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Environmental Impact Assessment Report (EIAR) For the Proposed Littleton Wind Farm, Co. Tipperary

Volume 2 - Main EIAR

Chapter 12 - Shadow Flicker

Prepared for:
Littleton Wind Farm DAC

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TABLE OF CONTENTS

LIST OF APPENDICES (VOLUME 3)

LIST OF FIGURES (VOLUME 4)

LIST OF TABLES

12. SHADOW FLICKER

12.1 Introduction

This chapter has been prepared to assess the likely significant direct and indirect effects of shadow flicker from the operation of the proposed Littleton Wind Farm (the 'Proposed Wind Farm') in County Tipperary. The Proposed Development consists of a 11 no. turbine wind farm and associated infrastructure including internal access tracks, hard standings, additional amenity trails, an onsite borrow pit, peat deposition areas, a permanent meteorological mast, an onsite 110kV substation and associated grid connection infrastructure, internal electrical and communications cabling, temporary construction compounds, drainage infrastructure, biodiversity management and enhancement measures, temporary accommodation works along the Proposed Turbine Delivery Route and all associated works related to the construction of the Proposed Development. Further description of the Proposed Development can be found within Section 4.2 of EIAR Chapter 4.

This report presents the results of an assessment that has been conducted to determine the potential for shadow flicker effects at residential receptors in the area surrounding the Proposed Wind Farm. The description of the methodology is presented including a summary of relevant guidance and the scope of the assessment. A detailed appraisal of the existing environment and potential impacts caused by shadow flicker is outlined along with mitigation measures that may be required. The potential for cumulative impact with other existing and permitted wind farms in the area is also appraised.

12.1.1 Statement of Authority

This assessment has been undertaken by Faolán Ly and reviewed by Mark Tideswell, of TNEI Group (TNEI).

Faolán Ly is a Graduate Consultant with one year of experience working in Environmental Consultancy. Faolán has a BSc in Physics and is an Affiliate Member of the Institute of Acoustics (IoA), and in his time at TNEI has provided support on numerous shadow flicker assessments.

Mark is a Principal Consultant with twelve years' experience working in the Environmental Consultancy sector and with a focus on the technical aspects of renewable energy developments, including site finding, GIS mapping services, shadow flicker and noise assessments. Mark's qualifications include a BSc (Hons) in Music Technology, the IoA Diploma in Acoustics and Noise Control, and Mark is a Full Member of the Institute of Acoustics. Mark has considerable experience in undertaking shadow flicker assessments in both the UK and Ireland, both in support of planning applications as well as post-consent compliance and complaints investigations.

A detailed description of the Proposed Development to be assessed in this EIAR Chapter is provided in Chapter 4. For the purpose of this assessment, a candidate turbine has been assumed, with 119 m hub height and 200 m tip height.

12.1.2 Scope of Assessment

12.1.2.1 Definition of Shadow Flicker

Under certain combinations of geographical position, wind direction, weather conditions and times of day and year, the sun may pass behind the rotors of a wind turbine and cast a shadow over the windows of nearby buildings. When the blades rotate and the shadow passes a window, to a person within that room the shadow appears to 'flick' on and off; this effect is known as 'shadow flicker'. The phenomenon occurs only within occupied buildings where shadows are cast across a window aperture, and the effects are typically considered up to a maximum distance of 10 times the rotor diameter from each wind turbine.

Where moving shadows from operational wind turbine blades are cast across the ground, this is referred to as Shadow Throw. There is no requirement to assess 'shadow throw' in Ireland or internationally, and consequently, there are no guidelines on how to assess it. On this basis, shadow throw has not been considered further within this assessment.

12.1.2.2 Study Area

The Site is located in a rural area in County Tipperary, approximately 12 km south-east of Thurles, approximately 5 km south-west of Urlingford, Co. Kilkenny. The surrounding landscape features bogs, moors and heath, coniferous forestry, mixed forestry, land principally occupied by agriculture, non-irrigate land, pastures and transitional woodland scrub. The Site is generally surrounded by farmland but there are extensive conifer plantations outside the eastern and western boundaries, as well as a mixture of forestry and peatland habitats, with scattered dwellings present nearby. The Site location is shown on Figure 12-1, Volume 4.

The 10 times rotor diameter criterion, which effectively sets the size of the study area, is detailed in several international publications including the German 'Guideline for Identification and Evaluation of the Optical Emissions of Wind Turbines' (2002), the UK's 'Update of UK Shadow Flicker Evidence Base' (Parsons Brinkerhoff for DECC, 2011), the Irish Government 'Wind Energy Development Guidelines' (DEHLG 2006), and Irish Wind Energy Association guidelines (IWEA, 2012).

Specifically, the WEDGS 2006 state that:

> *"At distances greater than 10 rotor diameters from a turbine, the potential for shadow flicker is very low."*

And the IWEA 2012 guidelines state that:

> *"The assessment of potentially sensitive locations or receptors within a distance of ten rotor diameters from proposed turbine locations will normally be suitable for EIA purposes"*

Due to the latitude of the Site and the positioning of the sun relative to the proposed wind turbines, there is a limited area over which it is geometrically possible for shadows from the turbines to be cast. For sites in the northern hemisphere (as is the case for the Proposed Development) the sun will never be positioned directly north of a turbine, and as such shadows cannot be cast directly to the south. Additionally, when the sun is located directly to the south of a turbine (during the middle of the day), the sun will be at a high angle and consequently long shadows are not typically cast directly to the north. The area over which it is geometrically possible for shadows from the turbines to be cast is therefore limited and can be calculated using modelling software.

As such, the study area for this assessment has therefore been determined based on a two-stage process. The first stage considers a maximum distance of 1,620 m (10 x 162 m rotor) from each of the wind turbines. The second stage considers the calculated area over which it is geometrically possible for shadows from the turbines to be cast and excluding areas (in particular to the south of the turbines) where there is no possibility of shadows from the turbines being cast. The resulting study area is shown in Figure 12-1, Volume 4.

The assessment considers all potential shadow flicker sensitive receptors identified within the study area, which includes habitable residential buildings and buildings that are mixed residential and commercial. Three commercial receptors have also been identified. No other sensitive property types were identified within the study area. TNEI have identified 36 receptors within the study area and labelled them as Shadow Flicker Assessment Location (SFAL) as shown on Figure 12-1, Volume 4 and with coordinates also presented in Table 1 in Appendix 12-1. No receptors have been identified within 500 m of the proposed turbine locations.

12.1.2.3 Effects to be Assessed

This chapter quantifies through modelling the theoretical number of hours per annum where shadow flicker may occur at each identified receptor and if required, identify mitigation measures which will be implemented if necessary, during operation of the Proposed Development.

12.2 Methodology

12.2.1 Prediction Method

It is possible to predict the total theoretical number of hours per year that shadow flicker may occur from the relative position of the turbines to the receptors, the geometry of the wind turbines, the latitude of the wind turbine site and the size and orientation of the windows potentially affected. The predictions can be used to identify the time(s) of day and year and identify any turbines for which curtailment may be required in order to mitigate the effects of shadow flicker. The predictions assume that during daylight hours the sun is shining all day, every day.

The potential for shadow flicker to occur and the intensity and duration of any effects depend upon the following factors:

1. the location and orientation of the window relative to the turbines;
2. whether a window has direct, unobstructed line of sight to the turbine rotor;
3. the distance of the building from the turbines;
4. the turbine geometry;
5. the time of year (which impacts the trajectory of the sun’s path across the sky);
6. the frequency of cloudless skies (particularly at low elevations above the horizon); and,
7. the wind direction (which impacts on turbine orientation).

Several specialist software packages are available that can take account of factors 1-5 listed above to determine the maximum theoretical number of shadow flicker hours that could occur at each window under worst-case conditions. Weather conditions factors 6-7 cannot be predicted with certainty, however an estimation of cloudless skies (factor 6), can be made through an analysis of historic weather data.

This assessment presents two scenarios, a worst-case scenario (where average weather effects are not taken into account) and a more realistic scenario, where the model output accounts for estimates of typical weather conditions. As cloudless skies for the entire year cannot happen, the worst-case model output will therefore be more inherently conservative than the realistic case where average sunshine hours over a year are considered in the modelled levels of shadow flicker.

Where obstructions are present between a receptor and a turbine due to terrain, this is accounted for within the software model, however the model does not consider other obstructions that may be present (such as walls, buildings, and vegetation).

For this assessment, predictions of shadow flicker effects have been undertaken using industry standard software package EMD International WindPro, based on the proposed turbine locations and assuming turbine dimensions based on the candidate turbine, the Vestas V162 with a 200 m tip (as detailed in Table 12-3).

12.2.2 Assessment Methods

12.2.2.1 Local Planning Policy and Guidance

Tipperary County Development Plan

Volume 1 of the Tipperary County Development Plan 2022-2028 (Tipperary County Council, 2022) notes that the Wind Energy Development Guidelines (DEHLG, 2006) are currently under review, and notes that the Council will seek to apply the guidelines (and any review thereof) when assessing proposals for wind energy developments.

Volume 3, Appendix 2 'Renewable Energy Strategy' discusses the Tipperary Wind Energy Strategy, which aims to:

> *"… build upon its predecessors and develop an updated, county-wide tool for identifying potentially suitable locations for wind energy development and to guide future assessment of wind energy planning applications in the county. "*

Appendix 1 of the Tipperary Wind Energy Strategy states the following in relation to shadow flicker:

> *"Proposals for wind turbines must demonstrate that the orientation, private amenity space and disposition of windows in residential dwellings is such that the dwelling will be largely unaffected by shadow flicker and that the amenity of the dwelling will not be significantly impacted upon."*

and

> *"The Department of the Environment's most up to date Guidelines on Wind Energy shall be adhered to with regard to shadow flicker and noise issues."*

12.2.2.2 National Irish Policy and Guidance

Wind Energy Development Guidelines (DEHLG, 2006)

Guidance provided by the Irish Government Department of the Environment, Heritage and Local Government 'Wind Energy Development Guidelines' (DEHLG, 2006) states that:

> *"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."*

The wind farm has been designed to avoid shadow flicker but should it occur, levels will remain below the limits of 30 minutes per day and 30 hours per year.

Draft Revised Wind Energy Development Guidelines (DHPLG 2019)

The Department of Housing, Planning and Local Government published the Draft Revised Wind Energy Development Guidelines in December 2019. The draft revised guidelines set out a zero-shadow flicker policy, encouraging the use of technology for shadow flicker control, to prevent it occurring at sensitive receptors.

The 2019 revised guidelines are currently at draft stage. If new Guidelines are adopted before this application is adjudicated on by An Coimisiún Pleanála, the applicant would welcome the opportunity to demonstrate compliance with same.

Irish Wind Energy Association Best Practice Guidelines (IWEA 2012)

In March 2012, the Irish Wind Energy Association (IWEA) issued a document detailing best practice guidance for wind farms (IWEA, 2012).

The document provides a preferred methodology to predict the worst-case shadow flicker conditions in order to provide the most robust results from the assessment. With regards to shadow flicker, the IWEA guidelines state:

> *"The assessment of potentially sensitive locations or receptors within a distance of ten rotor diameters from proposed turbine locations will normally be suitable for EIA purposes"*

12.2.2.3 International Guidance on Shadow Flicker

'International Legislation and Regulations for Wind Turbine Shadow Flicker Impact ' (Koppen, 2017) presents an overview of the assessment methodologies most commonly used in countries that have their own specific legislation or guidance with regards to shadow flicker effects. The paper states that nearly all countries base their guidance on the German guidelines 'Guideline for Identification and Evaluation of the Optical Emissions of Wind Turbines' (2002).

The limit values within the German guidelines are a maximum of 30 minutes per day and 30 hours per year. These limits are, however, based on worst case conditions i.e. the total theoretical number of hours per year that shadow flicker could occur, assuming that the sun is always shining during daylight hours. If, however, a light intensity sensor is fitted as part of a wind turbine shadow flicker control system (i.e. considering real lighting conditions), then a target limit value of 8 hours per year can be used for real case shadow flicker.

Many countries have adopted the German guideline limits, either directly or with some small adjustments. Australia, Belgium (Walloon region), Brazil, Canada, India, Sweden, and USA all have a worst-case limit of 30 hours a year or 30 minutes a day. The UK has no set limit but also typically adopts these guideline levels for assessment purposes.

Belgium (Flanders region) sets a real case limit of 8 hours a year or 30 mins a day, Denmark a real case limit of 10 hours a year and Netherlands a real case limit of 17 days a year where shadow flicker occurs for more than 20 minutes a day.

12.2.2.4 Assessment Criteria

Based on the guidance summarised above, the assessment criteria have been set as a maximum shadow flicker exposure level of 30 minutes per day and 30 hours per year for any receptor within 10 rotor diameters of the wind turbines and within the study area. In lieu of the 500 m cut-off stated in the WEDG 2006 guidelines, a worst-case 10 rotor diameter (1,620m) cut-off has been used. Where applicable, commentary has been provided in relation to the 500 m regulatory requirement.

12.2.3 Field Assessment

Building location data was derived from a combination of GIS address data, information from relevant planning applications and a ground-proof house survey conducted by Fehily Timoney & Company. The supplied dataset covered an area at least 10 rotor diameters from the turbines. The dataset was refined through the use of aerial imagery to identify any additional buildings, as well as identifying building condition (habitable, derelict etc.), and building dimensions. A conservative approach was taken in assuming that all buildings are sensitive to shadow flicker effects across the full extent of their external façade. The resulting locations are referred to as Shadow Flicker Assessment Locations (SFALs).

In total, 36 receptors have been identified within the shadow flicker study area, as shown in Figure 12-1, Volume 4. None of the SFALs are located within the 500 m assessment area (WEDGs, 2006); the closest residential receptor to a wind turbine is SFAL02, 850 m southwest of T11, and the closest commercial receptor to a wind turbine is SFAL33, 610 m southwest of T09.

Appendix 12-1 contains the model input data for all of the receptors. All receptors have been modelled using a 'glass house' approach, which assumes the full external façade[1] of each building is sensitive to shadow flicker.

[1] The model considers a single façade based on worst-case (largest) dimensions, which is oriented face-on to each turbine during the calculation process as a conservative approach.

12.2.4 Theoretical Maximum and more realistic case scenarios

The shadow flicker model calculates the total theoretical occurrence of shadow flicker hours at all receptors per year based on a theoretical worst-case scenario that assumes the sky is always clear, the turbines are always spinning, the turbines and receptors are aligned face-on to each other, and that there is a clear and undisturbed line of sight between the receptors and the turbines (except where this is prevented due to topography). In reality the turbines will not always be orientated as described, clouds will obscure the sun and line of sight may be obscured by structures or vegetation. The theoretical worst-case scenario allows predictions of all possible shadow flicker occurrences; however, actual shadow flicker effects will only be possible for some of this time.

To provide a more realistic prediction of potential shadow flicker effects, historical weather data can be used to apply a correction factor, which considers the frequency of clear skies when shadows may be cast. Historic Data compiled by Met Éireann at the nearest long-term weather station to the Proposed Development (Kilkenny Weather Station, approximately 28 km east) has been used to determine the average sunshine hours; this data is presented in Table 12-1.

Table 12-1: Average Daily Sunshine Hours Per Month at Kilkenny Weather Station

Month	Mean Daily Sunshine Hours (hh:mm)[i]	Mean Percentage of Sunshine Hours per Day (%)[ii]
Jan	1.8	21.8
Feb	2.3	23.3
Mar	3.2	27.0
Apr	4.9	35.2
May	5.6	35.6
Jun	4.9	29.2
Jul	4.7	28.8
Aug	4.7	32.0
Sep	4.0	31.5
Oct	3.0	28.2
Nov	2.2	25.0
Dec	1.6	20.7

i Based on the 30-year Met Éireann average daily sunshine figures from the Kilkenny weather station (https://www.met.ie/cms/assets/uploads/2024/07/Kilkenny-1978%E2%80%932007-averages.html)
ii Based on the monthly potential sun hours from WindPro.

It is worth noting that a correction accounting for Percentage of Sunshine Hours per Day for the more realistic scenario does not account for additional reductions that could occur as a result of variations in wind speed, wind direction, or by determining whether there is line of sight between a turbine and receiver. The more realistic scenario is therefore still considered to be a conservative estimate.

12.2.5 Modelling Parameters

The levels of shadow flicker at each receptor have been calculated based on a 'greenhouse' modelling approach, where the entire length and height of each façade of a building is modelled as a window (and is therefore sensitive to shadow flicker). Each storey of a building is assumed to be 2.5 m in height; single storey receptors are 2.5 m high, and 2 story buildings are 5 m high. Building widths were measured using aerial imagery on Google Earth[2], with building heights checked using Google Street View. For properties where Google Street View was not available to check building heights, buildings were assumed to be two (2 no.) storeys high.

This approach has been taken in order to present a worst-case estimate of shadow flicker in the absence of any detailed window location data. In reality, only the glazed area of each façade would be sensitive to shadow flicker effects, therefore modelling the full facade will result in higher predicted levels than is actually possible. Also, on some facades there may not be any windows.

The input data used for the shadow flicker model is shown in Table 12-2.

Table 12-2: Receptor Modelling Inputs

SFAL ID	Easting	Northing	Façade Width (m)	Façade Height (m)
SFAL1	624172	653971	15.0	5.0
SFAL2	620634	650791	17.0	2.5
SFAL3	619491	651853	15.5	2.5
SFAL4	623793	653919	15.0	5.0
SFAL5	619829	651799	13.0	5.0
SFAL6	622227	652596	16.0	2.5
SFAL7	622201	652613	15.0	2.5
SFAL8	621765	652780	17.0	2.5
SFAL9	621734	652572	18.0	2.5
SFAL10	625147	655739	12.0	2.5
SFAL11	625113	655658	13.0	5.0
SFAL12	624964	655869	16.0	5.0
SFAL13	619719	651670	20.0	2.5
SFAL14	619747	651648	19.5	2.5
SFAL15	622270	652590	10.0	2.5
SFAL16	622263	652635	12.0	2.5
SFAL17	625014	655950	14.0	2.5
SFAL18	625024	655978	14.0	5.0
SFAL19	624998	655966	13.0	2.5

[2] WindPro modelling software takes a worst-case approach, where a single building façade is modelled per receptor, which is oriented directly towards each turbine in turn during the calculation process. As such, the façade widths used in the model are based on the widest point of each building.

SFAL ID	Easting	Northing	Façade Width (m)	Façade Height (m)
SFAL20	624911	654349	11.0	2.5
SFAL21	624692	654680	12.0	5.0
SFAL22	624297	654700	14.0	5.0
SFAL23	624257	654475	20.0	2.5
SFAL24	624179	653908	17.0	2.5
SFAL25	624791	654749	16.0	5.0
SFAL26	622397	652523	19.5	2.5
SFAL27	619822	651659	13.0	5.0
SFAL28	620256	652366	16.0	5.0
SFAL29	619593	652015	15.0	5.0
SFAL30	619852	651637	9.0	5.0
SFAL31	619348	652060	19.0	2.5
SFAL32	620541	650920	15.5	2.5
SFAL33	620485	651338	40.0	5.0
SFAL34	620282	651305	35.5	2.5
SFAL35	624922	655666	9.5	5.0
SFAL36	619347	651749	17.5	2.5

The proposed locations of the turbines were added to the model as shown in Table 12-3.

Table 12-3: Proposed Wind Turbine Locations

Turbine ID	ITM Coordinates (X)	ITM Coordinates (Y)
T1	624044	657148
T2	623721	656639
T3	623595	656033
T4	623023	656034
T5	622809	655374
T6	623461	655081
T7	622465	654873
T8	623020	654421
T9	620928	651759
T10	621249	651425
T11	621455	651016

12.3 Existing Environment

All receptors identified within the study area are assumed to be either residential or mixed residential and commercial buildings, and are located in a predominantly flat, rural landscape, with no major towns or large villages present. Two purely commercial receptors were also identified within the study area a specific note on which is included in Section 12.4.1. The majority of the area around the Proposed Wind Farm is farmland, bogland and some forestry, with trees and hedges along the field boundaries. With the limited potential for screening (i.e. proposed wind turbines well above ground), most of the receptors considered in this chapter are therefore likely to have clear line of sight to the proposed turbines. The locations of the proposed wind turbines in relation to the receptors are shown on Figure 12-1, Volume 4.

There are no existing wind turbines located within 10 rotor diameters of the properties considered in this assessment. The nearest wind farms to the Proposed Development single/two-turbine developments, shown on Figure 12-1, Volume 4. These are Glengoole Wind Farm approximately 2 km to the east, Ballincurry Wind Farm approximately 3 km to the south-east, Graigaman Wind Farm, approximately 4 km to the east. Other existing nearby wind farms include Knocknamuck/Cnoc Wind Farm, approximately 8 km to the east, Lisheen Wind Farm, approximately 8 km to the north, and Ballybay Wind Farm, approximately 9.3 km to the east As such, because of these distances, the existing environment contains no prospect for cumulative shadow flicker effects to occur.

12.4 Potential Impacts

12.4.1 Annual Impacts

Of the 36 receptors identified within the study area, 35 have the potential to receive shadow flicker effects.

The total theoretical maximum and more realistic prediction of shadow flicker hours have been compared against the assessment criteria for each receptor in Table 12-4. A full listing of the worst-case total theoretical instances of shadow flicker by turbine can also be found in Table 12-2 in Appendix 12-2, and shadow flicker instances by receptor are shown in Table 12-1 in Appendix 12-1.

Total theoretical maximum levels, based on a worst-case scenario exceed 30 hours per year at 16 receptors. However, when considering a more realistic scenario accounting for typical sunshine hours, all receptors would be below the 30 hours threshold.

Two purely commercial receptors were included in the model, SFAL33 and SFAL34. These comprise a warehouse and an office/admin building both located adjacent to each other which form part of the former Bord na Móna peat processing factory and subsequent recycling facility. Given the nature of the businesses, the average length of these buildings is much larger than an average residential property, and given the "green-house" assumption of the model, this greatly increases the calculated shadow flicker times for these receptors. However, even with the increased theoretical maximum levels each commercial receptor is still below the 30 hours per year threshold when considering the realistic scenario.

For SFAL33, the latest shadow flicker event start time is 08:35 on the 22nd of October, and the latest end-time for a shadow flicker even is 08:54 for a period of three days on the 6, 7, and 8th of October. This means that all shadow flicker events are expected to occur outside of normal working hours. The same is true for SFAL34, with the latest shadow flicker start time being 08:20 on the 14th of October, and the latest shadow flicker end-time being 08:35 from the 29th of September to the 7th of October.

As noted in methodology section, the predicted levels of shadow flicker presented in this assessment is still considered conservative as allowances have not been made for the following which would reduce the predicted impacts:

- Receivers may be screened by cloud cast and/or vegetation.
- Each receptor identified may not have habitable rooms and windows facing in all directions onto the wind farm.
- The hours when the wind is blowing in a line between the turbine and the house may not coincide with sunny hours.
- The orientation of the window of a building. The 'glass house' model considered is very conservative as it assumes windows throughout 360 degrees .

12.4.2 Daily Impacts

Potential daily shadow flicker has been assessed based on the worst-case theoretical maximum levels, as the correction for annual average sunshine hours applied to the yearly levels cannot be applied on a daily basis. The data used to derive the correction is based upon monthly averages, which cannot be applied to daily levels with sufficient accuracy. Periods of cloudy weather are more likely to reduce the number of days shadow flicker can occur, rather than reduce the length of individual shadow flicker occurrences. As such, the assessment of daily impacts considers the maximum theoretical amount of shadow flicker only and is inherently conservative.

Table 12-4 presents a list of the predicted levels of shadow flicker, and highlights calculated/predicted levels which exceed the assessment criteria (shown in green for minutes/day and purple for hours/year). Further details, including the duration of individual shadow flicker events occurring at each receptor, are included in Table A12-2-1 in Appendix 12-2.

The predicted worst-case theoretical maximum hours per day of shadow flicker exceeds 30 minutes at 18 receptors.

Table 12-4: Shadow Flicker Predicted Levels by Receptor

SFAL ID	Coordinates (ITM)		Total Theoretical Days Per Year	Theoretical Maximum Level Per Day (HH:MM)	Theoretical Maximum Level Per Year (HH:MM)	More Realistic scenario level Per Year (HH:MM)
	X	Y				
SFAL01	624172	653971	60	00:34	22:25	07:24
SFAL02	620634	650791	82	00:49	49:19	16:25
SFAL03	619491	651853	34	00:27	09:46	02:51
SFAL04	623793	653919	66	00:41	32:20	09:37
SFAL05	619829	651799	79	00:37	28:45	08:34
SFAL06	622227	652596	91	00:29	32:26	07:15
SFAL07	622201	652613	88	00:28	30:07	06:43
SFAL08	621765	652780	62	00:34	30:20	06:32
SFAL09	621734	652572	90	00:38	39:27	08:55
SFAL10	625147	655739	32	00:23	07:53	02:38

SFAL ID	Coordinates (ITM)		Total Theoretical Days Per Year	Theoretical Maximum Level Per Day (HH:MM)	Theoretical Maximum Level Per Year (HH:MM)	More Realistic scenario level Per Year (HH:MM)
	X	Y				
SFAL11	625113	655658	34	00:24	08:43	02:55
SFAL12	624964	655869	105	00:30	35:48	11:04
SFAL13	619719	651670	75	00:34	25:16	07:59
SFAL14	619747	651648	76	00:34	26:48	08:32
SFAL15	622270	652590	92	00:28	30:49	06:54
SFAL16	622263	652635	88	00:28	28:34	06:21
SFAL17	625014	655950	119	00:28	35:22	11:06
SFAL18	625024	655978	102	00:28	30:00	09:34
SFAL19	624998	655966	120	00:29	35:52	11:15
SFAL20	624911	654349	0	00:00	00:00	00:00
SFAL21	624692	654680	48	00:31	16:27	05:31
SFAL22	624297	654700	141	00:47	75:40	23:12
SFAL23	624257	654475	80	00:32	22:25	06:42
SFAL24	624179	653908	68	00:33	24:40	08:00
SFAL25	624791	654749	40	00:29	12:44	04:16
SFAL26	622397	652523	71	00:26	16:14	03:41
SFAL27	619822	651659	81	00:36	29:52	09:30
SFAL28	620256	652366	112	00:48	51:24	12:04
SFAL29	619593	652015	36	00:29	11:27	03:16
SFAL30	619852	651637	84	00:37	31:17	10:01
SFAL31	619348	652060	29	00:24	07:34	02:09
SFAL32	620541	650920	111	00:44	54:07	17:13
SFAL33	620485	651338	138	00:59	84:43	26:42
SFAL34	620282	651305	165	00:45	81:38	25:11
SFAL35	624922	655666	71	00:28	20:16	06:15
SFAL36	619347	651749	31	00:24	07:59	02:28
Totals			Number of Receptors that may Experience:			
			Any Shadow Flicker	>30 Mins / Day	>30 Hours / Theoretical Maximum	>30 Hours / Year More realistic case
			35	18	16	0

As such, there is the potential for significant effects to occur as a result of shadow flicker at up to 18 receptors under worst-case conditions.

12.5 Mitigation Measures

Shadow flicker control modules, consisting of light sensors and specialised software, will be installed on the turbines to ensure that mitigation is implemented to reduce shadow flicker occurrence at any receptor. The locations and dimensions of the turbines and shadow flicker receptors can be input into the turbine control software, and when the theoretically optimal on-site conditions for shadow flicker are met (i.e. the light intensity is sufficient and shadow flicker might occur) during operation, then individual turbines would cease operation until the on-site conditions change, or the theoretical period has passed.

As discussed in Section 12.2.1, shadow flicker prediction modelling is inherently conservative and results in an unrealistically worst-case estimation of shadow flicker effects. As such, implementing mitigation based on prediction modelling can result in unnecessary turbine shutdowns, resulting in reduced renewable energy generation.

Littleton Wind Farm DAC will provide protection from shadow flicker by committing to curtailing turbines for all instances where shadow flicker effects are reported to occur at residential dwellings within 10 rotor diameters of the turbines. Shadow flicker occurrence will be identified following reports or complaints of shadow flicker from receptors within 10 rotor diameters of the turbines. A Complaints Investigation Procedure will be agreed with the Local Authority prior to the Proposed Development becoming operational, which will set out the steps to be followed in the event that shadow flicker related complaints are received.

Once reports of shadow flicker have been validated (confirmed via software model that shadow flicker can occur at the receptor at the reported time), mitigation will be implemented for all instances of shadow flicker occurrence at that receptor. However, it should be noted that when the conditions for shut down due to shadow flicker are met, there is a short period of time before complete shutdown occurs, as the turbines gradually slow down and stop turning. This will depend on the reaction time of the shadow flicker control modules and the particular turbine type, as well as the rotational speed at which the turbine is stopping from, and is likely to be within the scale of several seconds to around a minute.

Appendix 12-2 contains a list of times when each turbine could theoretically cause shadow flicker. These are given as an example of potential mitigation system inputs, and before any implementation a detailed review would be required for the key parameters such as final turbine locations and dimensions and detailed review of receptor rooms and windows.

Following mitigation, shadow flicker levels at all receptors within the study area will be reduced to negligible levels, and as such would not result in significant effects.

12.6 Residual Impacts

The results of the shadow flicker assessment predict that the Proposed Wind Farm has the potential to introduce shadow flicker at up to 35 receptors surrounding the site, based on a worst-case scenario where no mitigation measures are adopted. Following the implementation of a scheme of mitigation as described in Section 12.5, shadow flicker as a result of the Proposed Development would not occur (aside from any minor shadow flicker effects that may briefly occur before the control system can react and to stop the blades turning). As such, following mitigation any shadow flicker effects that may occur at receptors within 10 rotor diameters of a turbine are likely to be negligible.

Therefore, the Proposed Development complies with the shadow flicker policy as set out in the Wind Energy Development Guidelines 2006. The effects of shadow flicker from the project, either alone or in combination with other plans or projects, are therefore considered to be Not Significant.

12.7 Do-Nothing Scenario

In the 'Do-Nothing' Scenario, the Proposed Wind Farm would not be constructed and the potential occurrence of shadow flicker on local receptors would not occur.

Please note that irrespective of the consenting of the Proposed Wind Farm the remaining measures outlined in the Rehabilitation Plans, i.e. monitoring of the Littleton, Longfordpass and Lanespark Phase 1 measures and enhanced Phase 2 measures at nearby Ballybeg and Derryvella bogs, will continue to be implemented by BnM in agreement with the EPA. Please see Appendix 2.1 (Volume 3 of the EIAR) and Section 2.2.1 of Chapter 2 of the EIAR for further detail.

12.8 Conclusion

A shadow flicker assessment has been undertaken considering 36 potential shadow flicker receptors (a combination of residential and mixed residential-commercial use properties, and commercial properties) identified within the study area. The study area has been defined as the calculated area over which shadows from the turbines may be cast, limited to a maximum distance of 10 rotor diameters of the largest candidate wind turbine considered for the Proposed Wind Farm.

Predictions of Shadow Flicker occurrence were made in software WindPro for a theoretical maximum scenario and a more realistic scenario accounting for the percentage of sunlight hours.

Total theoretical maximum worst-case levels exceed Irish guidelines threshold of 30 hours per year at 16 receptors. However, when considering a more realistic scenario accounting for typical sunshine hours, 30 hours per year would also not be exceeded at any receptors. A separate criterion of daily occurrence was assessed, and it was found that the predicted maximum theoretical hours per day of shadow flicker exceeds the Irish guideline threshold of 30 minutes per day at 18 receptors. Mitigation measures are therefore recommended.

A "zero shadow flicker" strategy will be implemented using turbine control software to cease turbine operation during periods when shadow flicker is reported to occur. If this mitigation strategy is adopted, then minimal (near zero hours a year) shadow flicker would occur at any relevant receptors with habitable rooms and windows within 10 rotor diameters of the wind farm.

No cumulative impacts with other proposed or operational wind farms in the area are predicted to occur on any receptors in the study area due to distance from other projects that could possibly create shadow flicker.

In conclusion, the effects of shadow flicker from the project, either alone or in combination with other plans or projects, are therefore considered to be Not Significant.

12.9 References

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