Chapter 11:
Shadow Flicker

11.1 Introduction

11.1.1 Overview

This chapter addresses the potential impact of shadow flicker impacts to nearby properties within 1, 030 metres (Ten rotor diameters) from the proposed development. The assessment was carried out based the proposed 11 no. turbine layout with each turbine modelled for a hub height of 85meters and a rotor diameter of 103 meters.

GES Ltd was commissioned to undertake the shadow flicker assessment. The assessment has been carried in accordance with all statutory guidelines and uses methods which are recognised as best practice by the relevant environmental health organisations.

As with all tall structures, wind turbines can cast shadows on the neighbouring area when the sun is low in the sky. During sunny conditions under certain combinations of geographical position, meteorological conditions and the time of day, the sun may pass behind the moving rotor blades and cause a shadow to flicker on and off on neighbouring properties. This is known as shadow flicker. Nearby dwellings/buildings maybe affected by shadow flicker (i.e. when a turbine blade shadow passes an open door or window within a flicker zone) as the sunlight comes from one source. Shadow flicker is not as obvious outside as sunlight comes from all directions. The shadow flicker effect lasts only for a short period and happens only in certain specific combined circumstances such as when:

- The sun is shining and is at a low angle in the sky (after dawn and before sunset);
- The turbine is located directly between the sun and the affected property;
- The wind speed is high enough to move the turbine blades.

11.1.2 Methodology

11.1.2.1 Guidelines

The Wind Energy Development Guidelines for Planning Authorities 2006 state in respect of shadow flicker:

"Careful site selection, design and planning, and good use of relevant software, can help avoid the possibility of shadow flicker in the first instance. It is recommended that shadow flicker at neighbouring offices and dwellings within 500m should not exceed 30 hours per year or 30 minutes per day. At distances greater than 10 rotor diameters from a turbine, the potential for shadow flicker is very low. Where shadow flicker could be a problem, developers should provide calculations to quantify the effect and where appropriate take measures to prevent or ameliorate the potential effect, such as by turning off a particular turbine at certain times"

11.1.2.2 Passing Frequency

A periodic change in the light produced by the sun occurs at a particular location because of the rotating rotor. This is referred to as a pulsating light level. Research has shown that the consequences of the pulsating light level are dependent on the frequency. The frequency is determined by the speed of the rotor and the number of rotor blades in the case of wind turbines. From this research, including research done into the lighting of traffic tunnels, that most people tested experience the frequencies between 5 and 10 Hz virtually no nuisance is experienced. The proposed turbines to be installed have a typical rotational speed of 14.8rpm (revolutions per minute) and three rotor blades. The maximum passing frequency is, therefore 0.74Hz (44.4 times per minute), which is well below nuisance level. The effects of passing frequencies have, therefore, not been considered in this assessment.

11.1.2.3 Receptor Survey

The location of all properties near the proposed development was recorded using Ordnance Survey Ireland (OSI) data, a detailed planning registry search and a physical survey of the area. A total of 33

no. receptors within 1,030m radius (10 rotor diameters) of the proposed wind turbines were identified. The topography of the development and the elevation of nearby receptors was also modelled using OSI data.

11.1.2.4 Impact Prediction Model

WindPRO software, a detailed computer model which can estimate the possible occurrence of shadow flicker, was used to predict the likely impact of the proposed development. The calculations measured the minimum sun height of three degrees. The model is based on the proposed turbine specification, the exact co-ordinates of each receptor location relative to the proposed development and on historical meteorological data for this location.

It is important to note that each receptor is modelled in 'greenhouse' mode. This effectively assumes a conservative 'worst case' impact where each receptor is constructed entirely of glass (windows on all elevations) and that no intervening screening is afforded by walls, vegetation or other opaque objects.

11.1.2.5 Model Assumptions

Shadow flicker does not occur if the sun is not shining, therefore the probability of sunshine must be considered as part of this assessment. Historical metrological data from 1969 to 1993 from Kilkenny Met Station was used to assess the number of sunshine hours (20km from the proposed development site) (see **Table 11.1**)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.68	2.2	3.08	4.72	5.31	4.94	4.67	4.36	3.78	2.74	2.15	1.32

Table 11.1: Sunshine probability (Average daily sunshine hours)

A simple calculation using the above recorded data shows that the probability of sunshine is approximately 3.4 hours per day when averaged over a 12 month period. This will result in a significant decrease in the potential impact of shadow flicker when the 'worst case' scenario is adjusted.

There is a great difference in light level between a shadow at a short distance and a shadow at a long distance from the wind turbine. The potential impact is greatest at a short distance since the rotor blade screens the whole of the sun at a short distance. Shadows at a greater distance from the wind turbine have a low intensity since the blades no longer cover the sun completely and, therefore, the light contrast is strongly reduced. If an observer experiences shadow from the sun when it is lower than three degrees above the horizon, the distance to the wind turbine will be of such a great length that it is likely that the consequences of the intensity of the shadow can be ignored. Sunshine is, moreover, tempered by mist, cirrus clouds, vegetation growth or buildings in the surrounding area when the position of the sun is lower than three degrees. To account for this, the sun's minimum angle has been set at three degrees in the shadow flicker model.

The GE3.2-103 wind turbine, which is anticipated to be used on the site, has a cut in wind speed of 3m/s and cut out of 25m/s. According to the wind atlas, the average adjusted wind speed over the site is approximately 8.25m/s at 85 metres. Typically in Ireland, this wind speed is between 3 and 25m/s for 85% of the time (based on an average of 8m/s). Therefore the turbines are likely to be operational for 85% of the year.

The shadow flicker model assumes that the turbine rotor is rotating 100% of the time. Therefore, the model is conservative and it does not account for the turbine rotor not rotating due to grid unavailability, turbine maintenance and turbine breakdown. The turbine is likely to be non-operational for 4% of the time due to the above conditions.

Wind direction also plays an important role in the occurrence of shadow flicker. A wind turbine directs the rotor at right angles to the wind direction (turns the rotors to face the wind) when there is sufficient wind. The wind direction is, therefore, the determining factor for the position of the

rotor and also for the position of the rotor in relation to the sun. It is unlikely that the wind turbines will consistently fall to the 'worst case' scenario where the wind turbine is facing directly into or away from the sun. This factor has not been calculated into the assessment.

In summary, the 'worst case' shadow flicker calculation makes a number of conservative assumptions. For example, the model assumes a situation where the sun is always shining, there is adequate wind speed constantly, and when the wind and that the turbine rotor tracks the sun by yawing the turbine exactly as the sun moves. Model assumptions also include the following:

- The model uses Ordnance Survey Ireland digital data as its only topographical reference. Simulations are run on a "lunar landscape" without allowing for the obscuring effect of vegetation between the location of the residence and the position of the sun in the sky. Nor does the model consider any obscuring features around residences itself, which would minimise views of the site and hence reduce the potential for shadow flicker;
- The model operates on the assumption that sunny conditions coincide with the times of which shadow flicker will occur at each dwelling. During periods of cloudy, over-cast conditions shadow flicker will not occur;
- An assumption is made that the windows of the rooms where the effects may occur directly face the development and that the rooms are occupied and that the curtains or blinds if present are open;
- There will be no downtime for any of the turbines as a result of a mechanical fault, grid availability or routine maintenance.

It is important to stress that over the course of a year, it can be assumed in the model that it will be sunny a percentage of the year and to de-rate the 'worst case' predictions accordingly to find the 'expected' shadow flicker hours. However, over the course of a day, it cannot be assumed that it will only be sunny for a percentage of the day (it may be sunny all day). Therefore, it is not possible to de-rate the 'worst case' predictions to find the 'expected' shadow flicker hours over the course of a day. Therefore, the values presented in this chapter show conservative 'worst case' hours per day (in accordance with a precautionary approach) and 'expected' hours per year.

The 'worst case' calculations (hours per day) necessarily significantly over estimate the number of hours of shadow flicker per day experienced at any location. On the other hand, the 'expected' values (hours per year) consider the probability of sunshine at the proposed development site and therefore is more representative of the actual levels of shadow flicker which may be experienced. The percentage probability of sunshine is based on historical meteorological records for the area. Notably, the expected values cannot consider all of the variables which contribute to reduced levels of shadow flicker and as such these values also represent an over-estimation of the actual impact.

11.2 Description of the Existing Environment

The receiving baseline environment is rural and remote and as a result, the area is sparsely populated. Receptors in this area consist mainly of 'one-off' houses and isolated farm out-buildings. A total of 33 no. receptors have been identified within 1,030 metres of a proposed wind turbine (ten rotor diameters) (see **Figure 11.1**).

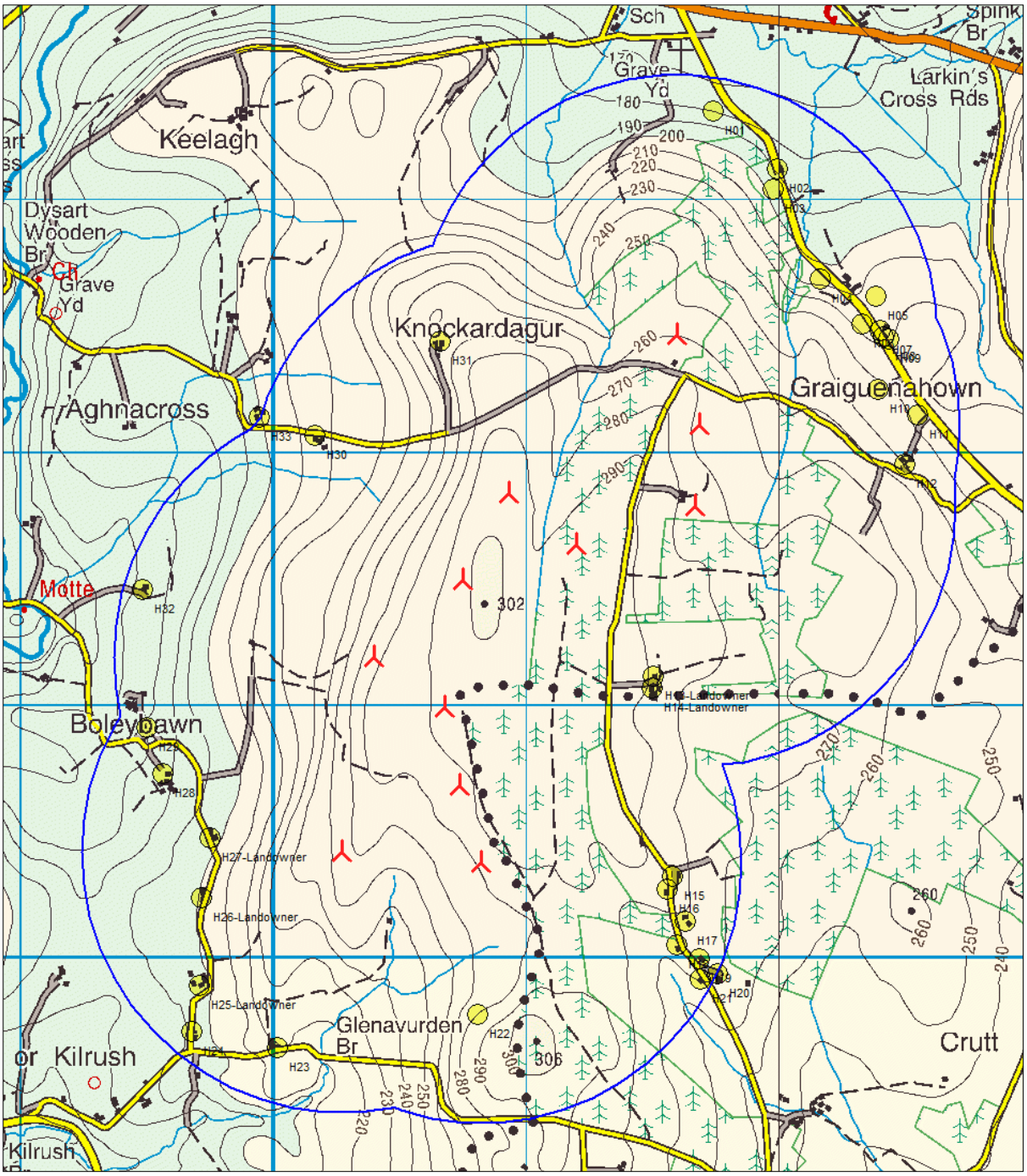


Figure 11.1: Setback map to dwellings/properties within 1,030m radius (10 rotor diameters) of proposed wind turbines

11.3 Description of Likely Impacts

11.3.1 Construction Phase

As the proposed turbines will not be operational during the construction phase there shall be no impact from shadow flicker.

11.3.2 Operational Phase

The 'worst case' results indicate that 21 no. receptors out of 33 no. receptors within a ten rotor diameter exceed 30 minutes per day. However, as explained above, it is reiterated that this calculation is a 'worst case' scenario and not representative of actual conditions. As explained above, this 'worst case' scenario will only occur under specific exceptional and circumstances when

the sun is at a certain position in the sky, the sun is shining, the turbines rotor is rotating and the turbine rotor is perpendicular to the shadow receptor.

Following this analysis, the variables outlined above were considered to calculate a more accurate expected prediction for shadow flicker over the course of a year. This de-rated calculation produced significantly different results and, as would be expected, predicts much lower levels of shadow flicker.

The shadow flicker results are detailed in **Table 11.2** and **Appendix 11.1** which shows the results of both shadow flicker calculations, indicating all receptors within ten rotor diameter which may be affected by shadow flicker. The table shows that none of the 33 no. receptors surveyed are predicted to experience shadow flicker in excess of 30 hours per annum. The highest predictions of shadow flicker relates to H26, H13 and H14 at approximately 18:07 hours, 15:49 hours and 14:46 hours per annum respectively. Notably all of these receptors are economically involved in the proposed development. All the remaining receptors will experience less than 30 hours per year, with 21 no. dwellings experiencing less than 10 hours per year.

As the predicted impact of shadow flicker will not exceed the allowable limits of 30 hours per year, mitigation by design has therefore reduced the potential impact of shadow flicker as far as is reasonably possible and the location of each proposed turbine has been carefully chosen to reduce the potential impact in relation to shadow flicker. A small amount of turbine curtailment may be required to ensure no dwellings experience more than 30 minutes per day. This can be achieved through accepted technological mitigation.

Dwelling ID	*Max Shadow hours per day ('Worst Case')*	*Shadow hours per year ('Expected')*
H01	00:15	00:24
H02	00:33	04:54
H03	00:50	06:25
H04	00:42	12:11
H05	00:30	08:16
H06	00:48	10:56
H07	00:36	08:48
H08	00:36	08:46
H09	00:36	08:22
H10	00:46	11:35
H11	00:30	07:48
H12	00:41	12:01
H13-Landowner	00:31	15:49
H14-Landowner	00:31	14:46
H15	00:32	08:23
H16	00:33	10:12
H17	00:30	08:34
H18	00:30	06:33
H19	00:27	05:32
H20	00:25	04:47
H21	00:27	06:07
H22	00:00	00:00
H23	00:00	00:00

H24	00:20	02:33
H25-Landowner	00:21	03:00
H26-Landowner	01:04	18:07
H27-Landowner	00:47	13:45
H28	00:48	08:43
H29	00:40	13:02
H30	00:44	09:12
H31	01:06	10:22
H32	00:25	08:15
H33	00:42	06:30

Table 11.2: Shadow Flicker Results

11.3.3 Decommissioning Phase

As the proposed turbines will not be operational during the decommissioning phase, there shall be no impact from shadow flicker.

11.4 Mitigation & Monitoring Measures

11.4.1 Construction Phase

No mitigation measures are required for the construction phase.

11.4.2 Operational Phase

Should it be required, effective technological solutions exist for shadow flicker monitoring and mitigation and are routinely included as conditions of consent for wind energy developments by Planning Authorities and An Bord Pleanála. Technological mitigation involves fitting a sensor to a turbine in a central location of the proposed development. Sensors may also be fitted to nearby properties. A number of site visits will then be carried out by a suitably qualified consultant at times to monitor the site when shadow flicker is predicted to occur. This on-site monitoring and data collection is then used to validate the accuracy of the shadow flicker model and the predicted impact at nearby receptors. The data collected will include:-

- The date, time, location (turbine ID) and duration of the measurement;
- Sunlight intensity;
- Wind speed;
- Wind direction/rotor angle.

Details of the equipment calibration will be noted to ensure accurate readings are taken. This will include the time and date of the calibration, the calibration level and the result.

Where shadow flicker levels are proven to be in excess of the recommended limits, the turbines can be simply programmed to automatically shut down where excessive shadow flicker levels occur. This approach will be implemented, as necessary, to ensure that the 20 no. dwelling predicted in the 'worst case' scenario do not exceed 30 minutes per day. The amount of turbine curtailment required to ensure this will have a negligible impact on the overall energy output of the wind farm.

As a consequence, routine technological mitigation measures exist to entirely exclude any adverse impact from shadow flicker on residential properties in the environs of the subject site.

11.4.3 Decommissioning

No mitigation measures are proposed during the decommissioning phase.

Appendix 11.1: Shadow Flicker Results

Project:
Pinewoods Wind Farm

Description:
Sunshine statistics based on data from1969-1993 from Kilkenny Met Station which is located 20km from the proposed site.
Wind Rose data based on 24 months data from an 80meter mast located on the proposed site.

Licensed user:
Galetech Energy Services
Cootehill Enterprise Park, Cootehill
IE-CO. Cavan
+353 86 8222803

Calculated:
13/04/2016 17:53/2.8.579

SHADOW - Main Result

Calculation: Shadow Flicker Predictions

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) [KILKENNY]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.68	2.20	3.08	4.72	5.31	4.94	4.67	4.36	3.78	2.74	2.15	1.32

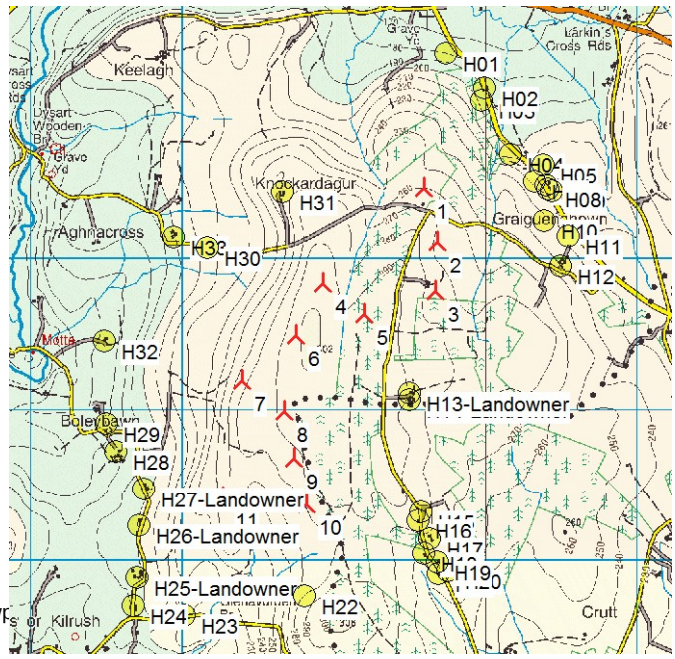
Operational time

N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW
205	237	241	239	162	254	897	481	739	775	838	1,100

W	WNW	NW	NNW	Sum
1,051	812	440	289	8,760

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_0.wp
Obstacles used in calculation
Eye height: 1.5 m
Grid resolution: 10.0 m



Scale 1:50,000

New WTG Shadow receptor

WTGs

	Irish Grid (IG)-IRELAND65 (IE) East	North	Z [m]	Row data/Description	WTG type Valid	Manufact.	Type-generator	Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Shadow data Calculation distance [m]	RPM [RPM]
1	251,604	182,460	258.7	T1	Yes	GE WIND ENERGY	GE 3.2 -103-3,200	3,200	103.0	85.0	1,600	14.8
2	251,693	182,105	267.5	T2	Yes	GE WIND ENERGY	GE 3.2 -103-3,200	3,200	103.0	85.0	1,600	14.8
3	251,676	181,781	273.2	T3	Yes	GE WIND ENERGY	GE 3.2 -103-3,200	3,200	103.0	85.0	1,600	14.8
4	250,937	181,833	297.7	T4	Yes	GE WIND ENERGY	GE 3.2 -103-3,200	3,200	103.0	85.0	1,600	14.8
5	251,205	181,628	299.3	T5	Yes	GE WIND ENERGY	GE 3.2 -103-3,200	3,200	103.0	85.0	1,600	14.8
6	250,756	181,489	302.7	T6	Yes	GE WIND ENERGY	GE 3.2 -103-3,200	3,200	103.0	85.0	1,600	14.8
7	250,403	181,186	278.9	T7	Yes	GE WIND ENERGY	GE 3.2 -103-3,200	3,200	103.0	85.0	1,600	14.8
8	250,682	180,984	292.8	T8	Yes	GE WIND ENERGY	GE 3.2 -103-3,200	3,200	103.0	85.0	1,600	14.8
9	250,742	180,675	291.0	T9	Yes	GE WIND ENERGY	GE 3.2 -103-3,200	3,200	103.0	85.0	1,600	14.8
10	250,826	180,372	287.6	T10	Yes	GE WIND ENERGY	GE 3.2 -103-3,200	3,200	103.0	85.0	1,600	14.8
11	250,276	180,413	260.8	T11	Yes	GE WIND ENERGY	GE 3.2 -103-3,200	3,200	103.0	85.0	1,600	14.8

Shadow receptor-Input

No.	Name	Irish Grid (IG)-IRELAND65 (IE) East	North	Z [m]	Width [m]	Height [m]	Height a.g.l. [m]	Degrees from south cw [°]	Slope of window [°]	Direction mode
A	H01	251,747	183,345	179.5	2.0	2.0	0.5	0.0	90.0	"Green house mode"
B	H02	252,003	183,118	189.9	2.0	2.0	0.5	0.0	90.0	"Green house mode"
C	H03	251,985	183,038	196.4	2.0	2.0	0.5	0.0	90.0	"Green house mode"
D	H04	252,171	182,682	208.9	2.0	2.0	0.5	0.0	90.0	"Green house mode"
E	H05	252,389	182,614	212.0	2.0	2.0	0.5	0.0	90.0	"Green house mode"
F	H06	252,334	182,504	217.9	2.0	2.0	0.5	0.0	90.0	"Green house mode"
G	H07	252,407	182,475	217.6	2.0	2.0	0.5	0.0	90.0	"Green house mode"
H	H08	252,419	182,452	218.8	2.0	2.0	0.5	0.0	90.0	"Green house mode"
I	H09	252,443	182,442	219.0	2.0	2.0	0.5	0.0	90.0	"Green house mode"
J	H10	252,398	182,245	230.0	2.0	2.0	0.5	0.0	90.0	"Green house mode"
K	H11	252,554	182,144	226.2	2.0	2.0	0.5	0.0	90.0	"Green house mode"
L	H12	252,505	181,946	240.1	2.0	2.0	0.5	0.0	90.0	"Green house mode"

To be continued on next page...

Project:
Pinewoods Wind Farm

Description:
Sunshine statistics based on data from1969-1993 from Kilkenny Met Station which is located 20km from the proposed site.
Wind Rose data based on 24 months data from an 80meter mast located on the proposed site.

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+353 86 8222803

Calculated:
13/04/2016 17:53/2.8.579

SHADOW - Main Result

Calculation: Shadow Flicker Predictions

...continued from previous page

No.	Name	Irish Grid (IG)-IRELAND65 (IE) East	North	Z	Width	Height	Height a.g.l.	Degrees from south cw	Slope of window	Direction mode
				[m]	[m]	[m]	[m]	[°]	[°]	
M	H13-Landowner	251,509	181,108	286.4	2.0	2.0	0.5	0.0	90.0	"Green house mode"
N	H14-Landowner	251,504	181,064	286.4	2.0	2.0	0.5	0.0	90.0	"Green house mode"
O	H15	251,584	180,317	281.7	2.0	2.0	0.5	0.0	90.0	"Green house mode"
P	H16	251,563	180,264	282.8	2.0	2.0	0.5	0.0	90.0	"Green house mode"
Q	H17	251,638	180,140	276.5	2.0	2.0	0.5	0.0	90.0	"Green house mode"
R	H18	251,603	180,046	273.4	2.0	2.0	0.5	0.0	90.0	"Green house mode"
S	H19	251,691	179,992	270.9	2.0	2.0	0.5	0.0	90.0	"Green house mode"
T	H20	251,763	179,930	266.8	2.0	2.0	0.5	0.0	90.0	"Green house mode"
U	H21	251,697	179,912	266.9	2.0	2.0	0.5	0.0	90.0	"Green house mode"
V	H22	250,816	179,769	278.8	2.0	2.0	0.5	0.0	90.0	"Green house mode"
W	H23	250,021	179,640	215.1	2.0	2.0	0.5	0.0	90.0	"Green house mode"
X	H24	249,684	179,702	193.7	2.0	2.0	0.5	0.0	90.0	"Green house mode"
Y	H25-Landowner	249,712	179,885	196.4	2.0	2.0	0.5	0.0	90.0	"Green house mode"
Z	H26-Landowner	249,723	180,232	200.3	2.0	2.0	0.5	0.0	90.0	"Green house mode"
AA	H27-Landowner	249,755	180,471	197.1	2.0	2.0	0.5	0.0	90.0	"Green house mode"
AB	H28	249,570	180,722	179.3	2.0	2.0	0.5	0.0	90.0	"Green house mode"
AC	H29	249,506	180,906	170.2	2.0	2.0	0.5	0.0	90.0	"Green house mode"
AD	H30	250,173	182,064	215.9	2.0	2.0	0.5	0.0	90.0	"Green house mode"
AE	H31	250,665	182,436	264.8	2.0	2.0	0.5	0.0	90.0	"Green house mode"
AF	H32	249,491	181,450	162.4	2.0	2.0	0.5	0.0	90.0	"Green house mode"
AG	H33	249,951	182,134	198.5	2.0	2.0	0.5	0.0	90.0	"Green house mode"

Calculation Results

Shadow receptor

No.	Name	Shadow, worst case Shadow hours per year [h/year]	Shadow days per year [days/year]	Max shadow hours per day [h/day]	Shadow, expected values Shadow hours per year [h/year]
A	H01	3:54	20	0:15	0:24
B	H02	37:54	86	0:33	4:54
C	H03	47:08	97	0:50	6:25
D	H04	80:29	164	0:42	12:11
E	H05	51:56	146	0:30	8:16
F	H06	64:30	152	0:48	10:56
G	H07	50:27	133	0:36	8:48
H	H08	49:39	131	0:36	8:46
I	H09	47:09	125	0:36	8:22
J	H10	63:05	153	0:46	11:35
K	H11	40:01	114	0:30	7:48
L	H12	62:16	161	0:41	12:01
M	H13-Landowner	91:34	252	0:31	15:49
N	H14-Landowner	85:05	248	0:31	14:46
O	H15	40:53	130	0:32	8:23
P	H16	50:58	140	0:33	10:12
Q	H17	43:38	130	0:30	8:34
R	H18	32:49	115	0:30	6:33
S	H19	27:51	109	0:27	5:32
T	H20	24:14	104	0:25	4:47
U	H21	31:38	96	0:27	6:07
V	H22	0:00	0	0:00	0:00
W	H23	0:00	0	0:00	0:00
X	H24	13:05	48	0:20	2:33
Y	H25-Landowner	14:29	55	0:21	3:00
Z	H26-Landowner	88:28	124	1:04	18:07
AA	H27-Landowner	67:08	141	0:47	13:45
AB	H28	45:53	135	0:48	8:43
AC	H29	67:59	196	0:40	13:02
AD	H30	53:47	154	0:44	9:12

To be continued on next page...

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Wind Rose data based on 24 months data from an 80meter mast located on the proposed site.

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SHADOW - Main Result

Calculation: Shadow Flicker Predictions

...continued from previous page

No.	Name	Shadow, worst case: Shadow hours per year [h/year]	Shadow, worst case: Shadow days per year [days/year]	Shadow, worst case: Max shadow hours per day [h/day]	Shadow, expected values: Shadow hours per year [h/year]
AE	H31	78:53	157	1:06	10:22
AF	H32	51:01	194	0:25	8:15
AG	H33	48:10	127	0:42	6:30

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

No.	Name	Worst case [h/year]	Expected [h/year]
1	T1	191:17	34:06
2	T2	134:37	23:28
3	T3	110:10	16:44
4	T4	83:32	12:20
5	T5	70:18	10:17
6	T6	97:33	17:47
7	T7	60:59	11:07
8	T8	70:36	12:48
9	T9	133:35	25:32
10	T10	185:27	35:17
11	T11	154:15	28:56

Project:
Pinewoods Wind Farm

Description:
Sunshine statistics based on data from1969-1993 from Kilkenny Met Station which is located 20km from the proposed site.
Wind Rose data based on 24 months data from an 80meter mast located on the proposed site.

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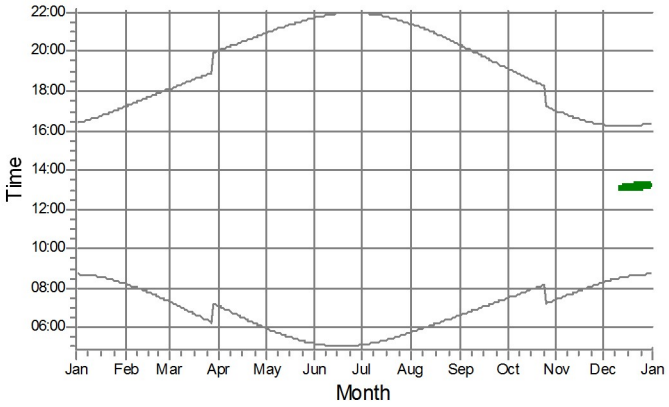
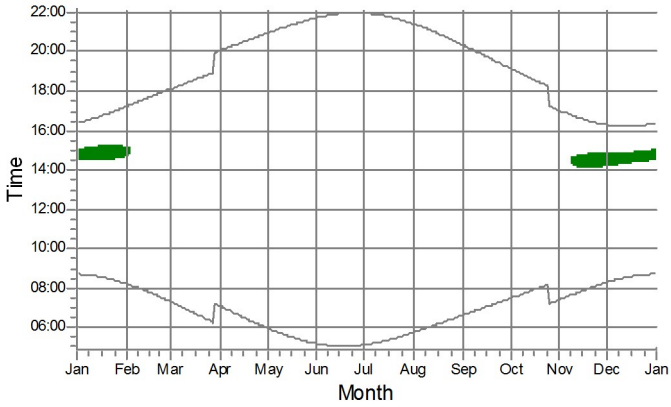
SHADOW - Calendar, graphical

Calculation: Shadow Flicker Predictions

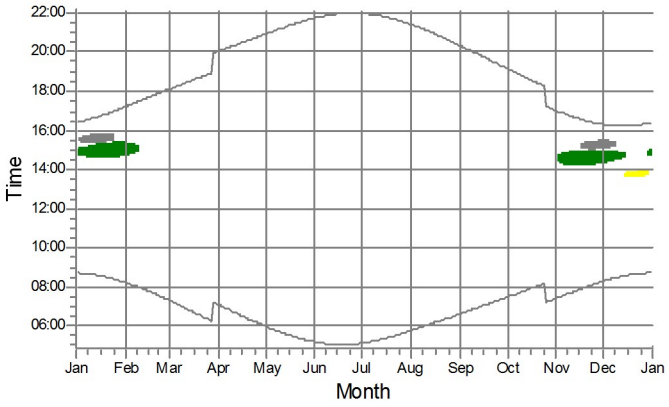
A: H01



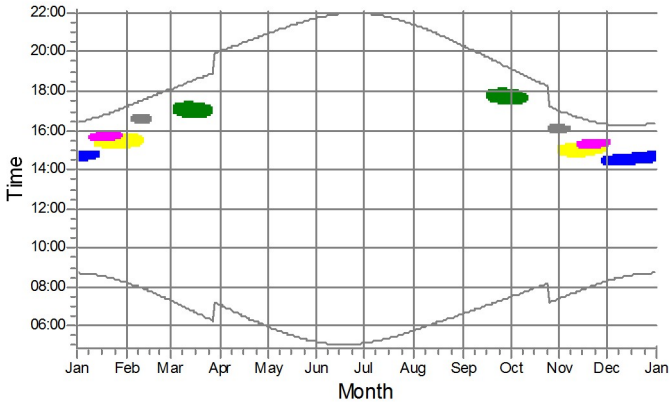
B: H02



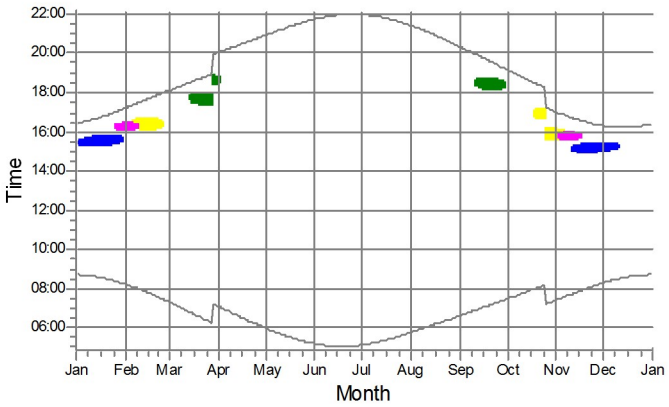
C: H03



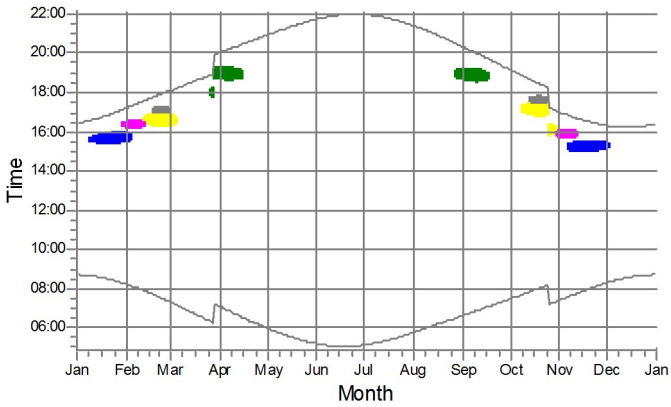
D: H04



E: H05



F: H06



WTGs

1: T1
2: T2
3: T3
4: T4
5: T5

Project:
Pinewoods Wind Farm

Description:
Sunshine statistics based on data from1969-1993 from Kilkenny Met Station which is located 20km from the proposed site.
Wind Rose data based on 24 months data from an 80meter mast located on the proposed site.

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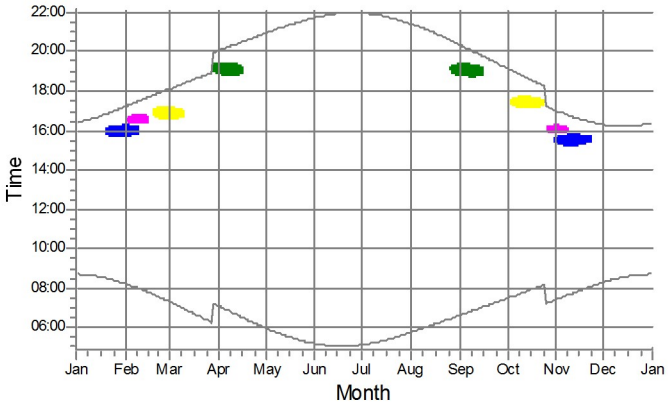
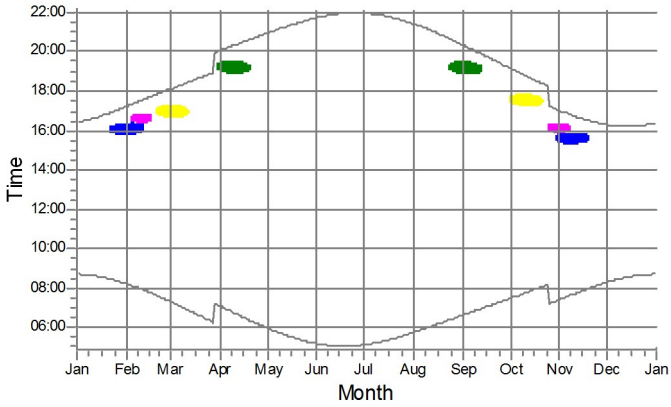
SHADOW - Calendar, graphical

Calculation: Shadow Flicker Predictions

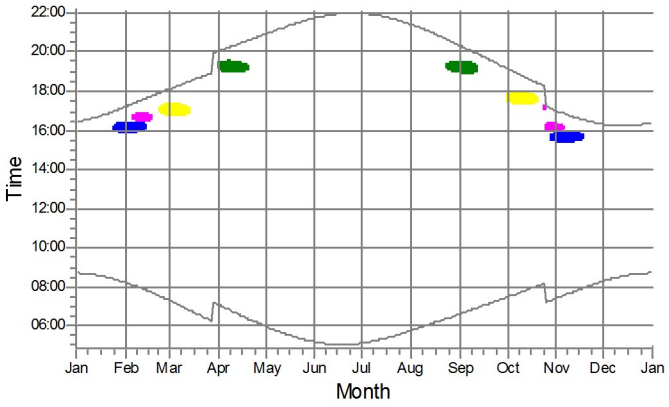
G: H07



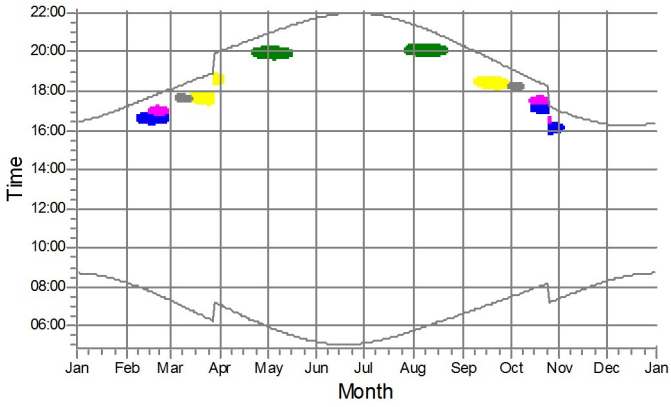
H: H08



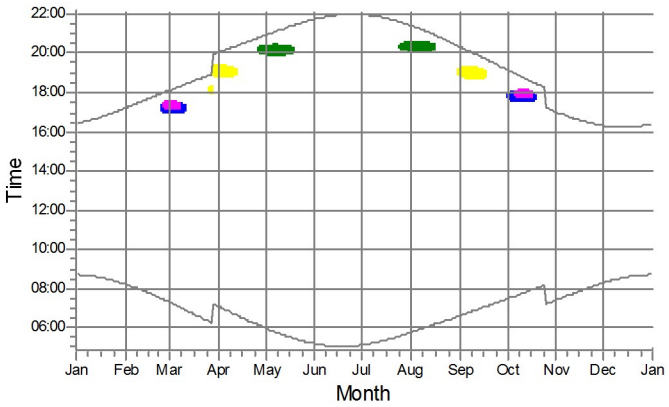
I: H09



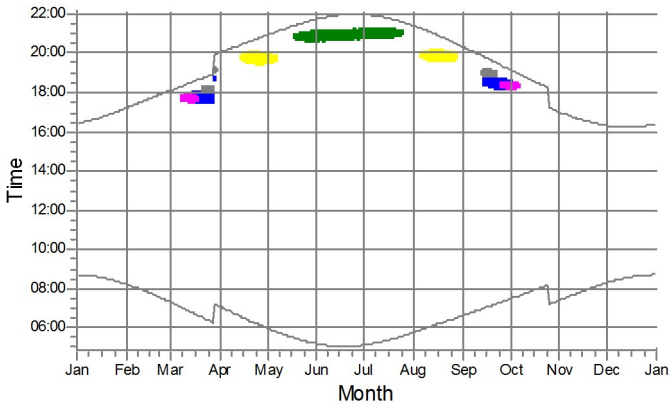
J: H10



K: H11



L: H12



WTGs

1: T1
2: T2
3: T3
4: T4
5: T5

Project:
Pinewoods Wind Farm

Description:
Sunshine statistics based on data from1969-1993 from Kilkenny Met Station which is located 20km from the proposed site.
Wind Rose data based on 24 months data from an 80meter mast located on the proposed site.

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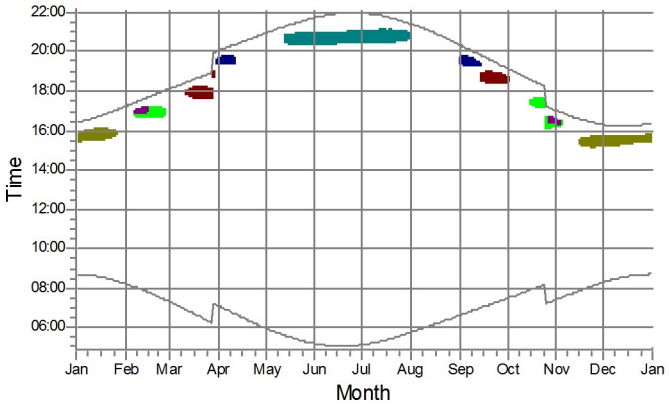
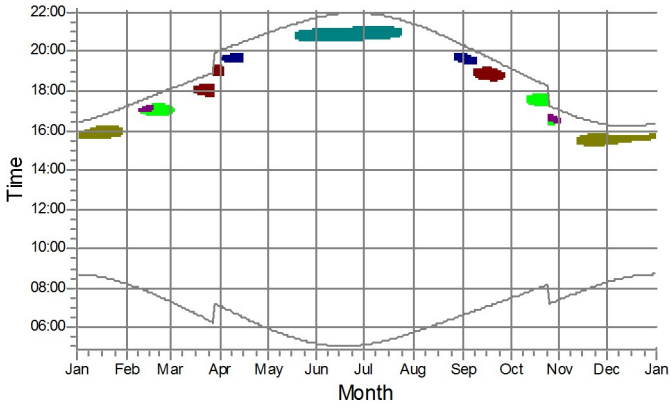
SHADOW - Calendar, graphical

Calculation: Shadow Flicker Predictions

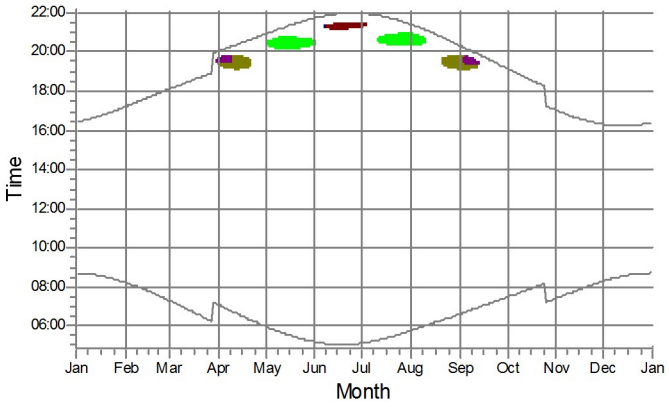
M: H13-Landow ner



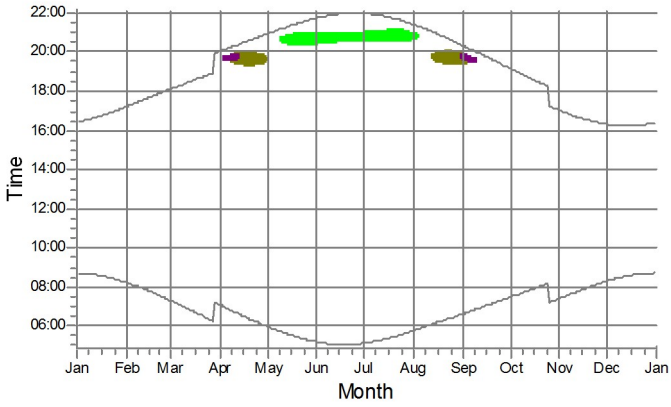
N: H14-Landow ner



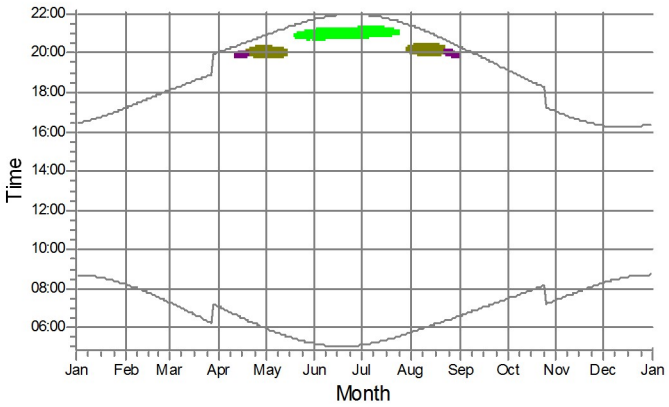
O: H15



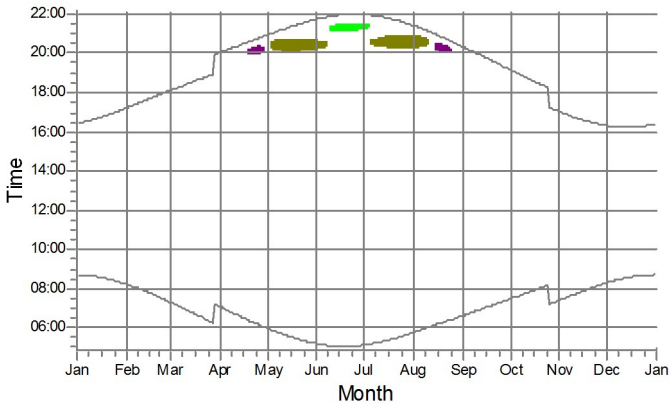
P: H16



Q: H17



R: H18



WTGs

6: T6	8: T8	10: T10
7: T7	9: T9	11: T11

Project:
Pinewoods Wind Farm

Description:
Sunshine statistics based on data from1969-1993 from Kilkenny Met Station which is located 20km from the proposed site.
Wind Rose data based on 24 months data from an 80meter mast located on the proposed site.

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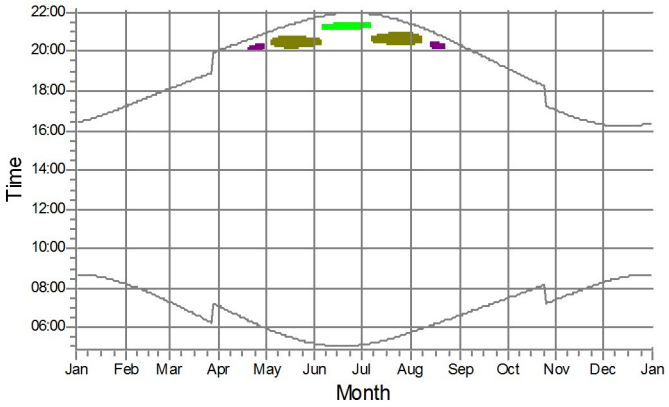
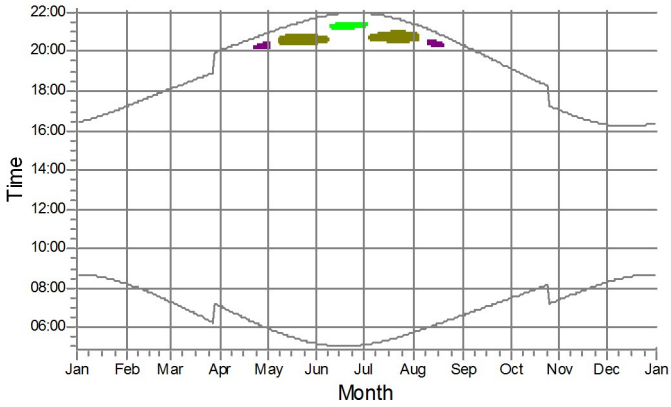
SHADOW - Calendar, graphical

Calculation: Shadow Flicker Predictions

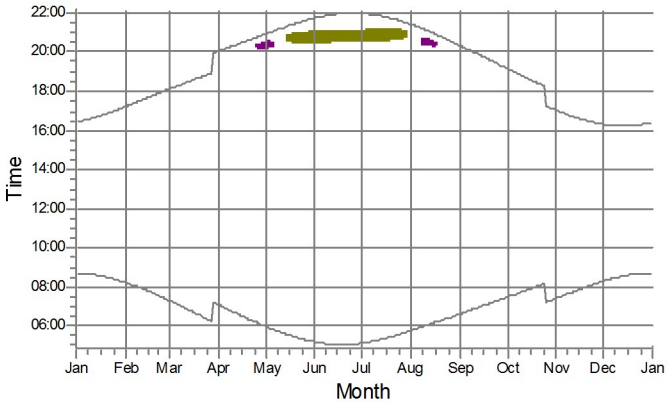
S: H19



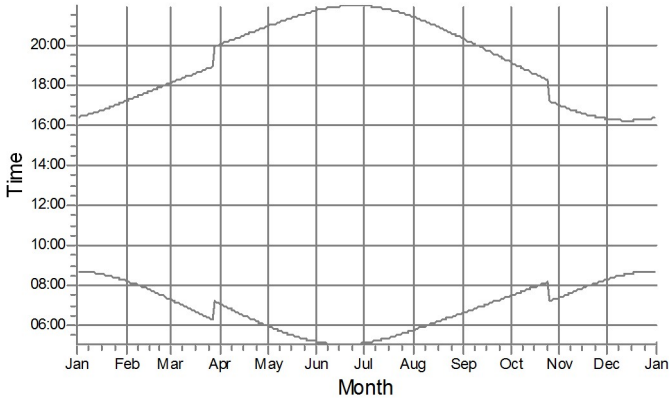
T: H20



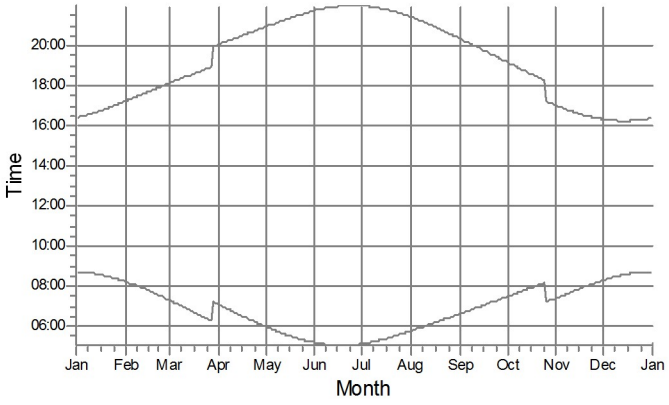
U: H21



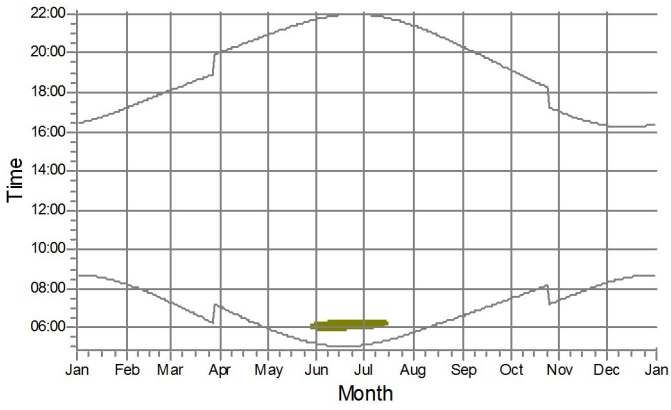
V: H22



W: H23



X: H24



WTGs

9: T9 10: T10 11: T11

Project:
Pinewoods Wind Farm

Description:
Sunshine statistics based on data from1969-1993 from Kilkenny Met Station which is located 20km from the proposed site.
Wind Rose data based on 24 months data from an 80meter mast located on the proposed site.

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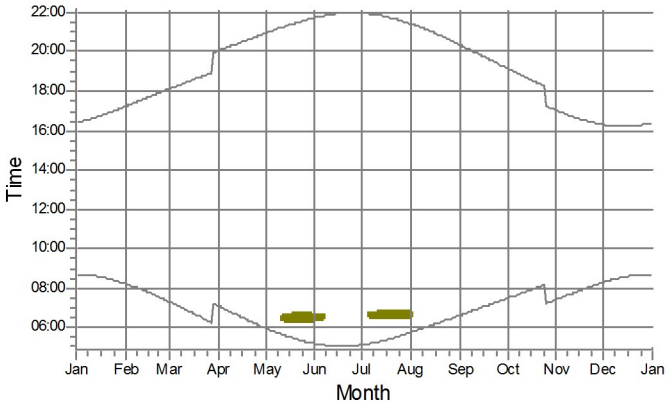
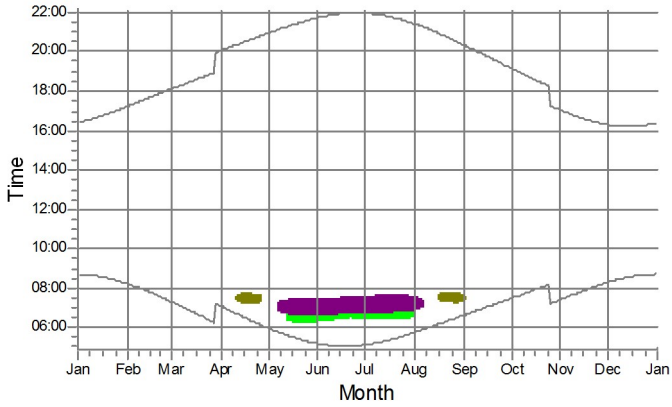
SHADOW - Calendar, graphical

Calculation: Shadow Flicker Predictions

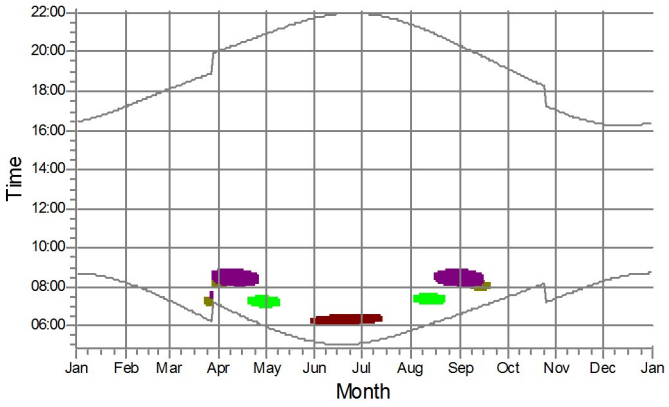
Y: H25-Landow ner



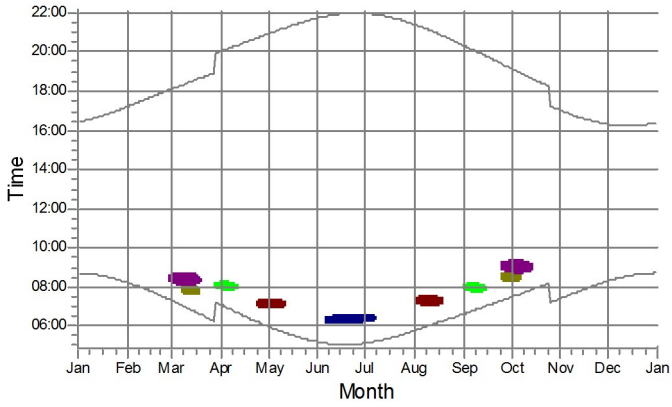
Z: H26-Landow ner



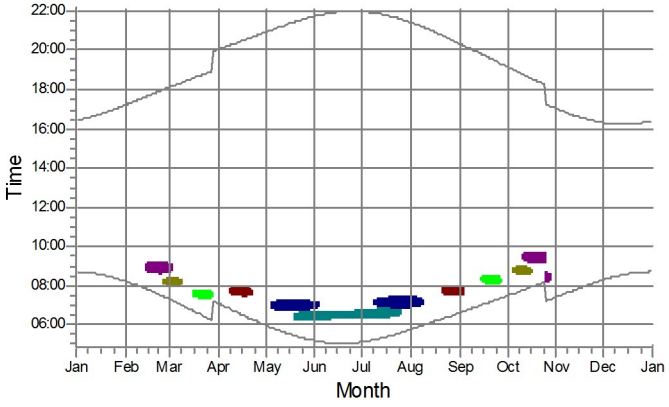
AA: H27-Landow ner



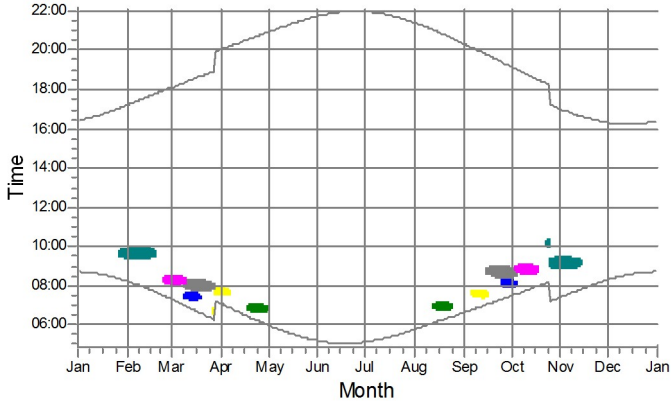
AB: H28



AC: H29



AD: H30



WTGs

1: T1	4: T4	7: T7	10: T10
2: T2	5: T5	8: T8	11: T11
3: T3	6: T6	9: T9	

Project:
Pinewoods Wind Farm

Description:
Sunshine statistics based on data from1969-1993 from Kilkenny Met Station which is located 20km from the proposed site.
Wind Rose data based on 24 months data from an 80meter mast located on the proposed site.

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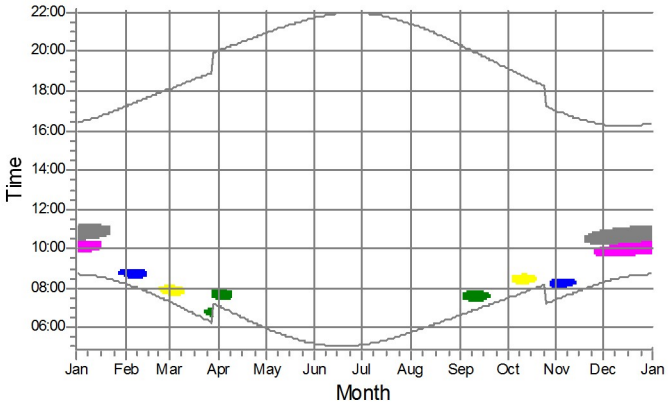
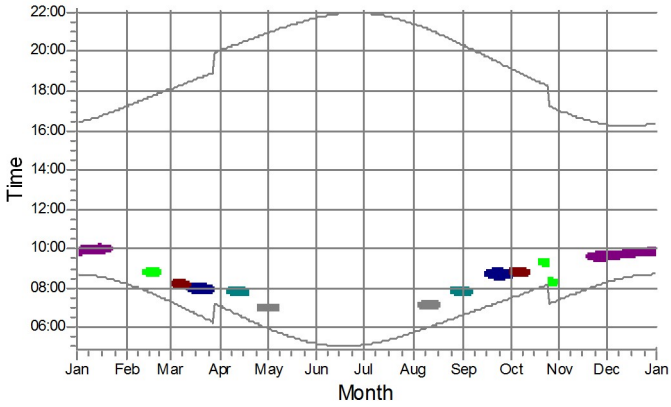
SHADOW - Calendar, graphical

Calculation: Shadow Flicker Predictions

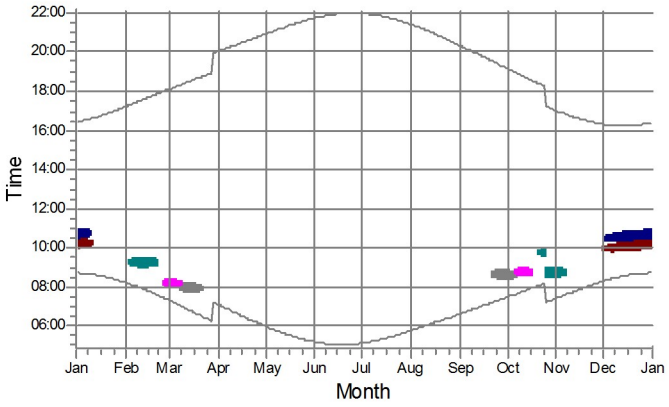
AE: H31



AF: H32



AG: H33



WTGs

1: T1	4: T4	7: T7	11: T11
2: T2	5: T5	8: T8	
3: T3	6: T6	9: T9	

Project:
Pinewoods Wind Farm

Description:
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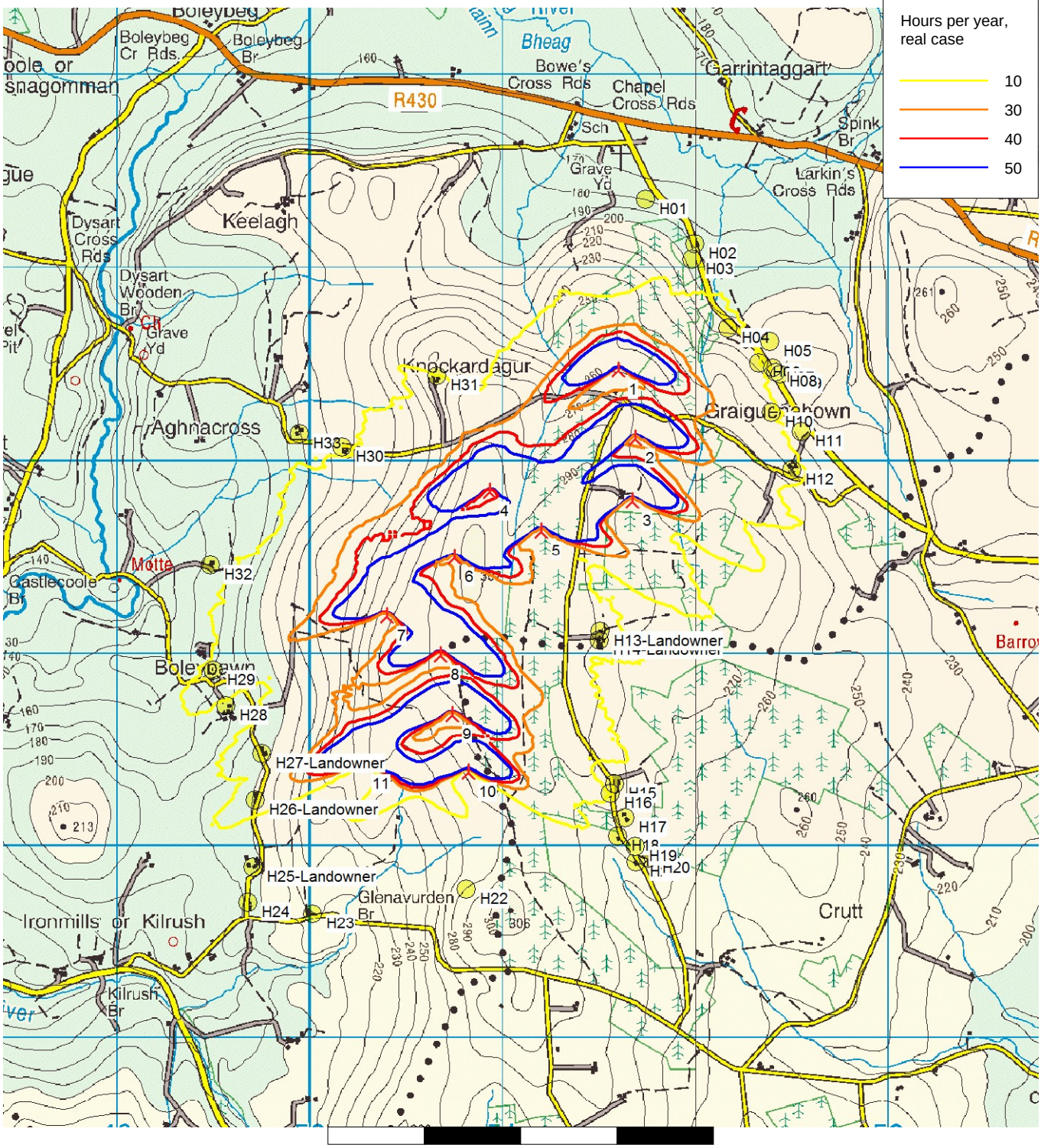
SHADOW - Map

Calculation: Shadow Flicker Predictions



Map: 50,000 Map , Print scale 1:30,000, Map center Irish Grid (IG)-IRELAND65 (IE) East: 251,060 North: 181,400

New WTG Shadow receptor

Flicker map level: Height Contours: CONTOURLINE_ONLINEDATA_0.wpo (1)