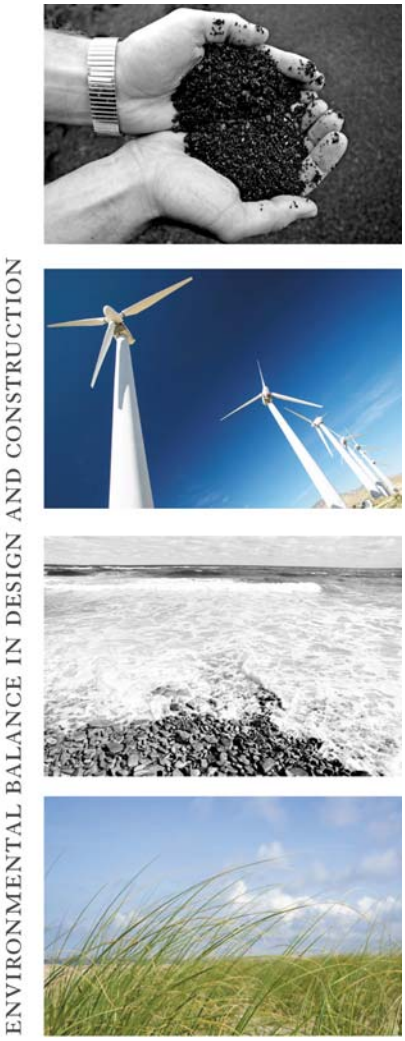

ELEMENT POWER IRELAND LTD.

ENVIRONMENTAL IMPACT STATEMENT FOR THE PROPOSED MAIGHNE WIND FARM IN COUNTY KILDARE AND COUNTY MEATH

VOLUME 2 – MAIN EIS

CHAPTER 12 – SHADOW FLICKER

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12 SHADOW FLICKER

12.1 Introduction

This chapter has been prepared to examine the potential impact of shadow flicker from the proposed Maighne Wind Farm in north County Kildare and south County Meath. It is important to note that the operation of modern wind turbines can be controlled to ensure that no houses will experience shadow flicker above the requirements of the Irish Wind Farm Planning Guidelines. The layout of the proposed development is considered, and mitigation measures to reduce or eliminate any potential impacts caused by shadow flicker are outlined.

12.1.1 Study Area

The proposed development consists of the erection of up to 47 no. wind turbines with a tip height of up to 169m, access tracks, a sub-station, a permanent metrological mast, borrow pits and associated works, temporary compounds as well as temporary minor alterations to the public road for the delivery of turbines to the site (turbine delivery route). The turbines are arranged in five wind farm clusters. The clusters are Ballynakill (10 turbines), Windmill (3 turbines), Drehid-Hortland (21 turbines), Derrybrennan (2 turbines) and Cloncumber (11 turbines). All clusters are connected via associated underground medium voltage (MV) cables which run predominately along the public road network linking back to a proposed sub-station on-site at Drehid. Here the power will be converted to AC up to a maximum voltage of 220kV for export to the Irish national grid via high voltage (HV) underground cables to either one of two existing substations located at Woodland, Co. Meath or Maynooth, Co. Kildare.

Whether the connection point to the national electricity transmission grid will be located at the Woodland or Maynooth substations will be determined by EirGrid plc, which is the statutory Transmission System Operator. Accordingly, the documentation submitted with this application for permission identified and evaluates 2 no. HV grid connection routes (which will operate at a voltage up to 220kV). The 2 no. HV grid connection cable routes included in this application will connect the proposed Maighne Wind Farm substation at Drehid to either one of two existing substations located at Woodland, Co. Meath or Maynooth, Co. Kildare. However, only one of these routes will be constructed following the identification of the preferred connection point by the Transmission System Operator.

For the purposes of this shadow flicker assessment the study area consists of all buildings and equine facilities within 10 rotor diameters of a proposed turbine in accordance with the "Best Practice Guidelines for the Irish Wind Energy Industry" (2012)[i]. A rotor diameter of 120m has been utilised as the size of the candidate turbine for the purposes of this assessment. Therefore, the study area for this shadow flicker assessment consists of all buildings and equine facilities within 1,200m of a proposed turbine. Should a larger rotor be used then the turbines will be operated to ensure shadow flicker effects will be maintained within the guideline limits. For this purpose, all buildings within 1,310m of a proposed turbine have also been identified (see Figure 11.1.1 to Figure 11.1.6).

12.1.2 What is Shadow Flicker?

In times of direct sunshine, and at certain times of the year, wind turbine blades could occasionally cast moving shadows on residences in close proximity to the turbines. These moving shadows of the turbine blades can periodically reduce light to a room causing the light to appear to flicker.

For shadow flicker to occur at a dwelling certain conditions must exist concurrently:

- There is sufficient sunlight to cast shadows i.e. no significant fog, mist or cloud cover.
- The turbine is directly between the sun and the dwelling.
- The dwelling has a window facing in the direction of the wind turbine.
- There is sufficient wind speed that the turbines are operating.
- The dwelling has a direct view of the turbine i.e. no screening (trees, hedges, etc.) or no obscuring features around the receivers which would minimise views of the development, and hence reduce or eliminate the potential for shadow flicker.

All five conditions outlined above must exist simultaneously for shadow flicker to occur at a dwelling. Shadow flicker does not generally have any effect on health or safety, but could on limited occasions present a brief nuisance effect for some neighbours.

12.2 Methodology

This section presents the methodology used in assessing the potential impact of shadow flicker from the wind farm on the receiving environment. The following sources of information were considered in this assessment:

- The design layout of the proposed development.
- Published literature as described below.
- Field assessment of the dwellings in the vicinity of the proposed development.
- A desk-based assessment of the dwellings with planning permission in the vicinity of the proposed development that are not yet constructed.

12.2.1 Relevant Guidance

The scope and methodology for the shadow flicker assessment has been devised in consideration of the following planning, policy and guidance documents:

- Wind Energy Development Planning Guidelines (2006)[ii]
- Best Practice Guidelines for the Irish Wind Energy Industry (2012)[iii]
- Guidelines on the Information to be Contained in Environmental Impact Statements (2002)[iv]
- Advice Notes on Current Practice in the preparation of Environmental Impact Statements (2003)[v]

A number of these guidelines are addressed in further detail in Chapter 3 - Policy of Volume 2 of the EIS.

We are aware that the DoEHLG Wind Energy Development Planning Guidelines are currently being revised and should these guidelines be finalised in advance of the Board's decision on the application for permission for this proposed development, the turbine shadow flicker control system (as outlined in Section 12.5) can be modified to meet the planning requirements and guidelines in place.

12.2.2 Consultation

This chapter considers the responses, with particular regard to concerns relating to shadow flicker, which were received following consultations with the statutory authorities and other relevant bodies, as summarised in Chapter 4 of Volume 2 of the EIS. During the public consultation process held prior to the submission of the application, some individuals raised concerns in relation to the potential impacts of shadow flicker and the guidelines and limits were discussed with these individuals.

12.2.3 Field Assessment

For the purposes of carrying out the shadow flicker assessment, a rotor diameter of 120m has been utilised as the size of the candidate turbine. This may not be the final rotor diameter, however it is representative of shadow flicker for a turbine with a tip height of 169m. The exact turbine will be dictated by the final selection of the turbine make and model post planning and the turbine shadow flicker control system will be programmed to ensure the shadow flicker limits will be in accordance with the relevant guidance for shadow flicker. A building survey was undertaken in November and December 2014 by Element Power Ireland Ltd. All buildings and equine facilities within 1,310m of a proposed turbine were recorded with all buildings within 1,200m (10 rotor diameters) included in the shadow flicker assessment for the proposed development.

12.2.4 Desk Study

In addition to considering all constructed buildings, a search was undertaken of Kildare and Meath County Councils' online planning database of all dwellings with valid planning permission, that have not yet been constructed, within 1,200m (10 rotor diameters) of a proposed turbine. These dwellings are included in the shadow flicker assessment for the proposed development.

12.2.5 Extent of Shadow Flicker Appraisal

A shadow flicker appraisal was carried out for all buildings, including all equine facilities, within 10 rotor diameters of a proposed turbine in accordance with the "Best Practice Guidelines for the Irish Wind Energy Industry" (2012)[vi].

As outlined in Section 12.2.3 above, for the purposes of this evaluation, a rotor diameter of 120m has been utilised as the size of a candidate turbine, therefore the assessment was carried out for all buildings within 1,200m of a proposed turbine. Should a larger rotor be used then the turbines will be operated to insure shadow flicker effects will be maintained within the guideline limits for shadow flicker. A shadow flicker assessment was carried out using ReSoft Windfarm software.

The closest meteorological station to the proposed Maighne Wind Farm with historical measurements compiled by Met Éireann is located at Casement Aerodrome. This data, presented in Table 12.1 below, represents the average sunshine per day as recorded over a 30 year period (1981 – 2010), the actual sunshine (daylight) hours at the proposed development site and therefore the percentage of time shadow flicker could actually occur is 31%.

Table 12.1: Average Monthly Sunshine Hours at Casement Aerodrome (1981 – 2010)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean Daily Duration [1]	1.7	2.5	3.3	5.1	6.0	5.3	4.9	4.8	4.1	3.3	2.2	1.5	3.7
Daylight hours [2]	8.1	9.8	11.9	13.3	15.4	15.9	15.6	14.2	12.4	10.2	8.8	7.3	11.9
% Sunshine	21	26	28	38	39	33	31	34	33	32	25	21	31

[1] Based on climatic data for Casement Aerodrome 1981-2010 (http://www.met.ie/climate-ireland/1981-2010/casement.html)
[2] Based on sunrise and sunset times for Dublin 2014 (http://www.sunrisesunset.com/)

The IWEA Guidelines recommend that any existing and/or permitted wind farm developments within 2km of the proposed development should be considered in a cumulative shadow flicker assessment. As there are no neighbouring wind farms within 2km of the proposed Maighne Wind Farm a cumulative shadow flicker assessment is not considered necessary.

12.2.6 Evaluation Criteria

Section 5.12 of the "Wind Energy Development Planning Guidelines" recommends that shadow flicker at any dwellings or offices within 500m of turbines should not exceed 30 hours per year or 30 minutes per day.

12.3 Existing Environment

There is currently no shadow flicker resulting from activities within the site of the proposed wind farm development.

A total of 994 buildings (including occupied and unoccupied dwellings, permitted dwellings that are not yet constructed and equestrian facilities) are located within 10 rotor diameters (1,200m) of a proposed turbine. All of these buildings are included in the shadow flicker assessment. The locations of these buildings can be identified on Figure 11.1.1 to Figure 11.1.6 in Volume 2a of the EIS.

Of the 994 buildings within 10 rotor diameters (1200m) of a proposed turbine:

- 7 buildings are located less than 500m from a proposed turbine (2 buildings are commercial sheds, 2 are derelict buildings, 1 is a derelict shed, 1 is a shed and 1 is a landowner dwelling)
- 84 buildings are located between 500m and 599m from a proposed turbine
- 117 buildings are located between 600m and 699m from a proposed turbine
- 134 buildings are located between 700m and 799m from a proposed turbine
- 223 buildings are located between 800m and 899m from a proposed turbine
- 151 buildings are located between 900m and 999m from a proposed turbine
- 157 buildings are located between 1,000m and 1,099m from a proposed turbine
- 121 buildings are located between 1,100m and 1,199m from a proposed turbine

Although this methodology is considered a more likely scenario, it is still a conservative estimate of the actual shadow flicker at each of the buildings as it assumes the rotor yaw is always perpendicular to the sun, a window faces directly onto the development and that there is no screening of vegetation.

A letter of consent has been provided from the landowner of the dwelling which is less than 500m from a proposed turbine (Building 983), and confirms that they are aware of the proposed development and are fully aware of the potential impacts. A copy of this letter is contained in Appendix A.

12.4 Potential Impacts

The results of the shadow flicker modelling are summarised in Table 1 of Appendix R. The model calculates times throughout the year when a turbine, viewed from the window of a building, is in line with the sun, and therefore the potential exists for shadow flicker to occur.

The results of the shadow flicker modelling for maximum daily shadow flicker are based on the assumption that daylight hours consist of 100% sunshine and therefore represent a worst-case scenario. No account of screening has been taken into consideration, and it has been assumed that every building has a window facing directly onto each turbine.

As discussed in Section 12.2.5 above, the actual sunshine (daylight) hours representative of the proposed development site and therefore the percentage of time shadow flicker could actually occur is 31%. Therefore, a column has been added to Table 1 of Appendix R which applies this factor of 31% to the predicted maximum amount of annual shadow flicker.

From these results there are 42 buildings where the potential annual shadow flicker guideline limit (30 hours) is exceeded when the 31% sunshine assumption is applied.

It should be noted that the guideline limits apply to buildings within 500m of a turbine. In the case of the proposed Maighne Wind Farm, only 7 of the 994 buildings assessed are within 500m of a proposed turbine. Of these 7 buildings, 2 buildings are commercial sheds, 2 are derelict buildings, 1 is a derelict shed, 1 is a shed and 1 is a consenting landowner dwelling.

A summary of the results of the shadow flicker modelling, as shown in Table 1 of Appendix R, are set out in Section 12.4.1 below.

Mitigation measures will be implemented to ensure that no exceedance of shadow flicker guideline limits takes place at any dwellings.

As discussed is this Section, these results are based on 31% sunshine scenario assessment of potential shadow flicker impacts.

12.4.1 Annual Shadow Flicker Limits

When the 31% sunshine assumption is applied to these annual shadow flicker results, the number of buildings where potential shadow flicker occurrences exceed the guideline limit of 30 hours per year is 42 buildings.

The breakdown of these 42 buildings is as follows, with a table of results shown in Table 12.2 for these 42 buildings:

- 19 buildings have potential annual shadow flicker occurrence of between 31-35 hours (1 of these buildings is a derelict shed)
- 8 buildings have potential annual shadow flicker occurrence of between 35-40 hours
- 6 buildings have potential annual shadow flicker occurrence of between 40-45 hours.
- 5 buildings have potential annual shadow flicker occurrence of between 45-50 hours
- 3 buildings have potential annual shadow flicker occurrence of between 50-55 hours.
- 1 building has potential annual shadow flicker occurrence of greater than 55 hours (this building is a derelict shed).

Table 12.2: Annual Shadow Flicker for 42 buildings which exceed 30 hours per year when 31% sunshine assumption is applied

Building No	Nearest Turbine	Distance from Nearest Turbine (m)	Length of Time Affected by Shadow Flicker Assuming 100 % Sunshine		Hours per Year Assuming 31% sunshine	Comment
			Maximum Minutes per Day on Day Affected	Hours per Year		
7	11	620	49	109	34	Dwelling
54	41	639	72	145	45	Dwelling
55	41	554	97	175	54	Dwelling
56	41	510	104	169	52	Dwelling
245	41	597	86	171	53	Shed
375	1	725	44	101	31	Dwelling
381	3	721	40	102	32	Dwelling
382	3	694	42	115	36	Dwelling
383	3	523	55	144	45	Dwelling
384	4	614	48	143	44	Dwelling
385	4	574	51	154	48	Dwelling
386	4	573	55	158	49	Dwelling

Building No	Nearest Turbine	Distance from Nearest Turbine (m)	Length of Time Affected by Shadow Flicker Assuming 100 % Sunshine		Hours per Year Assuming	Comment
466	4	500	74	137	42	Dwelling
554	10	529	80	115	36	Shed
555	10	578	70	99	31	Shed
556	10	483	92	116	36	Shed
585	7	201	110	365	113	Derelict Shed
657	30	673	46	107	33	Dwelling
658	30	580	52	119	37	Dwelling
659	30	539	54	106	33	Dwelling
660	30	536	55	139	43	Dwelling
661	30	630	48	114	35	Dwelling
662	30	635	47	105	32	Dwelling
663	30	672	45	101	31	Dwelling
733	30	521	53	118	36	Dwelling
878	30	585	52	127	39	Shed
886	11	543	54	105	33	Dwelling
922	12	530	77	155	48	Dwelling
923	14	524	72	155	48	Dwelling
927	12	563	50	114	35	Dwelling
982	21	501	56	101	31	Dwelling
997	47	550	53	128	40	Dwelling
998	47	530	55	117	36	Dwelling
999	47	530	55	106	33	Dwelling
1002	47	581	50	99	31	Dwelling
1003	47	611	49	110	34	Dwelling
1004	47	638	46	99	31	Dwelling
1005	23	632	49	106	33	Dwelling
1038	17	544	81	157	49	Dwelling
1140	47	639	44	100	31	Mobile Home
1141	47	641	44	102	32	Mobile Home
1157	14	398	70	141	44	Derelict

12.4.2 Annual Shadow Flicker Taking Sunshine and Wind Direction Factors into Consideration

Based on the potential shadow flicker calculations for Maighne Wind Farm, a revised analysis for the more likely hours of shadow flicker occurring is outlined in Table 2 of Appendix R. This analysis assumes a 31% factor for average sunshine hours and takes account of the wind directionality, i.e. the wind turbine will not always be yawed such that the rotor is in the worst case orientation (i.e. perpendicular to the sun-turbine vector) and any other orientation will reduce the area of the projected shadow, and hence the shadow flicker duration. This is also accounted for, as detailed below.

Wind direction frequency distribution was collected on site between 05 November 2014 and 03 December 2014. Using this data, it is possible to estimate the probability of a rotor being orientated within 30 degrees (30°) of a vector perpendicular to the turbine. This maximum probability of the rotor being orientated within 30° of sun (turbine vector) is estimated at a reduction of 42% based on the most onerous wind direction.

An approximation of the 'estimated actual' shadow flicker occurrence can be calculated by combining the two probabilities of sunshine and wind direction, i.e. rotor alignment, as outlined in Table 2 of Appendix R.

This revised 'estimated actual' shadow flicker is still considered conservative as the following items are not considered:

- Some receivers may be screened by vegetation
- Not all receivers have windows facing onto the wind farm

When the 31% sunshine and the 42% wind direction assumptions are applied to the annual shadow flicker results, the number of buildings where potential shadow flicker occurrences exceed the guideline limit of 30 hours per year is 1 building. This is building no. 585 (see Figure 11.1.1) which is a derelict shed with an 'estimated actual' shadow flicker of 48 hours per year.

As outlined in Section 12.5 below mitigation measures will be implemented to ensure that no exceedance of shadow flicker guideline limits takes place at any dwellings.

12.5 Mitigation Measures

As described in Section 12.3, all the buildings within 10 rotor diameters of the nearest proposed turbines were assessed for the potential impact of shadow flicker. Given the conservative nature of the model, which does not take into account that the hours when the wind is blowing in the direction parallel to a line between the turbine and the houses will be considerably less than 100% and will in many cases not coincide with sunny hours, the predicted shadow flicker at the buildings is a significant overestimate of the actual levels that may occur.

However, the conservative assessment has identified that there is the potential for buildings to experience shadow flicker in excess of the guideline limits. Where these conditions arise, the turbine(s) causing the shadow flicker exceedance will be shut down automatically for the duration of the period of time during which those conditions occur, so as to ensure that the guideline limits are not breached at any building.

This turbine shutdown is achieved through turbine control whereby turbines are programmed to stop operating at times where it is anticipated that the relevant guideline limits may be exceeded. This will be improved by connecting the system with light sensors and control software such that the turbine(s) will only stop working if the conditions exist for shadow flicker, thus allowing the turbines to continue to generate electricity on cloudy days. Therefore, turbine control will ensure that no exceedance of the shadow flicker guideline limits takes place.

A preliminary assessment of the turbine control measures that would be required in order to ensure that shadow flicker at all buildings will not exceed 30 minutes per day was undertaken. This found that for shadow flicker at all buildings within 10 rotor diameters (1,200m) of a proposed turbine to be reduced so as not to exceed the maximum daily amount of 30 minutes, the proposed turbines will need to be shut down for approximately 1% of the potential operating time of the 47 proposed turbines (assuming 100% sunshine and the turbines could operate for 100% of the time).

It should be noted that this is a conservative figure, due to the conservative nature of the shadow flicker model, and the fact that this assessment was undertaken on a building-by-building basis whereby it does not take account of the scenario where a turbine shutdown to ensure that the maximum daily limit is not exceeded on one building may also reduce the shadow flicker at a neighbouring building.

As 1% shutdown of the potential operating time (assuming 100% sunshine and 100% wind direction) is a conservative figure, Table 12.3 below outlines the percentage of operational hours shut down required per year taking 31% sunshine and 42% wind direction into consideration. This revised 'estimated actual' shut down is still considered conservative due to the conditions outlined in Section 12.4.

Table 12.3: Total Percentage of Operational Hours Shut Down Time for Maighne (47 Turbine) Wind Farm

Factor of 31% applied to shut down time for average sunshine hours	0.31%
Probability of time the turbine rotor is orientated within 30° of the sun	42%
Total % of operational hours shut down per year	**0.13%**

In assessing the turbine shutdown requirements a procedure of evaluation of the existing screening, window orientation and the periods of shadow flicker actually occurring will be undertaken during the commissioning of the wind farm in consultation with any relevant land owner, or nearby receptors, in order to ensure that no exceedance of shadow flicker guideline limits takes place.

Mitigation measures will be implemented to ensure that no exceedance of shadow flicker guideline limits takes place at any dwellings.

We are aware that the DoEHLG Wind Energy Development Planning Guidelines are being revised and should these guidelines be finalised in advance of the Board's decision on the application for permission for this proposed development, the turbine shadow flicker control system can be modified to meet the planning requirements and guidelines in place.

12.6 Residual Impacts

Results of a conservative shadow flicker assessment predict that the proposed wind farm has the potential to introduce shadow flicker impacts at some buildings surrounding the wind farm. The implementation of the proposed mitigation measures however will ensure that shadow flicker at all buildings remain below the recommended guideline limits resulting in low-very low residual impact.

12.7 References

[i] Irish Wind Energy Association "Best Practice Guidelines for the Irish Wind Energy Industry" (2012), http://www.iwea.com/contentFiles/Documents%20for%20Download/Publications/IWEA%20Policy%20Documents/IWEA%20best%20practise%20guidelines.pdf

[ii] Department of the Environment, Heritage and Local Government (DoEHLG) "Wind Energy Development Planning Guidelines" (2006)

[iii] Irish Wind Energy Association "Best Practice Guidelines for the Irish Wind Energy Industry" (2012)

[iv] Environmental Protection Agency "Guidelines on the Information to be Contained in Environmental Impact Statements" (2002)

[v] Environmental Protection Agency "Advice Notes on Current Practice in the preparation of Environmental Impact Statements" (2003)

[vi] Irish Wind Energy Association "Best Practice Guidelines for the Irish Wind Energy Industry" (2012), http://www.iwea.com/contentFiles/Documents%20for%20Download/Publications/IWEA%20Policy%20Documents/IWEA%20best%20practise%20guidelines.pdf