15 SHADOW FLICKER

15.1 INTRODUCTION

This chapter assesses the effects of the Proposed Development (**Figure 1.2**) in terms of shadow flicker. The Proposed Development refers to all elements of the application for the construction of Tirawley Wind Farm (**Chapter 2: Development Description**). Where negative effects are predicted, the chapter identifies appropriate mitigation strategies therein. The assessment considers the potential effects during the operational phase of the Proposed Development.

Shadow flicker will not occur during the construction or decommissioning phase of the Proposed Development. Shadow flicker is an effect caused by the sun shining behind the rotating blades of a turbine relative to a nearby sensitive receptor which causes a momentary shadow on a window of that sensitive receptor. This shadow can appear as a flickering of sun light due to the rotating blades. Therefore, shadow flicker will only occur during the operational phase of the Proposed Development.

Common acronyms used throughout this EIAR can be found in **Appendix 1.4.** This chapter of the EIAR is supported by Figures provided in Volume III and by the following Appendix documents provided in Volume IV of this EIAR:

- **Appendix 15.1 Shadow Flicker Analysis**

15.1.1 Statement of Authority

This chapter has been prepared by Ms. Kathlyn Feeney of Jennings O'Donovan & Partners Limited (JOD). Kathlyn Feeney is Graduate Environmental Scientist with a First-Class Honours Degree (BSc. Hons) in Environmental Science. She forms part of the Environmental team responsible for preparing the EIAR Chapters. Kathlyn has one year's experience writing EIARs, Feasibility Studies, Screening Reports, and Appropriate Assessments for Wind Farms. Kathlyn also has experience using software such as ArcGIS and WindPro 4.2 for shadow flicker analysis. Kathlyn has carried out shadow flicker modelling and assessments for a number of large-scale wind farms for EIARs.

The Chapter has been reviewed by Mr. David Kiely of JOD. Mr. Kiely has 43 years' experience in the civil engineering and environmental sector. He has obtained a bachelor's degree in civil engineering and a Masters in Environmental Protection, has overseen the construction of over 50 wind farms and has carried out numerous soils and geology assessments for EIAR's. He has been responsible in the overall preparation of in excess of 60 EIA Reports (EIAR's).

15.1.2 Assessment Structure

In line with the revised EIA Directive and current EPA guidelines listed in **Chapter 1**, **Section 1.5** the structure of this shadow flicker and electromagnetic interference chapter is as follows:

- Assessment methodology and significance criteria
- Description of baseline conditions at the Wind Farm Site including the likely evolution of the baseline
- Limitations of the assessment
- Identification and assessment of effects of shadow flicker and electromagnetic interference associated with the Proposed Development, during the construction, operational and Decommissioning phases of the Proposed Development
- Mitigation measures to avoid or reduce the effects identified
- Identification and assessment of residual impact of the Proposed Development considering mitigation measures
- Identification and assessment of cumulative effects if and where applicable

The information presented in this chapter and the appendices is considered appropriate to allow Mayo County Council to carry out an adequate assessment of the Proposed Development.

15.2 SHADOW FLICKER

This chapter comprehensively assesses the potential shadow flicker effects of the operational stage of the Proposed Development. No shadow flicker will occur during the construction or decommissioning phases. The grid connection and Turbine Delivery Route are not included in this assessment as shadow flicker relates to the turbines only.

15.2.1 Assessment Methodology

This assessment of shadow flicker involved the following:

- Evaluation of potential effects (see **Section 15.2.6**) includes predicting the shadow flicker effects on the sensitive receptors within the Study Area, and comparing them against the 2006 Guidelines
- Evaluation of the significance of effects using the methodology set out in **Chapter 1: Introduction**, **Section 1.10.3**
- Identification of measures to avoid and mitigate potential effects

The Study Area is defined as 10 times the maximum potential rotor diameter (10 x 117 m = 1,170 m). A shadow flicker computer model (WindPRO 4.2) was used to calculate the

occurrence of shadow flicker at relevant receptors to the Proposed Development. The output from the calculations is analysed to identify and assess potential shadow flicker effects. Wind turbines, like other tall structures, can cast long shadows when the sun is low in the sky. The sensitive receptors were identified using a combination of Ordnance Survey of Ireland (OSI) Maps, AutoCAD drawings and from internet mapping resources including Eircode Finder, Google Street View, Google Earth, Bing Maps, a planning permission search using the Mayo County Council web resource and from a visit in September 2023 to the Study Area. The desktop sensitive receptor search was originally completed in March 2023 with regular rechecks completed to ensure no new receptors are identified within the Study Area. The output from the calculations is analysed to identify and assess potential shadow flicker effects. Wind turbines, like other tall structures, can cast long shadows when the sun is low in the sky. A minimum separation distance from all sensitive receptors of 540 m has been used with the Proposed Development design. There are 100 No. receptors within 1.17 km of any proposed wind turbine location. There is 1 no. dwelling (H2) within 500 m of any proposed wind turbine location which will remain unoccupied for the operational life cycle of development and 1 no. unoccupied dwelling (H1) which will be used as an operations building associated with the Proposed Development.

The 2019 Draft Revised Wind Energy Guidelines confirms that:
"Shadow Flicker occurs when the sun is low in the sky and the rotating blades of a wind turbine casts a moving shadow which if it passes over a window in a nearby house or other property results in a rapid change or flicker in the incoming sunlight. The time period in which a neighbouring property may be affected by shadow flicker is completely predictable."

In order to ensure the full extent of the moving shadow which would be created by the turning turbines is considered in the assessment the following scenario was modelled:
16 no. Vestas V117, 4.3 MW wind turbines;

- *Overall ground to blade tip height of 135 m,*
- *A rotor diameter of 117 m, and*
- *A hub height of 76.5 m.*

This scenario was included in the assessment. There are no nearby wind farms (within 2 km), therefore there is no predicted cumulative effects assessed. The nearest wind farm is Killala Community Wind Farm located 5.2 km southeast.

Where negative effects are predicted, this section identifies appropriate mitigation strategies. The assessment considers the potential effects during the operational phase of the Proposed Development.

A shadow flicker computer model was used to calculate the occurrence of shadow flicker at relevant receptors to the Proposed Development. The output from the calculations is analysed to identify and assess potential shadow flicker effects. This is further detailed in **Appendix 15.1**.

Shadow flicker lasts only for a short period and happens only in certain specific combined circumstances. The circumstances required for shadow flicker to occur are:
the sun is shining and at a low angle in the sky; and the turbine is directly between the sun and the affected sensitive receptor, and there is enough wind energy to ensure that the turbine blades are moving, and the turbine blades are positioned so as to cast a shadow on the receptor.

If any one of these conditions is absent, shadow flicker cannot occur.
The 2019 Draft Revised the Wind Energy Development Guidelines (WEDG)[1] also added the circumstance where:

- *"there is sufficient direct sunlight to cause shadows (cloud, mist, fog or air pollution could limit solar energy levels)" and note that*
- *"Generally only properties within 130 degrees either side of north, relative to the turbines, can be affected at these latitudes in the UK and Ireland – turbines do not cast long shadows on their southern side".*

Shadow flicker may have the potential to cause disturbance and annoyance to residents if it affects occupied rooms of a house. Persons with photosensitive epilepsy can be sensitive to flickering light between 3 and 60 Hertz (Hz). This is supported by research in recent years asserting that flicker from turbines must interrupt or reflect sunlight at frequencies greater than 3 Hz to pose a potential risk of inducing photosensitive seizures. The frequencies of flicker caused by modern wind turbines are less than 1 Hz and are well below the frequencies known to trigger effects in susceptible individuals. Therefore, any potential shadow flicker effect from the Proposed Development is considered an effect on residential amenity, rather than having the potential to affect the health of residents.

[1] Department of Housing, Planning and Local Government, 2019. *Draft Revised Wind Energy Development Guidelines*, Dublin. Government of Ireland. [Available Online: https://assets.gov.ie/46097/6e68ea81b8084ac5b7f9343d04f0b0ef.pdf]

Careful site selection, design and planning, and good use of relevant software to control the turbine operation can help reduce the possibility of shadow flicker. Modern wind turbines have the facility to measure sunlight levels and to reduce or stop turbine rotation if the conditions exist that would lead to any shadow flicker at neighbouring properties.

The distance and direction between the turbine and property is of significance because:
The duration of the shadow will be shorter the greater the distance (i.e., it will pass by faster)
The shadow flicker cast by rotating wind turbine blades will be reduced, the further a dwelling is from an operating turbine.

The path of the sun varies over the seasons resulting in a changing potential for a shadow to be cast throughout the year. Similarly, the sun's position in the sky over the course of a day is changing such that the shadow cast by a turbine is constantly changing. Shadow flicker is more likely to occur on sunny winter days when the sun is lower in the sky and shadows cast a greater distance from the turbine. Shadow flicker is more likely to occur to the east or west of the Wind Farm Site. This can be seen in **Appendix 15.1**.

15.2.2 Relevant Guidance

The relevant Irish guidance for shadow flicker is derived from the '*Wind Energy Development Guidelines*' (Department of the Environment, Heritage and Local Government (DoEHLG), 2006) the '*Best Practice Guidelines for the Irish Wind Energy Industry*' (Irish Wind Energy Association, 2012), and the Draft Revised Wind Energy Development Guidelines (Department of Housing, Local Government and Heritage, 2019).

The Department of Environment, Community and Local Government in its Wind Energy Development Guidelines (2006) (the 2006 Guidelines) considers that:
"*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 2006 Guidelines also state that:
"*It is recommended that shadow flicker at neighbouring offices and dwellings within 500 m should not exceed 30 hours per year or 30 minutes per day*".
The 2006 Guidelines state that shadow flicker lasts only for a short period of time and occurs only during certain specific combined circumstances, as follows:

the sun is shining and is at a low angle in the sky, i.e., just after dawn and before sunset; and the turbine is located directly between the sun and the affected property; and there is enough wind energy to ensure that the turbine blades are moving; and the turbine blades are positioned so as to cast a shadow on the receptor.

Although the DoEHLG thresholds apply to dwellings located within 500 metres of a proposed turbine location, for the purposes of this assessment, the guideline thresholds of 30 hours per year or 30 minutes per day have been applied to all properties located within ten rotor diameters (i.e., 1,170 metres (117 m)) of the proposed turbines within the Wind Farm Site (as per IWEA guidelines, 2012[2]). The 2006 Guidelines state that at distances greater than 10 rotor diameters from a turbine, the potential for shadow flicker is very low.
The adopted 2006 DoEHLG guidelines are currently under review. The Department of Housing, Local Government and Heritage released the 'Draft Revised Wind Energy Development Guidelines' in December 2019. The Draft Revised Wind Energy Development Guidelines (2019) provides for zero shadow flicker:
"Computational models can be used to accurately predict the strength and duration of potential shadow flicker during daylight hours for every day of the year. A Shadow Flicker Study detailing the outcome of computational modelling for the potential for shadow flicker from the development should accompany all planning applications for wind energy development.
If a suitable shadow flicker prediction model indicates that there is potential for shadow flicker to occur at any particular dwelling or other potentially affected property, then a review of site design involving the possible relocation of one or more turbines to explore the possibility of eliminating the occurrence of potential flicker is required. Following such a review, if shadow flicker is not eliminated for any dwelling or other potentially affected property then clearly specified measures which provide for automated turbine shut down to eliminate shadow flicker should be required as a condition of a grant of permission."

The Draft 2019 Guidelines are based on the recommendations set out in the 'Proposed Revisions to Wind Energy Development Guidelines 2006 – Targeted Review in relation to Noise, Proximity and Shadow Flicker' (December 2013) and the 'Review of the Wind Energy Development Guidelines 2006 – Preferred Draft Approach' (June 2017).

[2] Irish Wind Energy Association, 2012. *Best Practice Guidelines for the Irish Wind Energy Industry*, Cork: Wind Skillnet. [Available online: https://windenergyireland.com/images/files/9660bdfb5a4f1d276f41ae9ab54e991bb600b7.pdf]

The assessment herein is based on compliance with the current DoEHLG Guidelines limit (30 hours per year or 30 minutes per day). However, it should also be noted the Proposed Development can be brought in line with the requirements of the 2019 draft guidelines, should they be adopted while this application is in the planning system, through the implementation of the mitigation measures outlined herein.

15.2.3 Shadow Flicker Modelling

An industry standard wind farm assessment software package, WindPRO from EMD International Version 4.2 was used to prepare a model of the Proposed Development. The programme facilitates the analysis of a wind farm for possible shadow flicker occurrence at nearby houses. It allows for the production of maps, and shadow flicker prediction. The data output from the programme has been analysed and the receptors potentially vulnerable to shadow flicker were identified. The significance of shadow flicker effects was assessed.

Generic windows of 2 m width, 2 m height and 0.5 m above ground are applied in the model to each side of the house. The model assumes the receptor will not face any particular direction, but instead will face all directions. These windows represent an approximation of the existing windows on the houses facing north, south, east and west and provide an estimate of potential shadow flicker to a window on each side of the house. The software determines the times of day/year when the sun will be in line with the rotational components of the turbine and the house/receptor, thereby having the potential to cause shadow flicker. The software outputs details of potential shadow flicker, in this case by mean and maximum duration of the shadow flicker events, days per year and times of occurrence and maximum hours per year and maximum minutes per day of shadow flicker.

The following data inputs were required and used to produce an estimate of the effect of shadow flicker from the Wind Farm:

- Digital elevation model of the Proposed Development and areas around all properties within the model (10 m resolution – OS X, Y, and Z data points)
- Turbine locations
- Turbine dimensions (rotor diameter and hub height)
- Receptor locations (i.e., property locations)
- Bottom line height above ground 'window' (0.5 m above ground level)
- Wind direction for the Wind Farm Site to determine the period that the wind turbines will be in operation from the different wind directions during the year.

The software creates a mathematical model of the Proposed Development and its surroundings and uses this information to calculate specific theoretical times and durations of flicker effects for the identified properties. The following 'worst-case' assumptions were initially incorporated into the shadow flicker modelling:

there are no clouds and sunlight is always bright and direct the turbines are always rotating whereas this might not be the case due to maintenance works, break downs, wind speeds below the turbine threshold or curtailment there is no intervening structures or vegetation (other than topography) that may restrict the visibility of a turbine, preventing or reducing the effect a limit to human perception of shadow flicker is not considered by the model

The model operates by simulating the path of the sun during the year. The results of the model provide a calculation of theoretical specific times and durations of flicker effects for the identified properties. As previously stated, given the assumptions incorporated into the model, the calculations overestimate the duration of effects. The worst-case assumption is considered to be sufficient for the purposes of this assessment as it assumes the sky is always clear, the turbines are always aligned face-on to each window and that there is a clear and undisturbed line of sight between the windows of the receptors and the turbines (except where this is prevented due to topography). In reality, this will not occur; the turbines will not always be orientated as described, clouds will obscure the sun and line of sight may also be obscured (for example, from leaves on trees). The flicker effects will be substantially less than this and will not meet the results of the worst-case assumption.

The model also outputs a more realistic scenario, or "expected values". In this scenario, the only change in assumptions is that the statistically likely monthly sunshine frequency and wind direction frequency data is assessed. This assessment only changes the annual hours per year value and is not applied to the daily data. This is because it could be sunny, with the wind coming from the relevant direction, on any individual day. The data used in the model was the:

Long-term sunshine probability data from the Met Éireann synoptic station in Belmullet
Long-term wind rose data from the Met Éireann synoptic station in Belmullet.

15.2.4 Baseline Description & Likely Evolution of the Baseline

The Wind Farm Site is located in a sparsely populated rural area, typically ribbon development with sporadic cul-de-sacs. Should the Proposed Development not proceed, the surrounding areas will remain the same. Shadow flicker is directly associated with the operation of turbines.

Taking the above into consideration, JOD examined maps to identify receptors (dwellings) in the local area within a Study Area, a distance ten times the proposed rotor diameter of the proposed turbines (10 x 117 m = 1,170 m). The house numbers are based on a 2 km study area used in other assessments of the Proposed Development. There are 100 properties within the shadow flicker Study Area radius. H1 will be converted and used as a permanent operations office and H2 will remain unoccupied for the operational life cycle of the Proposed Development. The majority of houses are located to the east and north-east of the Proposed Development. The coordinates of each dwelling and its distance to the closest proposed turbine are listed in **Table 15.1** and are shown in **Figure 2.4.**

Table 15.1: Properties within the Shadow Flicker Study Area

Current House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H1*	515110	837466	AT12	265
H2*	515526	833767	AT01	322
H3	516227	836339	AT08	555
H4	514628	834072	AT05	555
H5	516241	833804	AT01	559
H6	515489	833504	AT01	567
H7	517503	837983	AT15	601
H8	515450	832962	AT04	601
H9	515080	831996	AT02	602
H10	515456	833467	AT01	615
H11	516561	837118	AT16	624
H12	515575	835060	AT07	626
H13	515019	834112	AT05	634
H14	517530	838028	AT15	636
H15	517553	837950	AT15	647
H16	517556	837865	AT16	647
H17	515390	832068	AT02	664
H18	517622	837746	AT16	669
H19	517552	838096	AT15	675
H20	515559	834678	AT01	679
H21	516744	836946	AT16	680
H22	514721	837259	AT12	681

Current House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H23	515805	834702	AT01	687
H24	517581	838054	AT15	691
H25	515641	832856	AT02	715
H26	515947	834836	AT07	719
H27	517606	838071	AT15	720
H28	515886	834729	AT01	727
H29	517490	838353	AT15	742
H30	515462	834716	AT01	744
H31	516107	834819	AT07	751
H32	517583	838226	AT15	753
H33	515398	834709	AT05	753
H34	517725	837501	AT16	758
H35	517434	838443	AT15	762
H36	517697	837346	AT16	764
H37	514129	833845	AT06	769
H38	517741	837449	AT16	781
H39	517762	837602	AT16	790
H40	517663	838130	AT15	791
H41	517766	837561	AT16	794
H42	517762	837501	AT16	795
H43	517767	837579	AT16	795
H44	517742	837383	AT16	796
H45	515873	833236	AT01	798
H46	516625	836322	AT08	798
H47	517758	837737	AT16	800
H48	516764	835557	AT07	806
H49	517632	838261	AT15	812
H50	517638	837109	AT16	820
H51	517742	837283	AT16	828
H52	517457	838516	AT15	831
H53	516738	836261	AT08	859
H54	517836	837697	AT16	871

Current House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H55	516774	835227	AT07	879
H56	517806	837295	AT16	884
H57	516697	836380	AT08	891
H58	517489	838569	AT15	892
H59	517798	837225	AT16	902
H60	515557	831893	AT02	905
H61	516384	834641	AT01	905
H62	517792	837189	AT16	911
H63	516320	834718	AT07	912
H64	517729	837077	AT16	913
H65	514818	831687	AT02	916
H66	516817	836244	AT08	921
H67	517748	838272	AT15	921
H68	517791	837155	AT16	926
H69	517804	837142	AT16	944
H70	514941	831643	AT02	947
H71	517884	837289	AT16	959
H72	514595	831709	AT02	960
H73	517910	837382	AT16	960
H74	516822	835130	AT07	963
H75	516865	836247	AT08	965
H76	515173	831629	AT02	980
H77	517945	837469	AT16	980
H78	516609	833595	AT01	981
H79	515971	838486	AT14	998
H80	516040	838493	AT14	1010
H81	517816	838358	AT15	1020
H82	517798	838402	AT15	1025
H83	516975	835388	AT07	1031
H84	516953	836216	AT08	1034
H85	516624	833488	AT01	1045
H86	515505	831678	AT02	1052

Current House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H87	514472	831653	AT02	1064
H88	517382	836605	AT16	1064
H89	517041	835575	AT08	1082
H90	516551	833308	AT01	1090
H91	513601	835338	AT06	1093
H92	516678	834560	AT01	1095
H93	516041	838580	AT14	1097
H94	513331	834901	AT06	1100
H95	514539	831580	AT02	1100
H96	514340	837065	AT12	1102
H97	517409	836575	AT16	1102
H98	517850	838466	AT15	1103
H99	513352	834999	AT06	1114
H100	518085	837658	AT16	1115

*Note: H2 will remain unoccupied for the operational duration of the project. H1 will be an operations building associated with the project.

15.2.5 Limitations of the Assessment

As previously stated, this calculation is based on topography alone and excludes vegetation, buildings and other man-made structures. These factors cannot be accurately predicted due to the changeable nature of these variables.

15.2.6 Assessment of Expected Shadow Flicker Impact

In order to calculate more realistic and '*real world*' occurrences of shadow flicker for the receptors that are identified as potentially vulnerable to shadow flicker (**Table 15.1**), it is necessary to identify the likely meteorological conditions which are expected to be experienced at the Wind Farm Site. To estimate the likely duration of sunshine occurrence at the Wind Farm Site, historical meteorological data from Met Éireann is automatically uploaded by the software. Data from Belmullet meteorological observatory was used as this Met Éireann observatory is the closest to the Wind Farm Site and also measures multiple environmental parameters (**Table 15.2**). This gives a good representation of data for the Proposed Development. This data was utilised to consider the probability of sunshine occurrence, and thus allow the determination of '*projected*' values for shadow flicker occurrence.

Table 15.2: Average daily sunshine hours from Belmullet

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.36	2.16	2.65	4.82	5.79	4.41	4.42	4.07	3.73	2.48	1.71	0.89

The worst-case predicted hours for shadow flicker are reduced by the average time the weather is cloudy annually. As discussed above, to estimate the effect of sunshine occurrence, historical meteorological data is utilised to consider the likelihood of sunshine (the sunshine probability) at different times of the year. This allows the determination of '*expected*' values for shadow flicker occurrence. This is achieved by applying a reductive factor to the worst-case total hours per year of shadow flicker. 'Long term average sunshine hours' refers to data collected by Met Éireann.

Table 15.3 shows the potential and the expected shadow flicker values per year which are likely to be experienced by each receptor. '*Potential sunshine hours'* refers to the intervening time period between modelled sunrise and sunset. Although the projected duration of shadow flicker is reduced substantially for each dwelling, they are not eliminated entirely for all of the 100 receptors within the shadow flicker Study Area of the Proposed Development.

The expected daily shadow flicker cannot be predicted as this depends on multiple variable factors such as wind direction, wind speed, cloud cover and sunshine. These factors cannot be accurately predicted to give an expected minutes of shadow flicker per day. The maximum scenario in this assessment is based on the average sunshine and average wind direction for the Wind Farm Site.

The mitigation measures to avoid exceedance of the 2006 Guideline's thresholds is outlined in **Section 15.2.9**.

15.2.7 Assessment of Potential Effects

This assessment considers the potential shadow flicker effect of the Proposed Development on the remaining surrounding properties in terms of:

Predicting and assessing the extent of shadow flicker experienced by all properties within the shadow flicker Study Area Specifying mitigation measures, where deemed necessary.

The maximum expected daily shadow flicker for each receptor is outlined in the table below. This is the highest amount expected across the whole year on any given day. All other days will experience no more than this amount of shadow flicker, pre-mitigation.

The IWEA Guidelines recommend that all existing and / or permitted wind farm developments within 2 km of a proposed development should be considered in a cumulative shadow flicker assessment. There are no wind farms within 2 km of the Proposed Development to be considered with the Proposed Development for cumulative effects.

Table 15.3: Summary of Potential Shadow Flicker Listing for All Properties

Receptor ID	Specimen Turbine		
	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]
H1*	109:11	16:33	00:59
H2*	55:32	06:48	00:34
H3	110:08	15:30	00:54
H4	04:42	00:43	00:18
H5	85:01	15:12	00:52
H6	57:21	06:45	00:41
H7	70:29	10:03	00:45
H8	142:45	22:34	00:48
H9	00:00	00:00	00:00
H10	64:39	07:42	00:44
H11	101:23	17:06	00:41
H12	08:08	01:04	00:25
H13	41:26	06:41	00:37
H14	63:38	08:42	00:43
H15	61:26	09:05	00:42
H16	61:25	09:47	00:42
H17	00:00	00:00	00:00
H18	56:07	09:18	00:41
H19	57:37	07:36	00:41
H20	14:23	02:13	00:30
H21	69:29	11:26	00:31
H22	40:06	06:23	00:31
H23	08:26	01:16	00:24
H24	51:26	07:00	00:39
H25	73:12	12:18	00:39
H26	04:54	00:42	00:20
H27	47:39	06:28	00:38

Receptor ID	Specimen Turbine		
	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]
H28	06:57	01:02	00:22
H29	58:39	06:24	00:38
H30	16:56	02:31	00:34
H31	03:38	00:32	00:17
H32	52:03	06:23	00:37
H33	20:15	03:02	00:36
H34	64:07	11:34	00:36
H35	53:07	05:34	00:38
H36	50:22	09:09	00:37
H37	22:02	02:24	00:27
H38	60:03	10:45	00:36
H39	44:14	08:14	00:34
H40	40:10	05:21	00:35
H41	46:55	08:52	00:34
H42	58:45	10:41	00:35
H43	44:59	08:28	00:35
H44	52:31	09:25	00:36
H45	33:48	04:37	00:28
H46	99:27	14:20	00:37
H47	38:48	06:26	00:34
H48	48:17	08:57	00:35
H49	44:35	05:30	00:34
H50	00:00	00:00	00:00
H51	47:55	08:36	00:35
H52	45:58	04:36	00:37
H53	74:00	11:29	00:33
H54	32:58	05:37	00:31
H55	40:42	07:06	00:33
H56	43:06	07:50	00:32
H57	93:13	13:36	00:35
H58	38:54	03:51	00:33
H59	41:41	07:28	00:32
H60	00:00	00:00	00:00
H61	20:56	02:21	00:32
H62	37:51	06:42	00:32
H63	30:13	02:58	00:32
H64	09:20	01:30	00:21
H65	00:00	00:00	00:00
H66	66:36	10:27	00:30

Receptor ID	Specimen Turbine		
	Worst Case Shadow [h/year]	Expected Shadow [h/year]	Max. Expected Shadow [h/day]
H67	32:06	04:04	00:30
H68	33:45	05:53	00:32
H69	32:27	05:38	00:32
H70	00:00	00:00	00:00
H71	42:36	07:41	00:30
H72	00:00	00:00	00:00
H73	45:29	08:13	00:29
H74	40:07	06:54	00:31
H75	63:15	10:00	00:29
H76	00:00	00:00	00:00
H77	32:03	06:03	00:28
H78	21:00	04:07	00:30
H79	39:35	04:25	00:39
H80	34:44	04:07	00:46
H81	27:55	03:29	00:27
H82	29:58	03:39	00:28
H83	32:44	06:13	00:27
H84	56:19	09:01	00:27
H85	30:00	05:21	00:29
H86	00:00	00:00	00:00
H87	00:00	00:00	00:00
H88	25:42	04:18	00:18
H89	39:09	06:52	00:26
H90	06:13	00:52	00:15
H91	14:44	01:49	00:24
H92	09:50	01:16	00:26
H93	40:11	04:21	00:44
H94	11:45	01:39	00:29
H95	00:00	00:00	00:00
H96	29:43	04:50	00:23
H97	25:01	04:10	00:18
H98	27:27	03:17	00:26
H99	12:15	01:43	00:26
H100	20:09	03:32	00:24

*Note: H1 and H2 will be unoccupied for the duration of the development.

It can be demonstrated from **Table 15.3**, there will be 89 receptors out of 100 that will experience some degree of shadow flicker and 11 receptors that will experience no shadow flicker. H8 is expected to experience 22 hours 34 minutes of shadow flicker in a year, which

is the worst affected receptor. None of the receptors are expected to experience the 2006 Guidelines recommendation of 30 hours or more of shadow flicker per year in any of the scenarios. 56 sensitive receptors have the potential to exceed the 2006 Guidelines of a maximum 30 minutes of shadow flicker per day.

The closest sensitive receptor, H1 which is involved with the Project and will be converted to an operations building for the lifespan of the Proposed Development, is within 265 m of the closest turbine (AT12). This has 16 hours 33 minutes of expected shadow flicker per year, and a maximum of 59 minutes of shadow flicker per day. The closest inhabited dwelling to a turbine not associated with the Proposed Development (H5) is located 554 m from the nearest turbine (AT08). This has 15 hours 12 minutes of expected shadow flicker per year, and a maximum of 52 minutes of shadow flicker per day.

The calculated worst-case shadow flicker occurrences in the **Table 15.3** assumes the sun is always shining, that there is no cloud cover, the turbines are rotating and the dwelling is always occupied. As previously stated, this calculation is based on topography alone and excludes vegetation, buildings and other man-made structures. As can be seen in the shadow flicker assessment attached as **Appendix 15.1** all of the proposed turbines give rise to some degree of cumulative shadow flicker, if unmitigated.

15.2.8 Cumulative Effects

Cumulative shadow flicker effects could arise if dwellings are at risk from potential shadow flicker effects as a result of more than one wind farm. While separate wind farms are not likely to cause effects simultaneously, they could increase the cumulative total hours where a receptor is affected. In this instance, there are no proposed or operational within a 2 km range of the turbines that may cause cumulative effects.

15.2.9 Mitigation Measures & Residual Effects

15.2.9.1 Likely Evolution of the Baseline

The shadow flicker effect is related to the operational phase of a wind farm. If the Proposed Development were not to proceed, the effects described in this chapter will not occur.

15.2.9.2 Construction Phase

As previously stated, the shadow flicker effect is associated with the operational phase of the Wind Farm and has been scoped out for the construction phase. During construction there will be no shadow flicker effect and therefore no mitigation is required.

15.2.9.3 Operational Phase

Shadow control system will be installed on each of the wind turbines. The control system will calculate, in real-time:

- Whether shadow flicker has the potential to effect nearby properties, based on pre-programmed co-ordinates for the properties and turbines
- Wind speed (can affect how fast the turbine will turn and how quickly the flicker will occur)
- Wind direction
- The intensity of the sunlight

When the control system detects that the sunlight is strong enough to cast a shadow, and the shadow falls on a property or properties, then the turbine will automatically shut down; and will restart when the potential for shadow flicker ceases at the effected properties. Such systems are common in many wind farm developments and the technology has been well established. A case study in Scotland found that the use of turbine shut-down control modules for turbines which were causing shadow flicker at nearby offices was successful. The proposed method of mitigation will be implemented to mitigate shadow flicker effects at all sensitive receptors within the study area, allowing for a short period of time for the rotor to come to a stop. **Appendix 15.1** contains all calculated potential shadow flicker periods for each turbine. The relevant data will be input into the turbine control software. In the event that complaints of shadow flicker are received by the Developer / site operator or by Mayo County Council, an investigation will take place and the complaints frequency, duration and time of complaints will be considered and specialist modelling software will be used to confirm the occurrence(s). Should the complaint persist, a shadow flicker survey involving the collection of light data will also be carried out at the property in which the complaint was made. Further refinement of the blade shadow control system will be conducted to eliminate the shadow flicker occurrence from the specified turbines. This could result in the shutting off turbines at specific times of day.

15.2.9.4 Decommissioning Phase

As previously stated, the shadow flicker effect is associated with the operational phase of the Wind Farm and has been scoped out for the decommissioning phase. During decommissioning there will be no shadow flicker effect and therefore no mitigation is required.

15.2.9.5 Residual Effects

The results of the shadow flicker assessment predict that Tirawley Wind Farm has the potential to result in shadow flicker at a maximum of 108 receptors surrounding the Site. The implementation of mitigation to cease operation of the turbines during periods of potential shadow flicker will ensure that no shadow flicker effects above the recommended guidance are experienced at any sensitive receptor within the Study Area. It is therefore considered that Tirawley Wind Farm will comply with the 2006 Guidelines of no more than 30 minutes per day and or 30 hours per year of shadow flicker at neighbouring sensitive receptors within the Study Area. Following implementation of mitigation measures described in **Section 15.2.9.2**, the residual impact as a result of shadow flicker will be a neutral, imperceptible, long-term effect.

15.3 SUMMARY OF SIGNIFICANT EFFECTS

This chapter has assessed the significance of potential effects of the Proposed Development on shadow flicker.

This assessment has identified the potential for shadow flicker to affect 108 no. out of 119 no. receptors within the shadow flicker Study Area. It is proposed that a shadow control system be installed to eliminate the potential for shadow flicker from the Proposed Development above the recommendations of the 2006 Guidelines. This assessment has identified that by installing a blade shadow control system on the proposed turbines, there will be no significant direct or indirect effects. Given that only effects of significant effect or greater are considered "significant" in terms of the EIA Directive the potential effects of the Proposed Development as a result of shadow flicker, when mitigated, are considered to be not significant. The Proposed Development has been assessed as having the potential to result in neutral, imperceptible, long-term effects overall with regards to shadow flicker. There are no predicted cumulative effects.