 m) (5)

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [GELA]

Reference year for calendar

2022

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
4,68 5,56 6,38 7,53 8,42 9,58 10,34 9,72 8,14 6,82 5,66 4,46

Operational time

N NNE ENE E ESE SSE S SSW WSW W WNW NNW Sum
659 545 576 641 455 349 343 472 625 1.007 1.049 654 7.375
Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:16 16:55	07:06 17:25	06:35 17:55	06:50 19:24	06:09 19:50	05:44 20:16	05:45 20:26	06:06 20:11	06:32 19:33	06:56 18:48	06:25 17:06	06:56 16:46
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Potential sun hours	307	302	369	393	438	440	448	421	374	350	307	300
Sum of minutes with flicker	0	0	0	0	0	0	0	0	0	0	0	0

Table layout: For each day in each month the following matrix apply

Day in month Sun rise (hh:mm) Sun set (hh:mm) First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker
First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker

SHADOW - Calendar per WTG

WTG: 5 - GE WIND ENERGY 5.5-158 LT120 5500 158.0 !-! hub: 101,0 m (TOT: 180,0 m) (6)

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [GELA]

Reference year for calendar

2022

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
4,68 5,56 6,38 7,53 8,42 9,58 10,34 9,72 8,14 6,82 5,66 4,46

Operational time

N NNE ENE E ESE SSE S SSW WSW W WNW NNW Sum
659 545 576 641 455 349 343 472 625 1.007 1.049 654 7.375
Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:16 16:55	07:06 17:26	06:35 17:55	06:50 19:24	06:10 19:50	05:44 20:16	05:45 20:26	06:06 20:11	06:32 19:33	06:56 18:48	06:25 17:06	06:56 16:46
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31	07:07 17:24		06:52 19:23		05:45 20:15		06:05 20:12	06:31 19:35		06:24 17:07		07:16 16:54
Potential sun hours	307	302	369	393	438	440	448	421	374	350	307	300
Sum of minutes with flicker	0	0	0	0	0	0	0	0	0	0	0	0

Table layout: For each day in each month the following matrix apply

Day in month Sun rise (hh:mm) Sun set (hh:mm) First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker
First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker

SHADOW - Calendar per WTG

WTG: 6 - GE WIND ENERGY 5.5-158 GT120 5500 158.0 !-! hub: 120,9 m (TOT: 199,9 m) (7)

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [GELA]

Reference year for calendar

2022

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
4,68 5,56 6,38 7,53 8,42 9,58 10,34 9,72 8,14 6,82 5,66 4,46

Operational time

N NNE ENE E ESE SSE S SSW WSW W WNW NNW Sum
659 545 576 641 455 349 343 472 625 1.007 1.049 654 7.375
Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:16 16:55	07:06 17:26	06:35 17:55	06:50 19:24	06:09 19:50	05:44 20:16	05:45 20:26	06:06 20:11	06:32 19:33	06:56 18:48	06:25 17:06	06:56 16:46
2	07:16 16:56	07:06 17:27	06:34 17:56	06:49 19:24	06:08 19:51	05:44 20:17	05:46 20:26	06:07 20:10	06:33 19:32	06:57 18:46	06:26 17:05	06:57 16:45
3	07:16 16:56	07:05 17:28	06:33 17:57	06:47 19:25	06:07 19:52	05:44 20:17	05:46 20:26	06:08 20:09	06:33 19:30	06:58 18:45	06:27 17:04	06:58 16:45
4	07:16 16:57	07:04 17:29	06:31 17:58	06:46 19:26	06:06 19:53	05:43 20:18	05:47 20:26	06:08 20:08	06:34 19:29	06:59 18:43	06:28 17:03	06:59 16:45
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8	07:17 17:01	07:00 17:33	06:26 18:02	06:40 19:30	06:02 19:57	05:42 20:20	05:49 20:25	06:12 20:04	06:37 19:23	07:02 18:37	06:32 16:59	07:02 16:45
9	07:16 17:02	06:59 17:34	06:24 18:03	06:39 19:31	06:01 19:57	05:42 20:21	05:49 20:25	06:13 20:03	06:38 19:21	07:03 18:36	06:33 16:58	07:03 16:45
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Sum of minutes with flicker	0	0	0	0	0	0	0	0	0	0	0	0

Table layout: For each day in each month the following matrix apply

Day in month Sun rise (hh:mm) Sun set (hh:mm) First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker
First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker

SHADOW - Calendar per WTG

WTG: 7 - GE WIND ENERGY 5.5-158 GT120 5500 158.0 !-! hub: 120,9 m (TOT: 199,9 m) (8)

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [GELA]

Reference year for calendar

2022

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
4,68 5,56 6,38 7,53 8,42 9,58 10,34 9,72 8,14 6,82 5,66 4,46

Operational time

N NNE ENE E ESE SSE S SSW WSW W WNW NNW Sum
659 545 576 641 455 349 343 472 625 1.007 1.049 654 7.375
Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
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SHADOW - Calendar per WTG

WTG: 8 - GE WIND ENERGY 5.5-158 GT120 5500 158.0 !-! hub: 120,9 m (TOT: 199,9 m) (9)

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [GELA]

Reference year for calendar

2022

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

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20	07:14 17:12	06:47 17:46	06:08 18:13	06:23 19:40	05:51 20:07	05:42 20:25	05:57 20:20	06:22 19:50	06:47 19:05	07:13 18:21	06:45 16:50	07:11 16:47
21	07:13 17:14	06:46 17:47	06:07 18:14	06:22 19:41	05:50 20:08	05:42 20:25	05:57 20:20	06:23 19:48	06:48 19:03	07:14 18:19	06:46 16:49	07:11 16:48
22	07:13 17:15	06:44 17:48	06:05 18:15	06:21 19:42	05:50 20:08	05:42 20:26	05:58 20:19	06:23 19:47	06:49 19:02	07:15 18:18	06:47 16:49	07:12 16:48
23	07:12 17:16	06:43 17:49	06:04 18:15	06:19 19:43	05:49 20:09	05:43 20:26	05:59 20:18	06:24 19:46	06:50 19:00	07:16 18:17	06:48 16:48	07:12 16:49
24	07:12 17:17	06:42 17:50	06:02 18:16	06:18 19:44	05:48 20:10	05:43 20:26	06:00 20:18	06:25 19:44	06:50 18:58	07:17 18:16	06:49 16:48	07:13 16:49
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31	07:07 17:24		06:52 19:23		05:45 20:15		06:05 20:12	06:31 19:35		06:24 17:07		07:15 16:54
Potential sun hours	307	302	369	393	438	440	448	421	374	350	307	300
Sum of minutes with flicker	0	0	0	0	0	0	0	0	0	0	0	0

Table layout: For each day in each month the following matrix apply

Day in month Sun rise (hh:mm) Sun set (hh:mm) First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker
First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker

SHADOW - Calendar per WTG

WTG: 9 - GE WIND ENERGY 5.5-158 GT120 5500 158.0 !-! hub: 120,9 m (TOT: 199,9 m) (10)

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [GELA]

Reference year for calendar

2022

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
4,68 5,56 6,38 7,53 8,42 9,58 10,34 9,72 8,14 6,82 5,66 4,46

Operational time

N NNE ENE E ESE SSE S SSW WSW W WNW NNW Sum
659 545 576 641 455 349 343 472 625 1.007 1.049 654 7.375
Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:16 16:55	07:06 17:25	06:35 17:55	06:50 19:23	06:09 19:50	05:44 20:16	05:45 20:26	06:06 20:11	06:32 19:33	06:56 18:48	06:25 17:06	06:56 16:46
2	07:16 16:56	07:05 17:27	06:34 17:56	06:49 19:24	06:08 19:51	05:44 20:16	05:46 20:26	06:07 20:10	06:32 19:32	06:57 18:46	06:26 17:05	06:57 16:45
3	07:16 16:56	07:05 17:28	06:33 17:57	06:47 19:25	06:07 19:52	05:44 20:17	05:46 20:26	06:08 20:09	06:33 19:30	06:58 18:45	06:27 17:04	06:58 16:45
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Potential sun hours	307	302	369	393	438	440	448	421	374	350	307	300
Sum of minutes with flicker	0	0	0	0	0	0	0	0	0	0	0	0

Table layout: For each day in each month the following matrix apply

Day in month Sun rise (hh:mm) Sun set (hh:mm) First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker
First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker

SHADOW - Calendar per WTG

WTG: 10 - GE WIND ENERGY 5.5-158 LT120 5500 158.0 !-! hub: 101,0 m (TOT: 180,0 m) (11)

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [GELA]

Reference year for calendar

2022

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
4,68 5,56 6,38 7,53 8,42 9,58 10,34 9,72 8,14 6,82 5,66 4,46

Operational time

N NNE ENE E ESE SSE S SSW WSW W WNW NNW Sum
659 545 576 641 455 349 343 472 625 1.007 1.049 654 7.375
Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:16 16:55	07:06 17:25	06:35 17:55	06:50 19:23	06:09 19:50	05:44 20:16	05:45 20:26	06:06 20:11	06:32 19:33	06:56 18:48	06:25 17:06	06:56 16:46
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Potential sun hours	307	302	369	393	438	440	448	421	374	350	307	300
Sum of minutes with flicker	0	0	0	0	0	0	0	0	0	0	0	0

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)	First time (hh:mm) with flicker	Last time (hh:mm) with flicker	Minutes with flicker
	Sun set (hh:mm)	First time (hh:mm) with flicker	Last time (hh:mm) with flicker	Minutes with flicker

SHADOW - Calendar per WTG

WTG: 11 - GE WIND ENERGY 5.5-158 LT120 5500 158.0 !-! hub: 101,0 m (TOT: 180,0 m) (12)

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [GELA]

Reference year for calendar

2022

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
4,68 5,56 6,38 7,53 8,42 9,58 10,34 9,72 8,14 6,82 5,66 4,46

Operational time

N NNE ENE E ESE SSE S SSW WSW W WNW NNW Sum
659 545 576 641 455 349 343 472 625 1.007 1.049 654 7.375
Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
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Potential sun hours	307	302	369	393	438	440	448	421	374	350	307	300
Sum of minutes with flicker	0	0	0	0	0	0	0	0	0	0	0	0

Table layout: For each day in each month the following matrix apply

Day in month Sun rise (hh:mm) First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker
Sun set (hh:mm) First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker

SHADOW - Calendar per WTG

WTG: 12 - GE WIND ENERGY 5.5-158 LT120 5500 158.0 !-! hub: 101,0 m (TOT: 180,0 m) (13)

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [GELA]

Reference year for calendar

2022

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
4,68 5,56 6,38 7,53 8,42 9,58 10,34 9,72 8,14 6,82 5,66 4,46

Operational time

N NNE ENE E ESE SSE S SSW WSW W WNW NNW Sum
659 545 576 641 455 349 343 472 625 1.007 1.049 654 7.375
Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:16 16:55	07:06 17:25	06:35 17:55	06:50 19:23	06:09 19:50	05:44 20:16	05:45 20:26	06:06 20:11	06:32 19:33	06:56 18:48	06:25 17:06	06:56 16:45
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Potential sun hours	307	302	369	393	438	440	448	421	374	350	307	300
Sum of minutes with flicker	0	0	0	0	0	0	0	0	0	0	0	0

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)	First time (hh:mm) with flicker	Last time (hh:mm) with flicker	Minutes with flicker
	Sun set (hh:mm)	First time (hh:mm) with flicker	Last time (hh:mm) with flicker	Minutes with flicker

SHADOW - Calendar per WTG

WTG: 13 - GE WIND ENERGY 5.5-158 LT120 5500 158.0 !-! hub: 101,0 m (TOT: 180,0 m) (14)

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [GELA]

Reference year for calendar

2022

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
4,68 5,56 6,38 7,53 8,42 9,58 10,34 9,72 8,14 6,82 5,66 4,46

Operational time

N NNE ENE E ESE SSE S SSW WSW W WNW NNW Sum
659 545 576 641 455 349 343 472 625 1.007 1.049 654 7.375
Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:16 16:55	07:06 17:25	06:35 17:55	06:50 19:23	06:09 19:50	05:44 20:16	05:45 20:26	06:06 20:11	06:32 19:33	06:56 18:48	06:25 17:06	06:56 16:45
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28	07:09 17:21	06:37 17:54	06:56 19:20	06:13 19:47	05:46 20:13	05:44 20:26	06:03 20:14	06:28 19:39	06:54 18:52	07:21 18:11	06:53 16:46	07:14 16:52
29	07:08 17:22	06:36 17:55	06:55 19:21	06:12 19:48	05:46 20:14	05:44 20:26	06:03 20:13	06:29 19:37	06:55 18:51	07:22 18:10	06:54 16:46	07:15 16:52
30	07:08 17:23	06:35 17:56	06:54 19:22	06:11 19:49	05:45 20:14	05:45 20:26	06:04 20:13	06:30 19:36	06:55 18:49	06:23 17:08	06:55 16:46	07:15 16:53
31	07:07 17:24	06:34 17:57	06:53 19:23	06:10 19:50	05:45 20:15	05:45 20:26	06:05 20:12	06:31 19:34	06:24 17:07	06:24 16:57	06:56 16:46	07:15 16:54
Potential sun hours	307	302	369	393	438	440	448	421	374	350	307	300
Sum of minutes with flicker	0	0	0	0	0	0	0	0	0	0	0	0

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)	First time (hh:mm) with flicker	Last time (hh:mm) with flicker	Minutes with flicker
	Sun set (hh:mm)	First time (hh:mm) with flicker	Last time (hh:mm) with flicker	Minutes with flicker

SHADOW - Calendar per WTG

WTG: 14 - GE WIND ENERGY 5.5-158 LT120 5500 158.0 !-! hub: 101,0 m (TOT: 180,0 m) (15)

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [GELA]

Reference year for calendar

2022

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
4,68 5,56 6,38 7,53 8,42 9,58 10,34 9,72 8,14 6,82 5,66 4,46

Operational time

N NNE ENE E ESE SSE S SSW WSW W WNW NNW Sum
659 545 576 641 455 349 343 472 625 1.007 1.049 654 7.375
Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:16 16:55	07:06 17:25	06:35 17:55	06:50 19:23	06:09 19:50	05:44 20:16	05:45 20:26	06:06 20:11	06:32 19:33	06:56 18:48	06:25 17:06	06:56 16:45
2	07:16 16:56	07:05 17:27	06:34 17:56	06:49 19:24	06:08 19:51	05:44 20:16	05:46 20:26	06:07 20:10	06:32 19:32	06:57 18:46	06:26 17:05	06:57 16:45
3	07:16 16:56	07:05 17:28	06:33 17:57	06:47 19:25	06:07 19:52	05:44 20:17	05:46 20:26	06:07 20:09	06:33 19:30	06:58 18:45	06:27 17:04	06:58 16:45
4	07:16 16:57	07:04 17:29	06:31 17:58	06:46 19:26	06:06 19:53	05:43 20:18	05:47 20:26	06:08 20:08	06:34 19:29	06:59 18:43	06:28 17:03	06:59 16:45
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Potential sun hours	307	302	369	393	438	440	448	421	374	350	307	300
Sum of minutes with flicker	0	0	0	0	0	0	0	0	0	0	0	0

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)	First time (hh:mm) with flicker	Last time (hh:mm) with flicker	Minutes with flicker
	Sun set (hh:mm)	First time (hh:mm) with flicker	Last time (hh:mm) with flicker	Minutes with flicker

SHADOW - Calendar per WTG

WTG: 15 - GE WIND ENERGY 5.5-158 LT120 5500 158.0 !-! hub: 101,0 m (TOT: 180,0 m) (16)

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [GELA]

Reference year for calendar

2022

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
4,68 5,56 6,38 7,53 8,42 9,58 10,34 9,72 8,14 6,82 5,66 4,46

Operational time

N NNE ENE E ESE SSE S SSW WSW W WNW NNW Sum
659 545 576 641 455 349 343 472 625 1.007 1.049 654 7.375
Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:16 16:55	07:06 17:26	06:36 17:55	06:50 19:24	06:10 19:50	05:45 20:16	05:45 20:27	06:06 20:11	06:32 19:33	06:57 18:48	06:25 17:06	06:56 16:46
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31	07:07 17:25		06:52 19:23		05:45 20:15		06:05 20:12	06:31 19:35		06:24 17:08		07:16 16:54
Potential sun hours	307	302	369	393	438	440	448	421	374	350	307	300
Sum of minutes with flicker	0	0	0	0	0	0	0	0	0	0	0	0

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)	First time (hh:mm) with flicker	Last time (hh:mm) with flicker	Minutes with flicker
	Sun set (hh:mm)	First time (hh:mm) with flicker	Last time (hh:mm) with flicker	Minutes with flicker

SHADOW - Calendar per WTG

WTG: 16 - GE WIND ENERGY 5.5-158 LT120 5500 158.0 !-! hub: 101,0 m (TOT: 180,0 m) (17)

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [GELA]

Reference year for calendar

2022

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
4,68 5,56 6,38 7,53 8,42 9,58 10,34 9,72 8,14 6,82 5,66 4,46

Operational time

N NNE ENE E ESE SSE S SSW WSW W WNW NNW Sum
659 545 576 641 455 349 343 472 625 1.007 1.049 654 7.375
Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:16 16:55	07:06 17:26	06:36 17:55	06:50 19:24	06:10 19:50	05:45 20:16	05:45 20:27	06:06 20:11	06:32 19:33	06:57 18:48	06:25 17:06	06:56 16:46
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12	07:16 17:05	06:56 17:38	06:20 18:06	06:34 19:33	05:58 20:00	05:42 20:22	05:51 20:24	06:15 20:00	06:41 19:17	07:06 18:32	06:37 16:56	07:06 16:45
13	07:16 17:06	06:55 17:39	06:19 18:07	06:33 19:34	05:57 20:01	05:42 20:23	05:52 20:24	06:16 19:58	06:42 19:15	07:07 18:31	06:38 16:55	07:06 16:46
14	07:16 17:07	06:54 17:40	06:17 18:08	06:32 19:35	05:56 20:02	05:42 20:23	05:53 20:23	06:17 19:57	06:42 19:14	07:08 18:29	06:39 16:54	07:07 16:46
15	07:16 17:08	06:53 17:41	06:16 18:08	06:30 19:36	05:55 20:03	05:42 20:24	05:53 20:23	06:18 19:56	06:43 19:12	07:09 18:28	06:40 16:54	07:08 16:46
16	07:15 17:09	06:52 17:42	06:14 18:09	06:29 19:37	05:55 20:04	05:42 20:24	05:54 20:23	06:19 19:55	06:44 19:11	07:10 18:26	06:41 16:53	07:08 16:46
17	07:15 17:10	06:51 17:43	06:13 18:10	06:27 19:38	05:54 20:04	05:42 20:24	05:55 20:22	06:19 19:54	06:45 19:09	07:11 18:25	06:42 16:52	07:09 16:47
18	07:15 17:11	06:50 17:44	06:11 18:11	06:26 19:39	05:53 20:05	05:42 20:25	05:55 20:22	06:20 19:52	06:46 19:08	07:12 18:24	06:43 16:51	07:10 16:47
19	07:14 17:12	06:48 17:45	06:10 18:12	06:25 19:40	05:52 20:06	05:42 20:25	05:56 20:21	06:21 19:51	06:47 19:06	07:13 18:22	06:44 16:51	07:10 16:47
20	07:14 17:13	06:47 17:46	06:08 18:13	06:23 19:41	05:51 20:07	05:42 20:25	05:57 20:20	06:22 19:50	06:47 19:05	07:14 18:21	06:45 16:50	07:11 16:48
21	07:13 17:14	06:46 17:47	06:07 18:14	06:22 19:41	05:51 20:08	05:42 20:26	05:58 20:20	06:23 19:49	06:48 19:03	07:14 18:20	06:46 16:50	07:12 16:48
22	07:13 17:15	06:45 17:48	06:05 18:15	06:21 19:42	05:50 20:09	05:43 20:26	05:58 20:19	06:24 19:47	06:49 19:02	07:15 18:18	06:47 16:49	07:12 16:49
23	07:12 17:16	06:43 17:49	06:04 18:16	06:20 19:43	05:49 20:09	05:43 20:26	05:59 20:18	06:24 19:46	06:50 19:00	07:16 18:17	06:48 16:49	07:13 16:49
24	07:12 17:17	06:42 17:50	06:02 18:17	06:18 19:44	05:49 20:10	05:43 20:26	06:00 20:18	06:25 19:45	06:51 18:59	07:17 18:16	06:49 16:48	07:13 16:50
25	07:11 17:18	06:41 17:51	06:01 18:17	06:17 19:45	05:48 20:11	05:43 20:26	06:01 20:17	06:26 19:43	06:52 18:57	07:18 18:15	06:50 16:48	07:14 16:50
26	07:11 17:19	06:40 17:52	05:59 18:18	06:16 19:46	05:48 20:12	05:44 20:26	06:07 20:16	06:27 19:42	06:52 18:56	07:19 18:13	06:51 16:47	07:14 16:51
27	07:10 17:20	06:38 17:53	06:58 19:19	06:14 19:47	05:47 20:12	05:44 20:27	06:02 20:15	06:28 19:40	06:53 18:54	07:20 18:12	06:52 16:47	07:14 16:51
28	07:09 17:21	06:37 17:54	06:56 19:20	06:13 19:48	05:46 20:13	05:44 20:27	06:03 20:15	06:29 19:39	06:54 18:53	07:21 18:11	06:53 16:47	07:15 16:52
29	07:09 17:22		06:55 19:21	06:12 19:49	05:46 20:14	05:45 20:27	06:04 20:14	06:29 19:38	06:55 18:51	07:22 18:10	06:54 16:46	07:15 16:53
30	07:08 17:24		06:53 19:22	06:11 19:50	05:45 20:15	05:45 20:27	06:05 20:13	06:30 19:36	06:56 18:50	06:23 17:09	06:55 16:46	07:15 16:53
31	07:07 17:25		06:52 19:23		05:45 20:15		06:05 20:12	06:31 19:35		06:24 17:08		07:16 16:54
Potential sun hours	307	302	369	393	438	440	448	421	374	350	307	300
Sum of minutes with flicker	0	0	0	0	0	0	0	0	0	0	0	0

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)	First time (hh:mm) with flicker	Last time (hh:mm) with flicker	Minutes with flicker
	Sun set (hh:mm)	First time (hh:mm) with flicker	Last time (hh:mm) with flicker	Minutes with flicker

SHADOW - Calendar per WTG

WTG: 17 - GE WIND ENERGY 5.5-158 LT120 5500 158.0 !-! hub: 101,0 m (TOT: 180,0 m) (18)

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [GELA]

Reference year for calendar

2022

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
4,68 5,56 6,38 7,53 8,42 9,58 10,34 9,72 8,14 6,82 5,66 4,46

Operational time

N NNE ENE E ESE SSE S SSW WSW W WNW NNW Sum
659 545 576 641 455 349 343 472 625 1.007 1.049 654 7.375
Idle start wind speed: Cut in wind speed from power curve

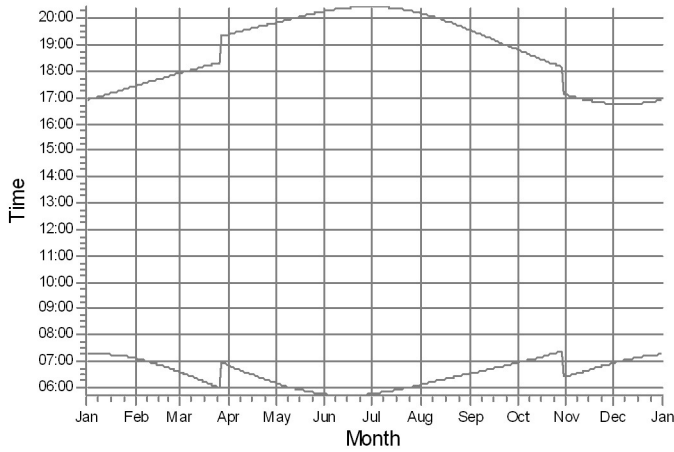
	January	February	March	April	May	June	July	August	September	October	November	December
1	07:16 16:55	07:06 17:26	06:36 17:55	06:50 19:24	06:10 19:50	05:45 20:16	05:45 20:27	06:06 20:11	06:32 19:33	06:57 18:48	06:25 17:07	06:56 16:46
2	07:16 16:56	07:06 17:27	06:34 17:56	06:49 19:25	06:09 19:51	05:44 20:17	05:46 20:27	06:07 20:10	06:33 19:32	06:57 18:47	06:26 17:05	06:57 16:46
3	07:16 16:57	07:05 17:28	06:33 17:57	06:47 19:25	06:07 19:52	05:44 20:17	05:46 20:26	06:08 20:09	06:34 19:30	06:58 18:45	06:27 17:04	06:58 16:45
4	07:16 16:57	07:04 17:29	06:31 17:58	06:46 19:26	06:06 19:53	05:44 20:18	05:47 20:26	06:09 20:08	06:34 19:29	06:59 18:44	06:28 17:03	06:59 16:45
5	07:17 16:58	07:03 17:30	06:30 17:59	06:45 19:27	06:05 19:54	05:43 20:19	05:47 20:26	06:09 20:07	06:35 19:27	07:00 18:42	06:29 17:02	07:00 16:45
6	07:17 16:59	07:02 17:31	06:29 18:00	06:43 19:28	06:04 19:55	05:43 20:19	05:48 20:26	06:10 20:06	06:36 19:26	07:01 18:41	06:30 17:01	07:01 16:45
7	07:17 17:00	07:01 17:32	06:27 18:01	06:42 19:29	06:03 19:56	05:43 20:20	05:48 20:26	06:11 20:05	06:37 19:25	07:02 18:39	06:31 17:00	07:01 16:45
8	07:17 17:01	07:00 17:33	06:26 18:02	06:40 19:30	06:02 19:57	05:43 20:20	05:49 20:26	06:12 20:04	06:38 19:23	07:03 18:38	06:32 16:59	07:02 16:45
9	07:17 17:02	06:59 17:34	06:24 18:03	06:39 19:31	06:01 19:58	05:42 20:21	05:50 20:25	06:13 20:03	06:38 19:22	07:03 18:36	06:33 16:59	07:03 16:45
10	07:16 17:03	06:58 17:36	06:23 18:04	06:37 19:32	06:00 19:58	05:42 20:21	05:50 20:25	06:14 20:02	06:39 19:20	07:04 18:35	06:35 16:58	07:04 16:45
11	07:16 17:04	06:57 17:37	06:22 18:05	06:36 19:33	05:59 19:59	05:42 20:22	05:51 20:25	06:14 20:01	06:40 19:18	07:05 18:33	06:36 16:57	07:05 16:45
12	07:16 17:05	06:56 17:38	06:20 18:06	06:34 19:33	05:58 20:00	05:42 20:22	05:51 20:24	06:15 20:00	06:41 19:17	07:06 18:32	06:37 16:56	07:06 16:45
13	07:16 17:06	06:55 17:39	06:19 18:07	06:33 19:34	05:57 20:01	05:42 20:23	05:52 20:24	06:16 19:58	06:42 19:15	07:07 18:31	06:38 16:55	07:06 16:46
14	07:16 17:07	06:54 17:40	06:17 18:08	06:32 19:35	05:56 20:02	05:42 20:23	05:53 20:23	06:17 19:57	06:42 19:14	07:08 18:29	06:39 16:54	07:07 16:46
15	07:16 17:08	06:53 17:41	06:16 18:08	06:30 19:36	05:55 20:03	05:42 20:24	05:53 20:23	06:18 19:56	06:43 19:12	07:09 18:28	06:40 16:54	07:08 16:46
16	07:15 17:09	06:52 17:42	06:14 18:09	06:29 19:37	05:55 20:04	05:42 20:24	05:54 20:23	06:19 19:55	06:44 19:11	07:10 18:26	06:41 16:53	07:08 16:46
17	07:15 17:10	06:51 17:43	06:13 18:10	06:27 19:38	05:54 20:04	05:42 20:24	05:55 20:22	06:19 19:54	06:45 19:09	07:11 18:25	06:42 16:52	07:09 16:47
18	07:15 17:11	06:50 17:44	06:11 18:11	06:26 19:39	05:53 20:05	05:42 20:25	05:55 20:22	06:20 19:52	06:46 19:08	07:12 18:24	06:43 16:52	07:10 16:47
19	07:14 17:12	06:48 17:45	06:10 18:12	06:25 19:40	05:52 20:06	05:42 20:25	05:56 20:21	06:21 19:51	06:47 19:06	07:13 18:22	06:44 16:51	07:10 16:47
20	07:14 17:13	06:47 17:46	06:08 18:13	06:23 19:41	05:51 20:07	05:42 20:25	05:57 20:20	06:22 19:50	06:47 19:05	07:14 18:21	06:45 16:50	07:11 16:48
21	07:13 17:14	06:46 17:47	06:07 18:14	06:22 19:41	05:51 20:08	05:42 20:26	05:58 20:20	06:23 19:48	06:48 19:03	07:14 18:20	06:46 16:50	07:12 16:48
22	07:13 17:15	06:45 17:48	06:05 18:15	06:21 19:42	05:50 20:09	05:43 20:26	05:58 20:19	06:24 19:47	06:49 19:02	07:15 18:18	06:47 16:49	07:12 16:49
23	07:12 17:16	06:43 17:49	06:04 18:16	06:20 19:43	05:49 20:09	05:43 20:26	05:59 20:18	06:24 19:46	06:50 19:00	07:16 18:17	06:48 16:49	07:13 16:49
24	07:12 17:17	06:42 17:50	06:02 18:17	06:18 19:44	05:49 20:10	05:43 20:26	06:00 20:18	06:25 19:45	06:51 18:59	07:17 18:16	06:49 16:48	07:13 16:50
25	07:11 17:18	06:41 17:51	06:01 18:17	06:17 19:45	05:48 20:11	05:43 20:26	06:01 20:17	06:26 19:43	06:52 18:57	07:18 18:15	06:50 16:48	07:14 16:50
26	07:11 17:19	06:40 17:52	05:59 18:18	06:16 19:46	05:48 20:12	05:44 20:26	06:07 20:16	06:27 19:42	06:52 18:56	07:19 18:13	06:51 16:47	07:14 16:51
27	07:10 17:20	06:38 17:53	06:58 19:19	06:14 19:47	05:47 20:12	05:44 20:26	06:02 20:15	06:28 19:40	06:53 18:54	07:20 18:12	06:52 16:47	07:14 16:51
28	07:09 17:21	06:37 17:54	06:56 19:20	06:13 19:48	05:46 20:13	05:44 20:27	06:03 20:15	06:29 19:39	06:54 18:53	07:21 18:11	06:53 16:47	07:15 16:52
29	07:09 17:22		06:55 19:21	06:12 19:49	05:46 20:14	05:45 20:27	06:04 20:14	06:29 19:38	06:55 18:51	07:22 18:10	06:54 16:46	07:15 16:53
30	07:08 17:24		06:53 19:22	06:11 19:50	05:45 20:15	05:45 20:27	06:05 20:13	06:30 19:36	06:56 18:50	06:23 17:09	06:55 16:46	07:15 16:53
31	07:07 17:25		06:52 19:23		05:45 20:15		06:05 20:12	06:31 19:35		06:24 17:08		07:16 16:54
Potential sun hours	307	302	369	393	438	440	448	421	374	350	307	300
Sum of minutes with flicker	0	0	0	0	0	0	0	0	0	0	0	0

Table layout: For each day in each month the following matrix apply

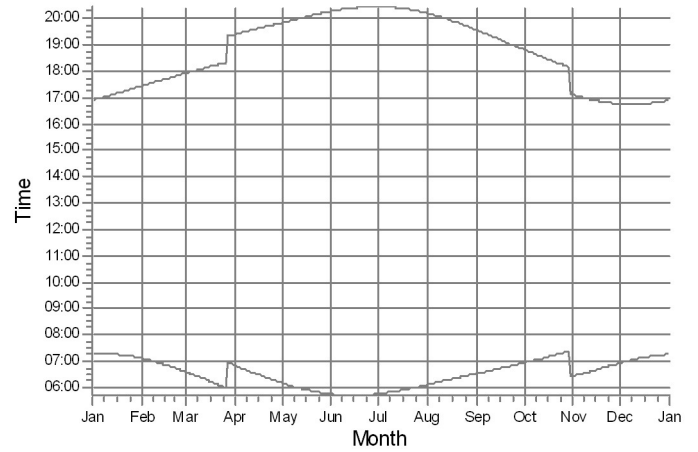
Day in month Sun rise (hh:mm) Sun set (hh:mm) First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker
First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker

SHADOW - Calendar per WTG, graphical

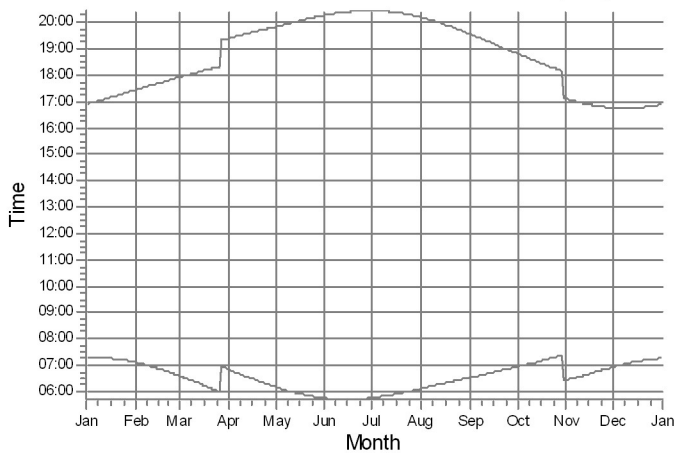
1: GE WIND ENERGY 5.3-158 GT120 5500 158.0 !hub: 120,9 m (TOT: 19



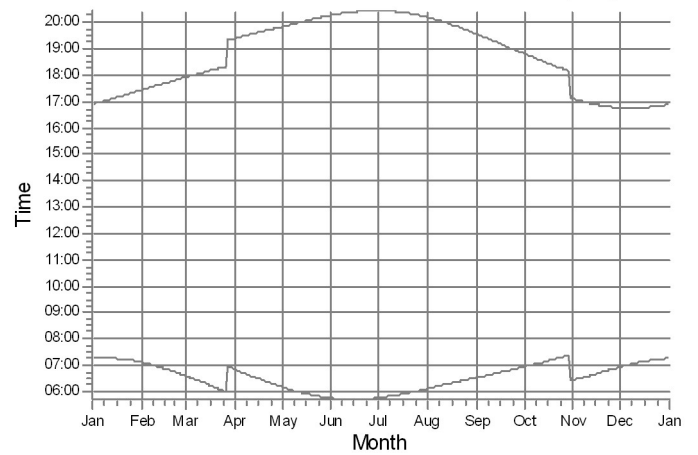
2: GE WIND ENERGY 5.5-158 GT120 5500 158.0 !hub: 120,9 m (TOT: 19



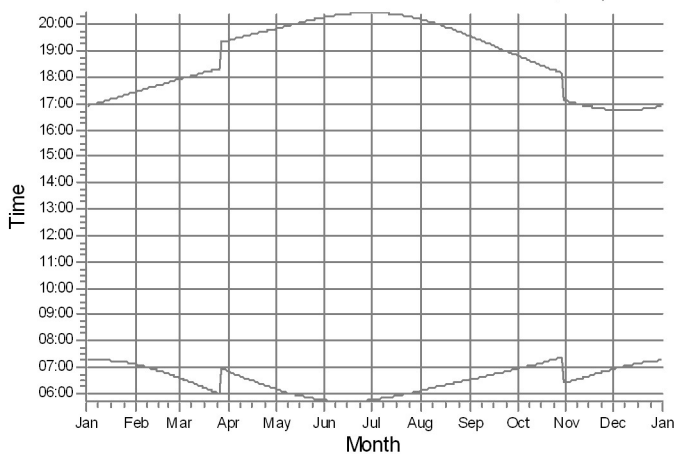
3: GE WIND ENERGY 5.5-158 GT120 5500 158.0 !hub: 120,9 m (TOT: 19



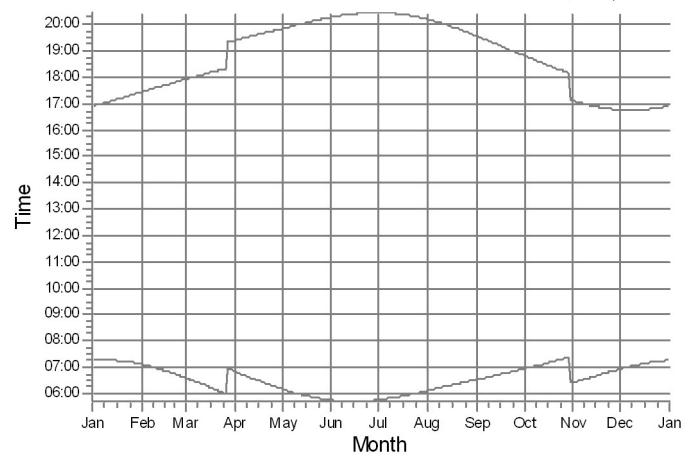
4: GE WIND ENERGY 5.5-158 GT120 5500 158.0 !hub: 120,9 m (TOT: 19



5: GE WIND ENERGY 5.5-158 LT120 5500 158.0 !hub: 101,0 m (TOT: 18



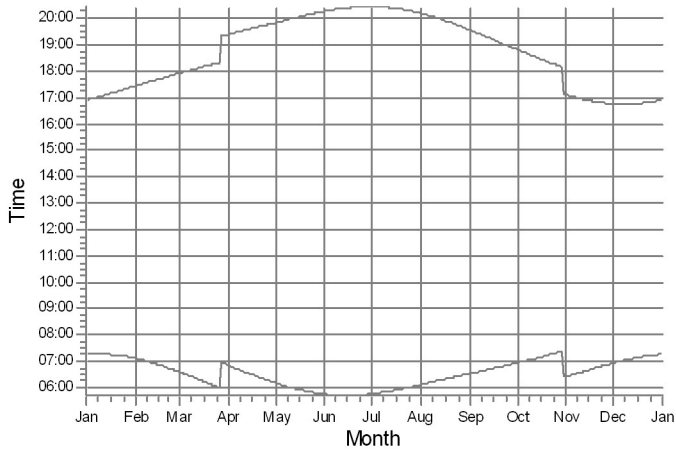
6: GE WIND ENERGY 5.5-158 GT120 5500 158.0 !hub: 120,9 m (TOT: 19



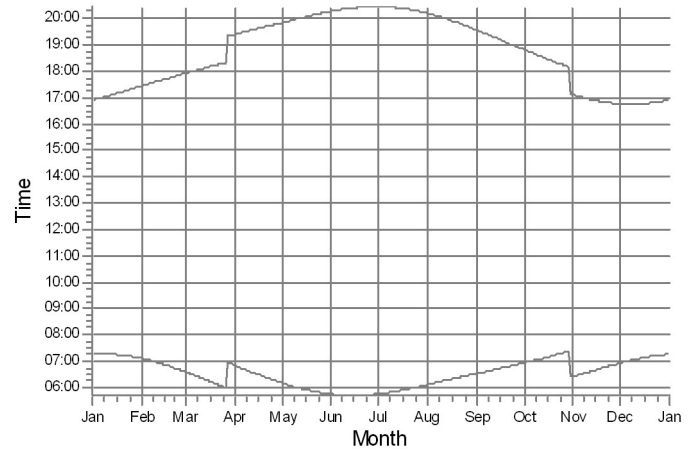
Shadow receptors

SHADOW - Calendar per WTG, graphical

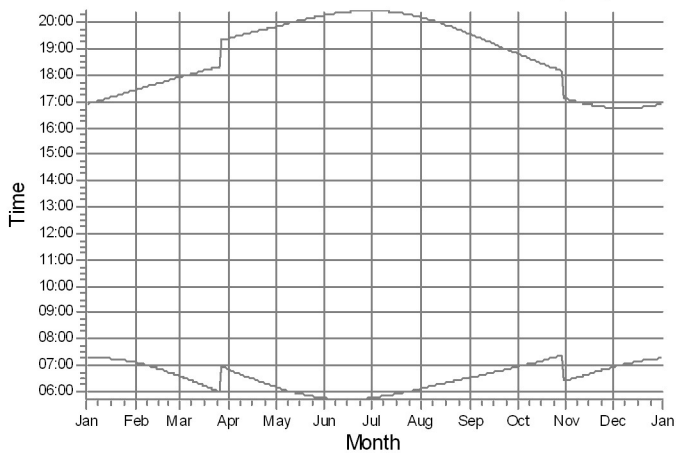
7: GE WIND ENERGY 5.5-158 GT120 5500 158.0 !hub: 120,9 m (TOT: 19



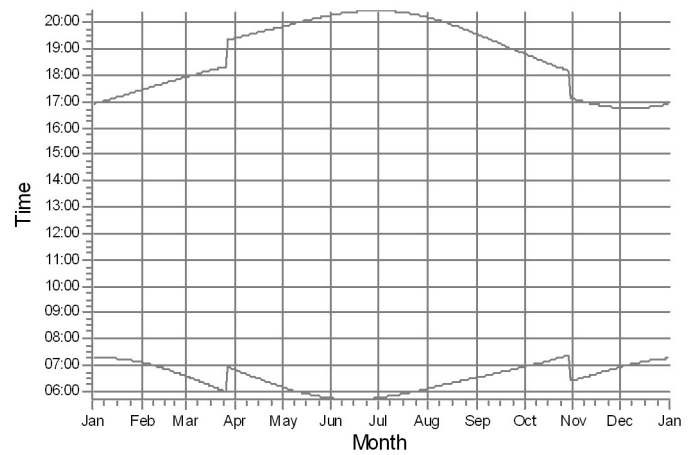
8: GE WIND ENERGY 5.5-158 GT120 5500 158.0 !hub: 120,9 m (TOT: 19



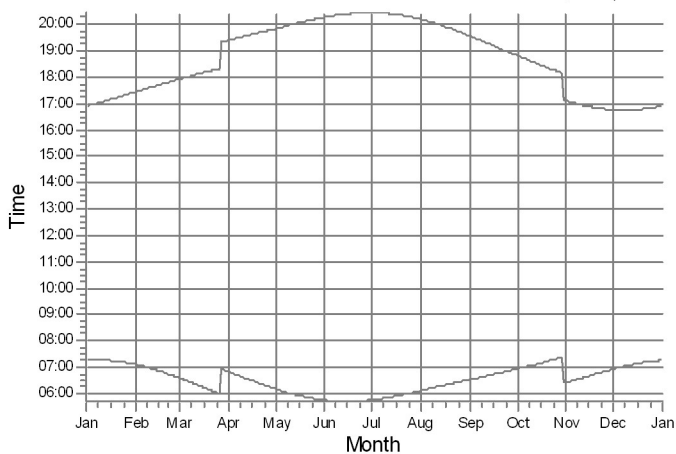
9: GE WIND ENERGY 5.5-158 GT120 5500 158.0 !hub: 120,9 m (TOT: 19



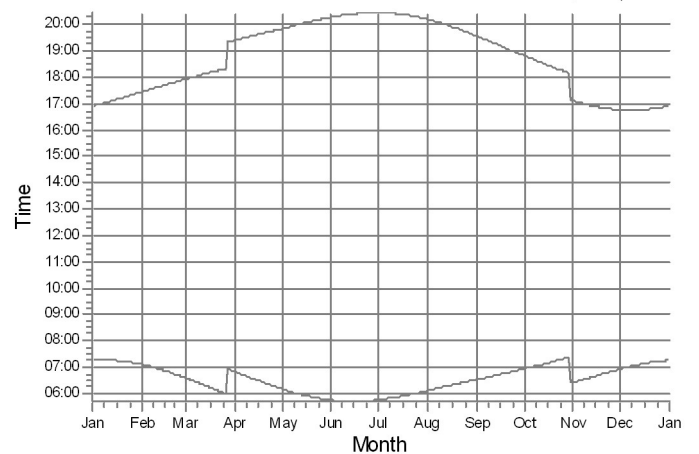
10: GE WIND ENERGY 5.5-158 LT120 5500 158.0 !hub: 101,0 m (TOT: 18



11: GE WIND ENERGY 5.5-158 LT120 5500 158.0 !hub: 101,0 m (TOT: 18



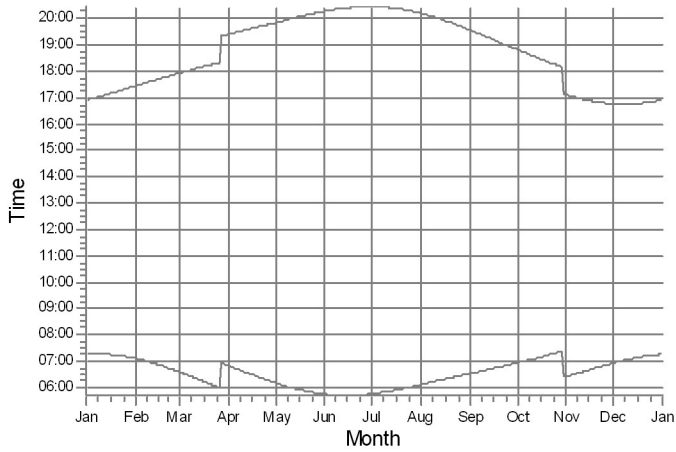
12: GE WIND ENERGY 5.5-158 LT120 5500 158.0 !hub: 101,0 m (TOT: 18



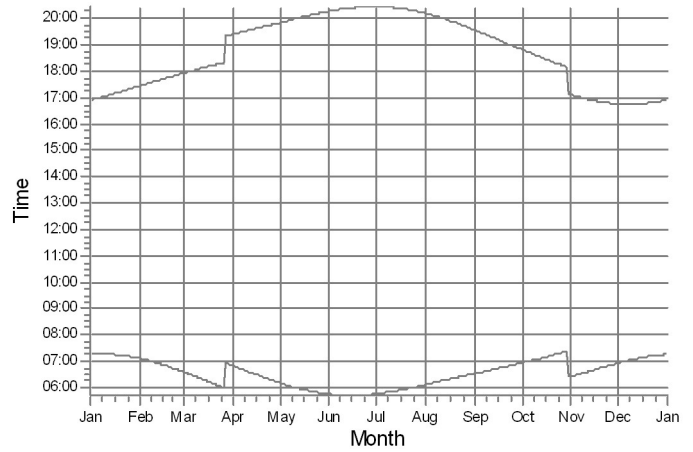
Shadow receptors

SHADOW - Calendar per WTG, graphical

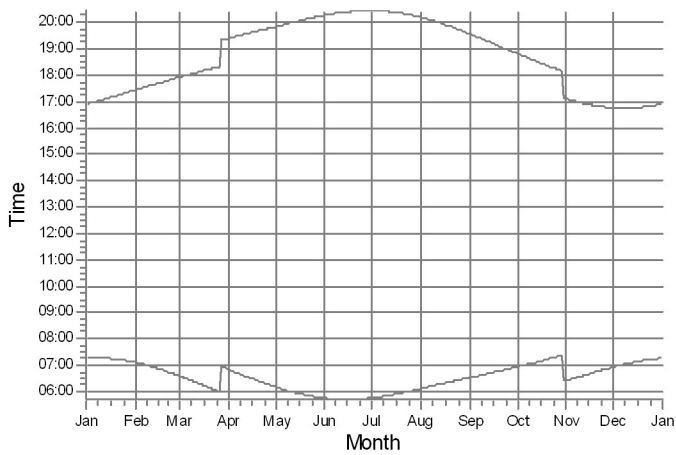
13: GE WIND ENERGY 5.5-158 LT120 5500 158.0 !-! hub: 101,0 m (TOT: 18



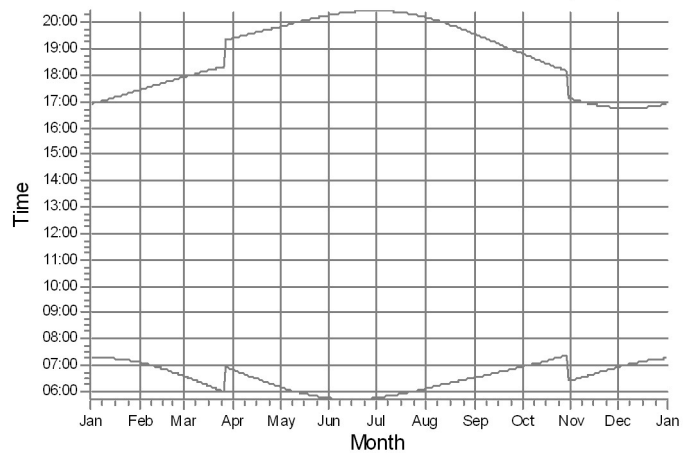
14: GE WIND ENERGY 5.5-158 LT120 5500 158.0 !-! hub: 101,0 m (TOT: 18



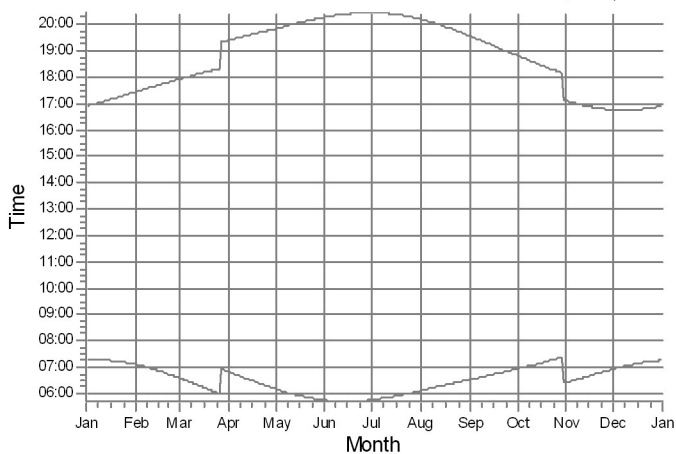
15: GE WIND ENERGY 5.5-158 LT120 5500 158.0 !-! hub: 101,0 m (TOT: 18



16: GE WIND ENERGY 5.5-158 LT120 5500 158.0 !-! hub: 101,0 m (TOT: 18

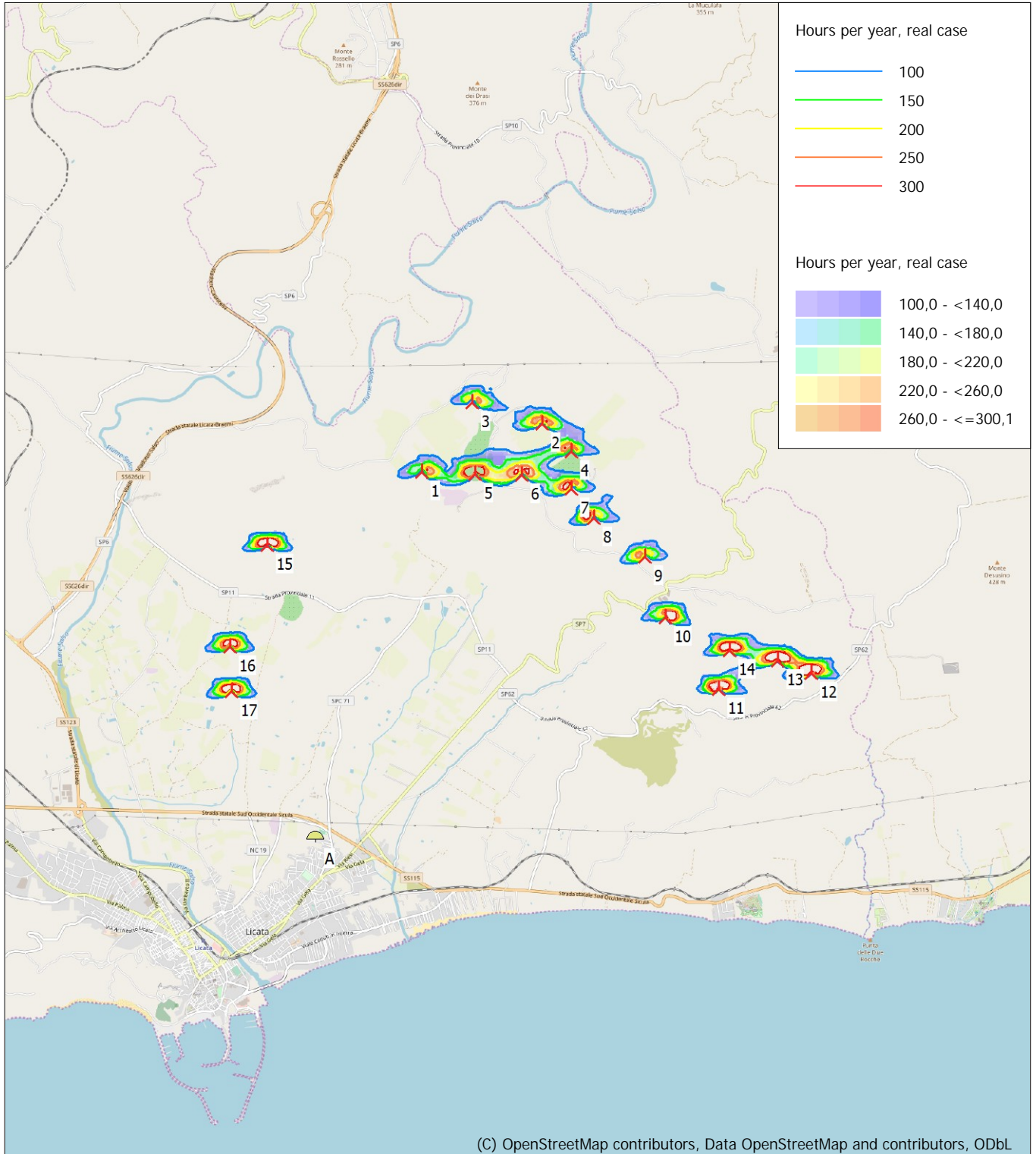


17: GE WIND ENERGY 5.5-158 LT120 5500 158.0 !-! hub: 101,0 m (TOT: 18



Shadow receptors

SHADOW - Map



Map: EMD OpenStreetMap , Print scale 1:75.000, Map center Geo WGS84 East: 13°59'07,15" E North: 37°08'56,57" N

New WTG

Shadow receptor

Flicker map level: Project Wizard Elevation Data Grid (Italian Elevation Model (TINITALY) - 10m)

Time step: 4 minutes, Day step: 14 days, Map resolution: 30 m, Visibility resolution: 15 m, Eye height: 1,5 m