13 SHADOW FLICKER

13.1 INTRODUCTION

This chapter assesses the likely significant direct and indirect effects of the Development in terms of shadow flicker. The Development refers to all elements of the application for the construction of Moanmore Lower Wind Farm as detailed in **Chapter 2: Project Description**. Where negative significant effects are predicted, the chapter identifies appropriate mitigation strategies therein. The assessment considers the potential effects during the Operational phase of the Development.

Shadow flicker only has the potential to occur during the operational phase of the 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 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 13.1 Shadow Flicker Analyses**

13.1.1 Statement of Authority

This chapter has been prepared by Ms. Sarah Moore and Mr. Padraig O'Dowd of Jennings O'Donovan & Partners Limited.

Ms. Sarah Moore is an Environmental Scientist in JOD with over 17 years of environmental consultancy experience. She has obtained a MSc in Environmental Engineering from Queens University, Belfast, and a BSc in Environmental Science from University of Limerick. Since joining JOD, Sarah has been involved as a Project Environmental Scientist on a range of renewable energy, wastewater, structures and commercial projects. She has experience in the preparation of Appropriate Assessments, Ecological Impact Assessments, Environmental Impact Assessments, Shadow Flicker analysis and Geographic Information Systems.

Mr. Padraig O' Dowd is a Junior Environmental Scientist at JOD. He holds a BA (Hons) in Creative Design, an MSc in Design Innovation, and a GradDip in Design Thinking for Sustainability. As a Graduate Member of IEMA, his expertise includes EIAR report writing, grant-funded research applications, and data analysis, with a focus on the environmental and renewable energy sectors. He also has research experience with Wind Energy Ireland. This chapter has been reviewed by Mr. David Kiely is Managing Director of JOD and holds a BE in Civil Engineering from University College Dublin and MSc in Environmental Protection from IT Sligo. He is a Fellow of Engineers Ireland, a Chartered Member of the Institution of Civil Engineers (UK). David has over four decades of experience in the preparation of EIARs and EISs for environmental projects including Wind Farms, Solar Farms, Wastewater Projects, and various commercial developments. David has also been involved in the construction of over 60 wind farms since 1997.

13.1.2 Assessment Structure

In line with the relevant legislation and guidelines identified in **Chapter 1, Section 1.6** and the topic-specific guidance described below, the structure of this shadow flicker chapter is as follows:

- Assessment methodology and significance criteria
- Description of baseline conditions at the Site, including the likely evolution of the baseline
- Identification and assessment of effects of shadow flicker associated with the Development, during the construction, operational and decommissioning phases of the Development
- Mitigation measures to avoid or reduce the effects identified
- Identification and assessment of residual impact of the Development after the application of 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 Clare County Council (the Planning Authority) to carry out an adequate EIA of the Development.

13.2 SHADOW FLICKER

This chapter comprehensively assesses the potential shadow flicker effects of the operational stage of the Development. The grid connection and turbine delivery route are not included in this assessment as shadow flicker relates to the turbines only.

13.2.1 Assessment Methodology

This assessment of shadow flicker involved the following:

- Evaluation of potential effects (See **Section 13.2.7**) includes predicting the shadow flicker effects for sensitive receptors within the Study Area and comparing them against the 2006 Wind Energy Development Guidelines[1]
- Comparison of results against the Draft 2019 Guidelines;
- Evaluation of the significance of effects using the methodology set out in **Chapter 1: Introduction**, **Section 1.9**
- Identification of measures to avoid and mitigate potential significant effects

The Study Area is defined as 10 times the widest possible potential rotor diameter within the range (10 x 136 m = 1,360 m). It is common practice to use a distance of ten rotor diameters as a maximum limit within which significant shadow flicker effects can occur, this is based on 2006 Guidelines which state: '*At distances greater than 10 rotor diameters from a turbine, the potential for shadow flicker is very low*'. As a precautionary measure, this was increased to 2,000 m (2km) for the inclusion of dwellings impacted in the cumulative assessment with the neighbouring Wind Farms. The Irish Wind Energy Industry[2] (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.

A shadow flicker computer model (WindPRO 4.0) was used to calculate the occurrence of shadow flicker at relevant receptors to the Development. The sensitive receptors were identified using a combination of GeoDirectory, Ordnance Survey of Ireland (OSI) Maps, AutoCAD drawings, internet resources including Eircode Finder, a planning permission search using the Clare County Council web resource and An Bord Pleanála web resource. A ground truth survey of all online sources was undertaken with a visit to 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 of 600m from all occupied sensitive receptors has been incorporated into the Project design, in line with the 2019 Guidelines. The closest inhabited dwellings are (H2 and H3) located 609m from the nearest turbine as shown in **Figure 1.3**. There is one property (H1*) located less than 600m from the proposed turbines.

[1] Department of Housing, Planning and Local Government, 2006. *Wind Energy Development Guidelines* (2006), Dublin. Government of Ireland. [Available Online: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.opr.ie/wp-content/uploads/2019/08/2006-Wind-Energy-Development-1.pdf]

[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] [Accessed at: 03/07/2024]

However, H1* is an old cottage that is being used as an equestrian tack-room and is not considered a sensitive receptor in this EIAR.

In order to ensure the full extent of the moving shadow which would be created by the movement of turbines in low sun light conditions the following scenario was modelled:

- Three 5MW wind turbines,
- Overall ground to blade tip height of 150m,
- A rotor diameter of 136m, and
- A hub height of 82m.

There is one nearby wind farm (within 2km), therefore the cumulative effect of the latter has also been assessed. The nearest wind farm is Moanmore Wind Farm located 1.7km northeast of the Site. Cumulative effects are assessed in **Section 13.2.8**.

Where negative significant effects are predicted, this section identifies appropriate mitigation strategies.

A shadow flicker computer model was used to calculate the occurrence of shadow flicker at all relevant receptors within the study area as defined. . The output from the calculations is analysed to identify and assess potential shadow flicker effects. This is further detailed in **Appendix 13.1**.

The 2006 Guidelines state that 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 aligned so as to cast a shadow on the receptor.

If any one of these conditions are absent, shadow flicker cannot occur.

13.2.2 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 (the "IWEA Guidelines")), and the 2019 *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 500m 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;
- the turbine is located directly between the sun and the affected sensitive receptor;
- there is enough wind energy to ensure that the turbine blades are moving; and
- the sun and the turbine blades are aligned 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 sensitive receptors located within 2 km of the proposed turbines within the Site (as per IWEA Guidelines).

The 2006 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 2019 Draft Revised Wind Energy Development Guidelines 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 2019 Draft Revised Wind Energy Development Guidelines (the "Draft 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).

The 2019 Draft Revised Wind Energy Development 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*."

The Draft Guidelines 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 these individuals. Therefore, any potential shadow flicker effect from the Development is considered an effect on residential amenity, rather than having the potential to affect the health of residents.

Careful site selection, design and planning, and good use of relevant software to control the turbine operation can help avoid 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 sensitive receptors.

The distance and direction between the turbine and sensitive receptor is of significance because:

- The duration of the shadow will be shorter the greater the distance (i.e., it will pass by quicker)
- The shadow flicker cast by rotating wind turbine blades will be reduced, the further a sensitive receptor 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 Site. This can be seen in **Appendix 13.1**.

The assessment herein is based on compliance with the current 2006 Guidelines limit (30 hours per year or 30 minutes per day). However, it should also be noted the 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 in **Section 13.4**, which allows for elimination of shadow flicker to affect an existing sensitive receptor.

13.2.3 Shadow Flicker Modelling

An industry standard wind farm assessment software package, WindPRO from EMD International Version 4.0 was used to prepare a model of the 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 from bottom line 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 Development and areas around all sensitive receptors within the model (10m resolution – OS X, Y, and Z data points)
- Turbine locations
- Turbine dimensions (rotor diameter and hub height)
- Receptor locations
- Bottom line height above ground 'window' (0.5m above ground level)
- Wind direction for the 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 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 sensitive receptors. 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 metric 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 Valentia.
- Long-term wind rose data were taken from the SEAI website and using the centre of the Site.

13.2.4 Baseline Description

The Development is located in a rural setting. Housing density in the area is low to medium. Should the Development not proceed, the surrounding areas will remain the same and receptors will not experience any shadow flicker effects associated with the Development. Shadow flicker is directly associated with the operation of turbines.

Taking the above into consideration, JOD examined maps and aerial photographs to identify sensitive receptors within two kilometres. The house survey was ground truth-ed to confirm there are a total of 183 receptors within 2,000m of any turbine. Although, as H1 not considered a sensitive receptor in this EIAR, there is 182 sensitive receptors within the shadow flicker Study Area. The coordinates of each dwelling and its distance to the closest proposed turbine are listed in **Table 13.1** and are shown in **Figure 1.3.**

Table 13.1: Sensitive Receptors within the shadow flicker study area

House ID	Easting ITM	Northing ITM	Closest Turbine	Distance to Closest Turbine (m)
H1*	498280	657469	T3	571
H2	498287	658418	T1	609
H3	497569	657205	T3	609
H4	498382	657964	T3	618
H5	498410	657916	T3	632
H6	497486	658726	T1	633
H7	498420	657877	T3	634
H8	498432	657801	T3	638

House ID	Easting ITM	Northing ITM	Closest Turbine	Distance to Closest Turbine (m)
H9	498431	657843	T3	640
H10	498261	658557	T1	661
H11	498184	658653	T1	672
H12	498456	657905	T3	674
H13	498486	657830	T3	694
H14	497318	658698	T1	695
H15	498510	657780	T3	715
H16	498533	657671	T3	745
H17	498482	658243	T1	746
H18	498172	658805	T1	786
H19	498566	657577	T3	795
H20	497071	658703	T2	802
H21	498151	658844	T1	808
H22	498150	658878	T1	837
H23	498454	658590	T1	839
H24	496946	658692	T2	843
H25	496668	657439	T2	850
H26	496635	657469	T2	859
H27	498140	658917	T1	867
H28	498492	658591	T1	872
H29	496881	658695	T2	879
H30	496848	658686	T2	889
H31	496798	658676	T2	910
H32	497329	656988	T3	911
H33	497332	656948	T3	944
H34	498181	656888	T3	964
H35	496711	658683	T2	970
H36	497339	656906	T3	978
H37	498240	656887	T3	990
H38	497332	656873	T3	1010
H39	498731	657336	T3	1032

House ID	Easting ITM	Northing ITM	Closest Turbine	Distance to Closest Turbine (m)
H40	497362	656826	T3	1039
H41	497317	656843	T3	1044
H42	496704	658783	T2	1052
H43	498359	656875	T3	1059
H44	498334	656854	T3	1064
H45	496286	658061	T2	1067
H46	498311	656836	T3	1068
H47	498544	657009	T3	1068
H48	496739	658836	T2	1075
H49	498713	657205	T3	1078
H50	498884	657642	T3	1097
H51	498629	658803	T1	1103
H52	497087	656875	T2	1106
H53	497262	656801	T3	1107
H54	497290	656784	T3	1109
H55	498124	656683	T3	1137
H56	497114	656834	T2	1140
H57	497914	656633	T3	1144
H58	496940	659020	T2	1145
H59	498027	656637	T3	1157
H60	497885	656613	T3	1161
H61	498728	657071	T3	1166
H62	497376	656675	T3	1173
H63	497443	656650	T3	1175
H64	496886	656865	T2	1179
H65	497473	656635	T3	1181
H66	497857	656591	T3	1182
H67	497502	656615	T3	1193
H68	497832	656572	T3	1200
H69	497803	656555	T3	1216
H70	496312	658591	T2	1217

House ID	Easting ITM	Northing ITM	Closest Turbine	Distance to Closest Turbine (m)
H71	498744	656992	T3	1228
H72	496277	658568	T2	1236
H73	498795	657042	T3	1238
H74	496707	656890	T2	1238
H75	496452	657094	T2	1238
H76	498847	658716	T1	1243
H77	496559	656976	T2	1253
H78	496506	657019	T2	1255
H79	499048	657629	T3	1261
H80	496597	656921	T2	1273
H81	497232	656617	T3	1284
H82	498850	657037	T3	1285
H83	497728	656482	T3	1291
H84	498763	656912	T3	1294
H85	496181	658531	T2	1303
H86	497786	656464	T3	1307
H87	498116	656502	T3	1309
H88	498155	656508	T3	1313
H89	498889	657037	T3	1317
H90	497247	656569	T3	1321
H91	498149	656490	T3	1329
H92	498785	656875	T3	1335
H93	496134	658563	T2	1359
H94	498752	656793	T3	1368
H95	496075	658482	T2	1379
H96	497374	659476	T1	1379
H97	497456	659513	T1	1396
H98	499204	657725	T3	1410
H99	496018	658458	T2	1423
H100	498989	656992	T3	1426
H101	498817	656759	T3	1438

House ID	Easting ITM	Northing ITM	Closest Turbine	Distance to Closest Turbine (m)
H102	499243	657751	T3	1448
H103	496529	659156	T2	1457
H104	499263	657825	T3	1469
H105	495970	658467	T2	1471
H106	498105	656327	T3	1477
H107	498835	656719	T3	1479
H108	496187	657029	T2	1481
H109	499096	657055	T3	1485
H110	497702	659639	T1	1493
H111	496528	659201	T2	1495
H112	495919	658416	T2	1502
H113	498838	656683	T3	1507
H114	498848	656658	T3	1532
H115	495911	658504	T2	1539
H116	497726	659690	T1	1543
H117	497720	659702	T1	1555
H118	496527	659272	T2	1556
H119	498858	656627	T3	1562
H120	498877	656638	T3	1567
H121	497712	659720	T1	1573
H122	497666	659725	T1	1580
H123	498239	656248	T3	1586
H124	498867	656595	T3	1591
H125	496593	659367	T2	1605
H126	498275	656236	T3	1608
H127	498357	656259	T3	1613
H128	498877	656564	T3	1621
H129	495877	658649	T2	1628
H130	495792	657434	T2	1638
H131	498385	656239	T3	1642
H132	495879	658693	T2	1645

House ID	Easting ITM	Northing ITM	Closest Turbine	Distance to Closest Turbine (m)
H133	495966	657036	T2	1656
H134	498323	656200	T3	1657
H135	499447	657920	T3	1659
H136	495869	658730	T2	1671
H137	498349	656194	T3	1671
H138	497726	659826	T1	1679
H139	498367	656184	T3	1687
H140	498380	656179	T3	1696
H141	499483	657944	T3	1697
H142	495884	658812	T2	1698
H143	498443	656200	T3	1699
H144	498475	656182	T3	1728
H145	498414	656153	T3	1732
H146	495834	658794	T2	1732
H147	499465	657289	T3	1738
H148	495845	657055	T2	1748
H149	499543	657842	T3	1749
H150	498135	659862	T1	1759
H151	497459	656039	T3	1764
H152	495891	658951	T2	1767
H153	498477	656117	T3	1789
H154	495809	658871	T2	1793
H155	499595	658009	T3	1816
H156	498888	656317	T3	1819
H157	495831	658975	T2	1830
H158	498896	656287	T3	1848
H159	495816	659005	T2	1859
H160	498569	656079	T3	1861
H161	495676	657117	T2	1867
H162	498907	656261	T3	1875
H163	497537	660013	T1	1877

House ID	Easting ITM	Northing ITM	Closest Turbine	Distance to Closest Turbine (m)
H164	498615	656073	T3	1886
H165	497275	655954	T3	1890
H166	499674	658050	T3	1900
H167	496916	659866	T1	1907
H168	498918	656226	T3	1910
H169	498745	656110	T3	1913
H170	495782	659054	T2	1915
H171	497902	655849	T3	1925
H172	497535	660067	T1	1931
H173	495793	659099	T2	1933
H174	498919	656196	T3	1935
H175	499694	657354	T3	1944
H176	498673	656022	T3	1957
H177	497990	660091	T1	1960
H178	497452	660089	T1	1964
H179	496934	659938	T1	1964
H180	498934	656167	T3	1967
H181	499156	656325	T3	1986
H182	498707	656005	T3	1988
H183	499750	657404	T3	1989
***H1** is an old cottage that is being used as an equestrian tack-room and is not considered a sensitive receptor.				

13.2.5 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.

13.2.6 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, it is necessary to identify the likely meteorological conditions which are expected to be experienced at the Site. To estimate the likely duration of sunshine occurrence at the Site, historical meteorological data from Met Éireann is automatically uploaded by the software. Data from Valentia meteorological observatory was used as this Met Éireann observatory is the closest to the Site and also measures multiple environmental parameters (**Table 13.2**). This gives a good representation of data for the 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 13.2. Average daily sunshine hours from Valentia (hours per day)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	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 impact 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 13.3 shows the worst-case and the expected shadow flicker values per year which are likely to be experienced by each sensitive 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 182 sensitive receptors within the shadow flicker Study Area.

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 site. The shadow flicker results showed that for the scenario assessed, 30 receptors (16.39%) would have a maximum shadow flicker over 30 minutes per day. This exceeds the 2006 Guidelines recommendation of 30 minutes per day and the Draft 2019 Guidelines policy of zero shadow flicker.

13.2.7 Assessment of Potential Effects

This assessment considers the potential shadow flicker effect of the Development on the surrounding sensitive receptors in terms of:

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

Table 13.3 assesses shadow flicker from the proposed Development across 182 sensitive receptors. The 'worst case' assessment assumes worst-case conditions where the sun is always shining, no cloud cover is present, turbines are continuously rotating, and sensitive receptors are always occupied. This calculation is based solely on topography, excluding potential mitigating factors such as vegetation, buildings, or other structures. The 'expected' values ('hours per year') consider the probability of sunshine and predominant wind direction based on historic meteorological data. Modelling over such a longer time span is therefore more accurate and more representative of the actual levels of shadow flicker which are likely to be experienced.

This assessment has identified the potential for shadow flicker to affect 84 sensitive receptors out of 182. Of the 84 affected sensitive receptors, 30 no. exceed the 2006 Guidelines recommendation of 30 minutes per day. Receptor H11 recorded the highest exceedance of the 2006 Guidelines with an exceedance of 43 minutes per day.

The receptors exceeding the 2006 Guidelines are as follows: H2, H4, H5, H6, H7, H8, H9, H10, H11, H12, H13, H14, H15, H16, H17, H18, H19, H20, H21, H22, H23, H24, H28, H29, H30, H31, H35, H42, H48 and H51.

The closest sensitive receptors (H2 & H3) are 609m from a proposed turbine. However, none of the sensitive receptors are expected to exceed the 2006 WEDGs recommendation of 30 hours per year in the 'real case' scenario.

Prior to mitigation, there will be likely significant shadow flicker effects on 30 no. sensitive receptors.

The Draft Revised Wind Energy Development Guidelines, December 2019, recommend that shadow flicker should not affect any sensitive receptor, therefore the relevant turbine (or turbines) must be shut down on a temporary basis until the potential for shadow flicker ceases. The mitigation measures to avoid exceedance of DoEHLG Guideline 2006 limits

(30 hours per year or 30 minutes per day) to the 30 no. properties highlighted in the above paragraph, are outlined in **Section 13.4.** The Development can also be brought in line with the Draft 2019 Guidelines should they be adopted while this application is in the planning system, through the implementation of the mitigation measures outlined in **Section 13.4**.

Table 13.3: Summary of Worst- and Expected-Case Shadow Flicker Exceedance Under 2006 Guidelines on Daily and Annual Basis

Dwelling ID	'Worst Case' Shadow Flicker			'Expected' Shadow Flicker		
	Moanmore Lower Wind Farm Flicker Levels – Compliance Threshold [h/day] (hrs:mins)	Moanmore Lower Wind Farm Flicker Levels Max. Shadow [h/day] (hrs:mins)	Level of Exceedance 2006 WEDGS	Predicted Shadow Flicker Levels – Compliance Threshold [h/year] (hrs:mins)	Predicted Shadow Flicker Expected Shadow [h/year] (hrs:mins)	Level of Exceedance 2006 Guidelines
H1*	00:30	00:59	**00:29**	30:00	12:22	0:00
H2	00:30	00:53	**00:23**	30:00	12:43	0:00
H3	00:30	00:00	00:00	30:00	00:00	0:00
H4	00:30	00:52	**00:22**	30:00	17:46	0:00
H5	00:30	00:50	**00:20**	30:00	16:53	0:00
H6	00:30	00:48	**00:18**	30:00	05:21	0:00
H7	00:30	00:50	**00:20**	30:00	17:14	0:00
H8	00:30	00:58	**00:28**	30:00	19:51	0:00
H9	00:30	00:51	**00:21**	30:00	17:46	0:00
H10	00:30	01:00	**00:30**	30:00	08:46	0:00
H11	00:30	01:13	**00:43**	30:00	09:56	0:00
H12	00:30	00:47	**00:17**	30:00	14:14	0:00
H13	00:30	00:47	**00:17**	30:00	14:20	0:00
H14	00:30	00:49	**00:19**	30:00	06:16	0:00
H15	00:30	00:51	**00:21**	30:00	14:14	0:00
H16	00:30	00:52	**00:22**	30:00	14:07	0:00
H17	00:30	00:42	**00:12**	30:00	11:33	0:00
H18	00:30	00:56	**00:26**	30:00	09:10	0:00
H19	00:30	00:45	**00:15**	30:00	09:47	0:00
H20	00:30	00:38	**00:08**	30:00	04:50	0:00
H21	00:30	00:53	**00:23**	30:00	06:39	0:00
H22	00:30	00:42	**00:12**	30:00	05:21	0:00
H23	00:30	00:41	**00:11**	30:00	08:25	0:00
H24	00:30	00:44	**00:14**	30:00	05:46	0:00

H25	00:30	00:26	00:00	30:00	04:29	0:00
H26	00:30	00:27	00:00	30:00	05:42	0:00
H27	00:30	00:22	00:00	30:00	04:13	0:00
H28	00:30	00:38	**00:08**	30:00	08:55	0:00
H29	00:30	00:43	**00:13**	30:00	05:54	0:00
H30	00:30	00:43	**00:13**	30:00	06:00	0:00
H31	00:30	00:42	**00:12**	30:00	06:17	0:00
H32	00:30	00:00	00:00	30:00	00:00	0:00
H33	00:30	00:00	00:00	30:00	00:00	0:00
H34	00:30	00:00	00:00	30:00	00:00	0:00
H35	00:30	00:41	**00:11**	30:00	05:58	0:00
H36	00:30	00:00	00:00	30:00	00:00	0:00
H37	00:30	00:00	00:00	30:00	00:00	0:00
H38	00:30	00:00	00:00	30:00	00:00	0:00
H39	00:30	00:29	00:00	30:00	03:42	0:00
H40	00:30	00:00	00:00	30:00	00:00	0:00
H41	00:30	00:00	00:00	30:00	00:00	0:00
H42	00:30	00:34	**00:04**	30:00	04:46	0:00
H43	00:30	00:00	00:00	30:00	00:00	0:00
H44	00:30	00:00	00:00	30:00	00:00	0:00
H45	00:30	00:29	00:00	30:00	03:31	0:00
H46	00:30	00:00	00:00	30:00	00:00	0:00
H47	00:30	00:06	00:00	30:00	00:22	0:00
H48	00:30	00:31	**00:01**	30:00	03:56	0:00
H49	00:30	00:28	00:00	30:00	05:30	0:00
H50	00:30	00:27	00:00	30:00	03:49	0:00
H51	00:30	00:32	**00:02**	30:00	06:18	0:00
H52	00:30	00:00	00:00	30:00	00:00	0:00
H53	00:30	00:00	00:00	30:00	00:00	0:00
H54	00:30	00:00	00:00	30:00	00:00	0:00
H55	00:30	00:00	00:00	30:00	00:00	0:00
H56	00:30	00:00	00:00	30:00	00:00	0:00
H57	00:30	00:00	00:00	30:00	00:00	0:00
H58	00:30	00:28	00:00	30:00	02:16	0:00
H59	00:30	00:00	00:00	30:00	00:00	0:00
H60	00:30	00:00	00:00	30:00	00:00	0:00
H61	00:30	00:16	00:00	30:00	02:24	0:00
H62	00:30	00:00	00:00	30:00	00:00	0:00
H63	00:30	00:00	00:00	30:00	00:00	0:00
H64	00:30	00:00	00:00	30:00	00:00	0:00
H65	00:30	00:00	00:00	30:00	00:00	0:00
H66	00:30	00:00	00:00	30:00	00:00	0:00

H67	00:30	00:00	00:00	30:00	00:00	0:00
H68	00:30	00:00	00:00	30:00	00:00	0:00
H69	00:30	00:00	00:00	30:00	00:00	0:00
H70	00:30	00:30	00:00	30:00	02:14	0:00
H71	00:30	00:10	00:00	30:00	01:13	0:00
H72	00:30	00:29	00:00	30:00	02:03	0:00
H73	00:30	00:17	00:00	30:00	02:25	0:00
H74	00:30	00:00	00:00	30:00	00:00	0:00
H75	00:30	00:19	00:00	30:00	01:38	0:00
H76	00:30	00:23	00:00	30:00	08:59	0:00
H77	00:30	00:19	00:00	30:00	02:12	0:00
H78	00:30	00:20	00:00	30:00	02:49	0:00
H79	00:30	00:20	00:00	30:00	02:22	0:00
H80	00:30	00:10	00:00	30:00	00:44	0:00
H81	00:30	00:00	00:00	30:00	00:00	0:00
H82	00:30	00:20	00:00	30:00	02:54	0:00
H83	00:30	00:00	00:00	30:00	00:00	0:00
H84	00:30	00:08	00:00	30:00	00:41	0:00
H85	00:30	00:25	00:00	30:00	01:40	0:00
H86	00:30	00:00	00:00	30:00	00:00	0:00
H87	00:30	00:00	00:00	30:00	00:00	0:00
H88	00:30	00:00	00:00	30:00	00:00	0:00
H89	00:30	00:20	00:00	30:00	03:12	0:00
H90	00:30	00:00	00:00	30:00	00:00	0:00
H91	00:30	00:00	00:00	30:00	00:00	0:00
H92	00:30	00:06	00:00	30:00	00:29	0:00
H93	00:30	00:22	00:00	30:00	01:28	0:00
H94	00:30	00:00	00:00	30:00	00:00	0:00
H95	00:30	00:22	00:00	30:00	01:22	0:00
H96	00:30	00:00	00:00	30:00	01:41	0:00
H97	00:30	00:00	00:00	30:00	02:11	0:00
H98	00:30	00:16	00:00	30:00	01:18	0:00
H99	00:30	00:21	00:00	30:00	01:15	0:00
H100	00:30	00:16	00:00	30:00	01:57	0:00
H101	00:30	00:00	00:00	30:00	00:00	0:00
H102	00:30	00:15	00:00	30:00	01:08	0:00
H103	00:30	00:17	00:00	30:00	00:36	0:00
H104	00:30	00:15	00:00	30:00	01:04	0:00
H105	00:30	00:20	00:00	30:00	01:08	0:00
H106	00:30	00:00	00:00	30:00	00:00	0:00
H107	00:30	00:00	00:00	30:00	00:00	0:00
H108	00:30	00:14	00:00	30:00	00:47	0:00

H109	00:30	00:14	00:00	30:00	00:57	0:00
H110	00:30	00:00	00:00	30:00	03:07	0:00
H111	00:30	00:17	00:00	30:00	00:35	0:00
H112	00:30	00:18	00:00	30:00	00:43	0:00
H113	00:30	00:00	00:00	30:00	00:00	0:00
H114	00:30	00:00	00:00	30:00	00:00	0:00
H115	00:30	00:18	00:00	30:00	00:39	0:00
H116	00:30	00:00	00:00	30:00	03:08	0:00
H117	00:30	00:00	00:00	30:00	03:05	0:00
H118	00:30	00:17	00:00	30:00	00:37	0:00
H119	00:30	00:00	00:00	30:00	00:00	0:00
H120	00:30	00:00	00:00	30:00	00:00	0:00
H121	00:30	00:00	00:00	30:00	02:58	0:00
H122	00:30	00:00	00:00	30:00	02:45	0:00
H123	00:30	00:00	00:00	30:00	00:00	0:00
H124	00:30	00:00	00:00	30:00	00:00	0:00
H125	00:30	00:16	00:00	30:00	00:52	0:00
H126	00:30	00:00	00:00	30:00	00:00	0:00
H127	00:30	00:00	00:00	30:00	00:00	0:00
H128	00:30	00:00	00:00	30:00	00:00	0:00
H129	00:30	00:17	00:00	30:00	00:33	0:00
H130	00:30	00:17	00:00	30:00	00:57	0:00
H131	00:30	00:00	00:00	30:00	00:00	0:00
H132	00:30	00:16	00:00	30:00	00:32	0:00
H133	00:30	00:14	00:00	30:00	01:28	0:00
H134	00:30	00:00	00:00	30:00	00:00	0:00
H135	00:30	00:11	00:00	30:00	00:38	0:00
H136	00:30	00:16	00:00	30:00	00:32	0:00
H137	00:30	00:00	00:00	30:00	00:00	0:00
H138	00:30	00:00	00:00	30:00	02:46	0:00
H139	00:30	00:00	00:00	30:00	00:00	0:00
H140	00:30	00:00	00:00	30:00	00:00	0:00
H141	00:30	00:10	00:00	30:00	00:35	0:00
H142	00:30	00:16	00:00	30:00	00:30	0:00
H143	00:30	00:00	00:00	30:00	00:00	0:00
H144	00:30	00:00	00:00	30:00	00:00	0:00
H145	00:30	00:00	00:00	30:00	00:00	0:00
H146	00:30	00:16	00:00	30:00	00:28	0:00
H147	00:30	00:09	00:00	30:00	00:20	0:00
H148	00:30	00:15	00:00	30:00	01:35	0:00
H149	00:30	00:10	00:00	30:00	00:16	0:00
H150	00:30	00:00	00:00	30:00	07:27	0:00

H151	00:30	00:00	00:00	30:00	00:00	0:00
H152	00:30	00:15	00:00	30:00	00:25	0:00
H153	00:30	00:00	00:00	30:00	00:00	0:00
H154	00:30	00:15	00:00	30:00	00:25	0:00
H155	00:30	00:00	00:00	30:00	00:00	0:00
H156	00:30	00:00	00:00	30:00	00:00	0:00
H157	00:30	00:00	00:00	30:00	00:00	0:00
H158	00:30	00:00	00:00	30:00	00:00	0:00
H159	00:30	00:00	00:00	30:00	00:00	0:00
H160	00:30	00:00	00:00	30:00	00:00	0:00
H161	00:30	00:00	00:00	30:00	00:00	0:00
H162	00:30	00:00	00:00	30:00	00:00	0:00
H163	00:30	00:00	00:00	30:00	01:28	0:00
H164	00:30	00:00	00:00	30:00	00:00	0:00
H165	00:30	00:00	00:00	30:00	00:00	0:00
H166	00:30	00:00	00:00	30:00	00:00	0:00
H167	00:30	00:00	00:00	30:00	00:00	0:00
H168	00:30	00:00	00:00	30:00	00:00	0:00
H169	00:30	00:00	00:00	30:00	00:00	0:00
H170	00:30	00:00	00:00	30:00	00:00	0:00
H171	00:30	00:00	00:00	30:00	00:00	0:00
H172	00:30	00:00	00:00	30:00	01:24	0:00
H173	00:30	00:00	00:00	30:00	00:00	0:00
H174	00:30	00:00	00:00	30:00	00:00	0:00
H175	00:30	00:00	00:00	30:00	00:00	0:00
H176	00:30	00:00	00:00	30:00	00:00	0:00
H177	00:30	00:00	00:00	30:00	03:32	0:00
H178	00:30	00:00	00:00	30:00	01:13	0:00
H179	00:30	00:00	00:00	30:00	00:00	0:00
H180	00:30	00:00	00:00	30:00	00:00	0:00
H181	00:30	00:00	00:00	30:00	00:00	0:00
H182	00:30	00:00	00:00	30:00	00:00	0:00
H183	00:30	00:00	00:00	30:00	00:00	0:00

13.2.8 Cumulative Effects

The IWEA Guidelines recommend considering all existing and/or permitted wind farm developments within 2 km of a proposed development in a cumulative shadow flicker assessment. 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 is one operational wind farm (Moanmore Wind Farm) within a 2 km range of the turbines that may cause cumulative effects.

Table 13.4 presents the assessment of worst-case and expected-case scenarios for shadow flicker from the Development and the cumulative wind farm development (Moanmore Wind Farm). This analysis identifies the sensitive receptors where cumulative shadow flicker is expected to occur, considering the cumulative Moanmore Wind Farm.

The assessment showed 13 no. receptors H96, H97, H110, H116, H117, H121, H122, H138, H150, H163, H172, H177, and H178 are predicted to be affected by the operational Moanmore Wind Farm and not the proposed Development (**Table 13.4**).

Out of 182 sensitive receptors, the following receptors have been identified to be impacted by cumulative flicker exposure from the proposed Development and the operational Moanmore Wind Farm:
H2, H6, H10, H11, H17, H18, H21, H22, H23, H27, H28, H51, and H76.

In the 'worst-case' scenario receptor H2 is anticipated to experience up to 96 hours and 17 minutes of shadow flicker annually under cumulative conditions, compared to 81 hours and 52 minutes from the Development alone. Similarly, receptor H11 is projected to have 90 hours and 2 minutes of cumulative flicker exposure, compared to 81 hours and 23 minutes from the Development alone. This assessment provides valuable insights into how cumulative developments may influence shadow flicker across various sensitive receptors, ensuring a comprehensive understanding of potential impacts.

Table 13.4: Assessment of Worst-Case and Expected Scenarios for the Proposed Development: Evaluating Predicted Cumulative Shadow Flicker Impacts on Sensitive Receptors from Neighbouring Operational Moanmore Wind Farm.

Dwelling ID	'Worst Case' Shadow Flicker		'Expected' Shadow Flicker	
	Moanmore Lower Wind Farm Shadow Flicker Worst Case Shadow [h/year] (hrs:mins)	Predicted Cumulative Shadow Flicker Worst Case Shadow [h/year] (hrs:mins)	Moanmore Lower Wind Farm Shadow Flicker Expected Shadow [h/year] (hrs:mins)	Predicted Cumulative Shadow Flicker Expected Shadow [h/year] (hrs:mins)
H1*	62:12	62:12	12:22	12:22
H2	81:52	**96:17**	09:46	**12:43**
H3	00:00	00:00	00:00	00:00
H4	93:09	93:09	17:46	17:46
H5	86:23	86:23	16:53	16:53
H6	35:45	**46:37**	03:17	**05:21**
H7	86:53	86:53	17:14	17:14
H8	97:57	97:57	19:51	19:51
H9	88:25	88:25	17:46	17:46
H10	55:56	**66:39**	06:28	**08:46**
H11	81:23	**90:02**	08:04	**09:56**
H12	72:29	72:29	14:14	14:14
H13	70:22	70:22	14:20	14:20
H14	63:06	63:06	06:16	06:16
H15	68:50	68:50	14:14	14:14
H16	68:14	68:14	14:07	14:07
H17	55:43	**71:58**	08:19	**11:33**
H18	45:19	**71:29**	04:03	**09:10**
H19	47:14	47:14	09:47	09:47
H20	44:26	44:26	04:50	04:50
H21	31:38	**50:45**	02:46	**06:39**
H22	19:44	**37:27**	01:42	**05:21**
H23	44:45	**61:17**	04:55	**08:25**
H24	53:47	53:47	05:46	05:46
H25	22:36	22:36	04:29	04:29
H26	29:18	29:18	05:42	05:42
H27	10:29	**26:34**	00:53	**04:13**
H28	44:55	**64:02**	04:56	**08:55**
H29	54:59	54:59	05:54	05:54
H30	55:42	55:42	06:00	06:00
H31	57:57	57:57	06:17	06:17

H32	00:00	00:00	00:00	00:00
H33	00:00	00:00	00:00	00:00
H34	00:00	00:00	00:00	00:00
H35	54:08	54:08	05:58	05:58
H36	00:00	00:00	00:00	00:00
H37	00:00	00:00	00:00	00:00
H38	00:00	00:00	00:00	00:00
H39	17:12	17:12	03:42	03:42
H40	00:00	00:00	00:00	00:00
H41	00:00	00:00	00:00	00:00
H42	44:37	44:37	04:46	04:46
H43	00:00	00:00	00:00	00:00
H44	00:00	00:00	00:00	00:00
H45	18:56	18:56	03:31	03:31
H46	00:00	00:00	00:00	00:00
H47	01:57	01:57	00:22	00:22
H48	37:43	37:43	03:56	03:56
H49	27:48	27:48	05:30	05:30
H50	17:33	17:33	03:49	03:49
H51	20:45	**41:01**	02:10	**06:18**
H52	00:00	00:00	00:00	00:00
H53	00:00	00:00	00:00	00:00
H54	00:00	00:00	00:00	00:00
H55	00:00	00:00	00:00	00:00
H56	00:00	00:00	00:00	00:00
H57	00:00	00:00	00:00	00:00
H58	22:45	22:45	02:16	02:16
H59	00:00	00:00	00:00	00:00
H60	00:00	00:00	00:00	00:00
H61	12:24	12:24	02:24	02:24
H62	00:00	00:00	00:00	00:00
H63	00:00	00:00	00:00	00:00
H64	00:00	00:00	00:00	00:00
H65	00:00	00:00	00:00	00:00
H66	00:00	00:00	00:00	00:00
H67	00:00	00:00	00:00	00:00
H68	00:00	00:00	00:00	00:00
H69	00:00	00:00	00:00	00:00
H70	15:16	15:16	02:14	02:14
H71	06:25	06:25	01:13	01:13
H72	13:45	13:45	02:03	02:03
H73	12:29	12:29	02:25	02:25

H74	00:00	00:00	00:00	00:00
H75	08:05	08:05	01:38	01:38
H76	17:17	**50:55**	02:03	**08:59**
H77	12:03	12:03	02:12	02:12
H78	15:02	15:02	02:49	02:49
H79	10:55	10:55	02:22	02:22
H80	04:05	04:05	00:44	00:44
H81	00:00	00:00	00:00	00:00
H82	15:02	15:02	02:54	02:54
H83	00:00	00:00	00:00	00:00
H84	03:40	03:40	00:41	00:41
H85	10:52	10:52	01:40	01:40
H86	00:00	00:00	00:00	00:00
H87	00:00	00:00	00:00	00:00
H88	00:00	00:00	00:00	00:00
H89	16:34	16:34	03:12	03:12
H90	00:00	00:00	00:00	00:00
H91	00:00	00:00	00:00	00:00
H92	02:32	02:32	00:29	00:29
H93	09:37	09:37	01:28	01:28
H94	00:00	00:00	00:00	00:00
H95	08:44	08:44	01:22	01:22
H96	00:00	**07:49**	00:00	**01:41**
H97	00:00	**10:43**	00:00	**02:11**
H98	06:27	06:27	01:18	01:18
H99	07:49	07:49	01:15	01:15
H100	10:05	10:05	01:57	01:57
H101	00:00	00:00	00:00	00:00
H102	05:48	05:48	01:08	01:08
H103	05:22	05:22	00:36	00:36
H104	05:30	05:30	01:04	01:04
H105	07:02	07:02	01:08	01:08
H106	00:00	00:00	00:00	00:00
H107	00:00	00:00	00:00	00:00
H108	03:46	03:46	00:47	00:47
H109	04:33	04:33	00:57	00:57
H110	00:00	**15:45**	00:00	**03:07**
H111	05:19	05:19	00:35	00:35
H112	04:29	04:29	00:43	00:43
H113	00:00	00:00	00:00	00:00
H114	00:00	00:00	00:00	00:00
H115	04:17	04:17	00:39	00:39

H116	00:00	**15:58**	00:00	**03:08**
H117	00:00	**15:45**	00:00	**03:05**
H118	05:33	05:33	00:37	00:37
H119	00:00	00:00	00:00	00:00
H120	00:00	00:00	00:00	00:00
H121	00:00	**15:22**	00:00	**02:58**
H122	00:00	**14:15**	00:00	**02:45**
H123	00:00	00:00	00:00	00:00
H124	00:00	00:00	00:00	00:00
H125	09:00	09:00	00:52	00:52
H126	00:00	00:00	00:00	00:00
H127	00:00	00:00	00:00	00:00
H128	00:00	00:00	00:00	00:00
H129	03:47	03:47	00:33	00:33
H130	04:23	04:23	00:57	00:57
H131	00:00	00:00	00:00	00:00
H132	03:38	03:38	00:32	00:32
H133	08:08	08:08	01:28	01:28
H134	00:00	00:00	00:00	00:00
H135	03:19	03:19	00:38	00:38
H136	03:35	03:35	00:32	00:32
H137	00:00	00:00	00:00	00:00
H138	00:00	**15:08**	00:00	**02:46**
H139	00:00	00:00	00:00	00:00
H140	00:00	00:00	00:00	00:00
H141	03:02	03:02	00:35	00:35
H142	03:32	03:32	00:30	00:30
H143	00:00	00:00	00:00	00:00
H144	00:00	00:00	00:00	00:00
H145	00:00	00:00	00:00	00:00
H146	03:16	03:16	00:28	00:28
H147	01:32	01:32	00:20	00:20
H148	08:34	08:34	01:35	01:35
H149	01:30	01:30	00:16	00:16
H150	00:00	**41:12**	00:00	**07:27**
H151	00:00	00:00	00:00	00:00
H152	03:19	03:19	00:25	00:25
H153	00:00	00:00	00:00	00:00
H154	03:01	03:01	00:25	00:25
H155	00:00	00:00	00:00	00:00
H156	00:00	00:00	00:00	00:00
H157	00:00	00:00	00:00	00:00

H158	00:00	00:00	00:00	00:00
H159	00:00	00:00	00:00	00:00
H160	00:00	00:00	00:00	00:00
H161	00:00	00:00	00:00	00:00
H162	00:00	00:00	00:00	00:00
H163	00:00	**08:36**	00:00	**01:28**
H164	00:00	00:00	00:00	00:00
H165	00:00	00:00	00:00	00:00
H166	00:00	00:00	00:00	00:00
H167	00:00	00:00	00:00	00:00
H168	00:00	00:00	00:00	00:00
H169	00:00	00:00	00:00	00:00
H170	00:00	00:00	00:00	00:00
H171	00:00	00:00	00:00	00:00
H172	00:00	**08:28**	00:00	**01:24**
H173	00:00	00:00	00:00	00:00
H174	00:00	00:00	00:00	00:00
H175	00:00	00:00	00:00	00:00
H176	00:00	00:00	00:00	00:00
H177	00:00	**23:27**	00:00	**03:32**
H178	00:00	**07:23**	00:00	**01:13**
H179	00:00	00:00	00:00	00:00
H180	00:00	00:00	00:00	00:00
H181	00:00	00:00	00:00	00:00
H182	00:00	00:00	00:00	00:00
H183	00:00	00:00	00:00	00:00

No shadow flicker is experienced at 99 No. dwellings out of 182 No. dwellings, due to the orientation of these dwellings with respect to the proposed turbines in all scenarios assessed and these are therefore ruled out for further assessment.

This assessment has identified the potential for shadow flicker to affect 84 sensitive receptors. Of these, 30 receptors exceed 30 minutes within 24 hours according to the Worst-Case Scenario for the Level of Exceedance under the 2006 Guidelines, with no receptor surpassing 30 hours of shadow flicker per year in the 'real case' scenario.

The Development has been assessed as having the potential to result in **neutral**, **imperceptible, long-term effects** overall with regards to shadow flicker. Given that only effects of significant impact or greater are considered "significant" in terms of the EIA

Directive the potential effects of the Development as a result of shadow flicker, are considered to be not significant.

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.

13.3 ASSESSMENT OF SIGNIFICANT EFFECTS

13.3.1 'Do-Nothing' Scenario

If the Project were not to proceed, the opportunity to generate renewable energy and electrical supply to the national grid would be lost, as would the opportunity to further contribute to meeting Government and EU targets for the production and consumption of electricity from renewable sources and the reduction of greenhouse gas emissions and compliance with the Climate Change and Low Carbon Emissions Act 2015-21 would be impeded.

Should the Project not proceed, the existing agricultural land-use practices will continue at the Site.

13.3.2 Construction Phase

As the proposed wind turbines will not be operational during the construction phase, shadow flicker will not occur.

13.3.3 Operational Phase

Assuming worst-case conditions, a total of 30 no. receptors may experience daily shadow flicker occurrences and would therefore require mitigation to reduce this to less than 30 minutes per day. No receptor surpasses the 30 hours of shadow flicker per year, as per the Guidelines.

A blade shadow control system will be installed on all turbines, which will eliminate shadow flicker effects from the Development to align with the requirements of the 2019 Draft Guidelines recommendation of zero shadow flicker and reduce any cumulative impacts.

13.3.4 Decommissioning Phase

As the proposed wind turbines will not be operational during the decommissioning phase, shadow flicker will not occur.

13.4 MITIGATION MEASURES & RESIDUAL EFFECTS

13.4.1 Likely Evolution of the Baseline

The shadow flicker effect is related to the operational phase of a wind farm.

13.4.2 Operational Phase

Unless otherwise required by a condition of planning, the turbines will be controlled to eliminate shadow flicker at sensitive receptors in the Study Area. To mitigate shadow flicker effects, shadow flicker control modules, consisting of light sensors and specialised software, will be installed on the turbines as part of a system to prevent operation during periods when shadow flicker may occur. **Appendix 13.1** contains all calculated potential shadow flicker periods for each turbine. The calculated potential shadow flicker periods will be input into the turbine control software and when the correct conditions are met e.g. the light intensity is sufficient, turbine orientation is correct etc. during these periods, individual turbines will cease operation until the conditions for shadow flicker are no longer present. These are standard, widely accepted control modules that are installed in most wind turbines.

13.4.3 Decommissioning Phase

As previously stated, the shadow flicker effect is associated with the operational phase of the wind farm. During decommissioning there will be no shadow flicker effect and therefore no mitigation is required.

13.4.4 Residual Effects

During the operational phase, a shadow flicker control system will be implemented to mitigate shadow flicker effects at all sensitive receptors within the study area. As described in **Section 13.4.2** the mitigation measure proposed is to use light sensors and specialised software to automatically control turbines to eliminate shadow flicker (allowing for a short period for shadow flicker conditions to be confirmed and for the turbine to come to a stop).

Following application of the proposed shadow flicker mitigation measure during the operational phase, it is concluded that residual shadow flicker effects would avoid adverse impacts on residential amenity in respect of shadow flicker (in accordance with objectives of the Clare Wind Energy Strategy, Annex A: Best Practice and General Considerations for wind energy developments in County Clare[3]), align with the requirements of the Draft

[3] chromeextension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.clarecoco.ie/services/planning/clarecountydevelopmentplan23-2029/volume-6-clare-wind-energy-strategy-clare-county-development-plan-2023-2029-55991.pdf

Revised Wind Energy Guidelines (2019) threshold limits, and would therefore be **not significant**.

13.5 ELECTROMAGNETIC INTERFERENCE

Electromagnetic fields ("EMF") are invisible lines of force that surround electrical equipment, power cords, wires that carry electricity and outdoor power lines. Electric and magnetic fields can occur together or separately and are a function of voltage and current. When an electrical appliance is plugged into the wall, an electric field is present (there is voltage but no current); when that appliance is turned on, electric and magnetic fields are present (there is both voltage and current). Both electric and magnetic fields decrease with distance. Electric fields are also dissipated by objects such as building materials. On a daily basis, people are exposed to extremely low frequency ("ELF") EMF as a result of using electricity. National and international health and scientific agencies have reviewed more than 35 years of research including thousands of studies. None of these agencies has concluded that exposure to ELF-EMF from power lines or other electrical sources is a cause of any long-term adverse effects on human, plant, or animal health. The International Commission on Non-Ionising Radiation Protection (ICNIRP) Guidelines give a limit of 100μT for sources of AC magnetic fields. This compares to 0.13μT that arises from a 110kV underground cable when directly above it; 1.29μT that arises from a 220kV underground cable when directly above it and 11.4μT that arises from a 400kV AC underground cable that is one metre deep and measured directly above it. This is detailed in information booklet published by ESB in 2017 called "EMF & You" which provides information about Electric & Magnetic Fields and the electricity network in Ireland.

In 2014, a study was undertaken in Canada, measuring electromagnetic fields around wind farms and the impact on human health. The study found that:
"there is nothing unique to wind farms with respect to EMF exposure; in fact, magnetic field levels in the vicinity of wind turbines were lower than those produced by many common household electrical devices and were well below any existing regulatory guidelines with respect to human health".

From the limit of 100μT for sources of AC magnetic fields given by the ICNIRP, a comparison of between 0.02μT and 0.41μT arises when turbines operate under "high wind" scenarios.

13.5.1 Assessment of Potential Impacts

During the construction phase, there are likely to be several sources of temporary electromagnetic emissions. Chief among these will be the brief use of electrical power tools and the use of electrical generators which may be brought onsite before mains electricity is provided. These devices are required by Irish and European law to comply with the EMC Directive 2014/30/EU. Compliance with this Directive will mean that the electromagnetic emissions from these devices will not cause interference to other equipment and therefore no significant effects are likely.

A telecoms impact assessment was conducted by AI Bridges, which identified two microwave radio links that could potentially be affected by the Development (Enet and ESB Networks. One of these is the Enet-licensed 8 GHz point-to-point (PTP) microwave radio link from Knockanore to Clohanbeg N.S. A thorough analysis of the Development's impact on telecommunications is provided in **Appendix 15.1:** No other potentially impacted links were identified, and it is considered that the operational phase of the wind farm will not significantly affect existing radio links. Any potential impacts have been mitigated through careful avoidance measures, as detailed in **Chapter 15: Material Assets, Section 15.6.5**. All electrical elements of the Development are designed to ensure compliance with Electro-Magnetic Fields (EMF) standards for human safety. Therefore, the effects on human health are considered to be not significant.

13.5.2 Mitigation Measures and Residual Effects

As the potential effects are localised and considered to be imperceptible in the long term, it is not necessary to implement mitigation measures. Residual effects will not occur.

13.5.3 Summary of Significant Effects

It is therefore considered that the Development will not result in any likely significant effects on any sensitive receptor due to EMI or ELF.

Based on the assessment above and the mitigation measure proposed there will be no likely significant effects related to shadow flicker.