14 SHADOW FLICKER

14.1 INTRODUCTION

This chapter of the EIAR assesses the effects of the Project in terms of shadow flicker. The Project refers to all elements of the application for the construction of Garrane Green Energy Project as detailed in **Chapter 2: Project 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 Project.

Shadow flicker only has the potential to occur during the operational phase of the Project. 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 Project.

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 14.1: Shadow Flicker Analyses**

14.1.1 Statement of Authority

This chapter has been prepared by Ms. Kathlyn Feeney of Jennings O'Donovan & Partners Limited. Kathlyn Feeney is an Environmental Scientist, who holds a Bachelor (Hons) Degree in Environmental Science from the Atlantic Technological University, Sligo. She forms part of the Environmental team responsible for preparing the EIAR Chapters. Kathlyn has experience writing EIARs, Feasibility Studies and Shadow Flicker analysis.

This chapter was reviewed by Ms. Sarah Moore who 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.

14.1.2 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
- Limitations of the assessment
- Identification and assessment of effects of shadow flicker associated with the Site, during the construction, operational and decommissioning phases of the Site
- Mitigation measures to avoid or reduce the effects identified
- Identification and assessment of residual impact of the Site 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 An Coimisiún Pleanála to carry out an adequate assessment of the Project.

14.2 SHADOW FLICKER

This chapter comprehensively assesses the potential shadow flicker effects of the operational stage of the Project. 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.

14.2.1 Assessment Methodology

This assessment of shadow flicker involved the following:

- Evaluation of potential effects (see **Section 14.2.6**) includes predicting the shadow flicker effects on the sensitive receptors within the Study Area of the candidate model and comparing them against the Wind Energy Development Guidelines (WEDG) (2006)[1] and with due regard of the 2019 Draft Revised Wind Energy Development Guidelines (WEDG)[2]. The draft WEDGs were published in December 2019 and are subject to a consultation process. It is noted that at the time of writing, the Draft 2019 WEDGs have not yet been adopted and the 2006 Guidelines referred to above remain in place.

[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] 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]

- Evaluation of the significance of effects using the methodology set out in **Chapter 1: Introduction, Section 1.9.3**
- Identification of measures to avoid and mitigate potential effects

The Study Area is defined as 10 times the rotor diameter of the wind turbine assessed in the EIAR (10 x 150m = 1,500m). 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'*.

A shadow flicker computer model (WindPRO 4.0) was used to calculate the occurrence of shadow flicker at relevant sensitive receptors to the Project. 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 Limerick City and County Council and Cork County Council web resources, An Coimisiún Pleanála web resource and from a site visit in May 2022 to the Study Area. The desktop sensitive receptor search was originally completed in August 2022 with regular rechecks completed to ensure any new sensitive 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. There are 113 No. sensitive receptors within 1.5km of any proposed wind turbine location. All sensitive receptors can be viewed within **Appendix 14.1** and also in **Figure 1.3**.

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*."

The turbine for this Wind Farm which was assessed in this Chapter is outlined in **Table 14.1** below:

Table 14.1: Turbine Parameters

Vestas V150	
Hub Height	95m
Rotor Diameter	150m
Turbine Blade Tip Height	170m

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

A shadow flicker computer model was used to calculate the occurrence of shadow flicker at relevant sensitive receptors to the Project. The output from the calculations is analysed to identify and assess potential shadow flicker effects. This is further detailed in **Appendix 14.1**. Cumulative effects were also assessed in **Section 14.2.8**.

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 sun and the turbine blades are positioned so as to cast a shadow on the sensitive receptor.

If any one of these conditions is absent, shadow flicker cannot occur.
The 2019 Draft Revised the Wind Energy Development Guidelines (WEDG)[3] 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".

[3] 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]

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

- As the distance between the turbine and the sensitive receptor increases, the duration of the shadow flicker decreases (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 14.1**.

14.2.2 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 with due regard to 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 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 turbine blades are positioned so as to cast a shadow on the sensitive 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 ten rotor diameters (i.e., 1,500 metres (150 m)) of the proposed turbines within the Site (as per IWEA best practice guidelines, 2012[4]). 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) aims to eliminate negative 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.

[4] 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]

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).

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 Project will be brought in line with the shadow flicker requirements of the 2019 Draft Wind Energy Development Guidelines through implementation of the mitigation measures outlined herein.

14.2.3 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 Project. 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 sensitive 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 sensitive 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 sensitive 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)
- Sensitive receptor locations
- Bottom line height above ground 'window' (0.5m above ground level)
- Wind speed and 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 Project and its surroundings and uses this information to calculate specific theoretical times and durations of flicker effects for the identified sensitive receptors. 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 sensitive 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 Cork Airport, co. Cork
- Long-term wind rose data from the SEAI Wind Mapping System (ITM co-ordinates 554000E, 627000N)

14.2.4 Baseline Description & Likely Evolution of the Baseline

The Site is located in a densely populated rural area, typically ribbon development with sporadic cul-de-sacs. Should the Project 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 and aerial imagery to identify sensitive receptors in the local area within a Study Area, a distance ten times the proposed rotor diameter of the proposed turbines (10 x 150m = 1,500m). The sensitive receptor list was ground truth-ed to confirm that there are 113 sensitive receptors within the shadow flicker Study Area radius. The coordinates of each sensitive receptor and its distance to the closest proposed turbine are listed in **Table 14.2** and are shown in **Figure 1.3.**

Table 14.2: Sensitive receptors within the shadow flicker study area

House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H1	554890	628270	T7	893
H2	554927	628102	T7	792
H3	554909	628076	T7	761
H4	555053	627900	T7	781
H5	555248	627163	T6	797
H6	555099	626752	T4	727
H7	555074	626712	T4	709
H8*	555045	626607	T4	708
H9	555044	626526	T2	704
H10	555100	626434	T1	722
H11	555177	626448	T1	795
H12	555329	626120	T1	839

House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H13	555250	626093	T1	757
H14	555329	625807	T1	867
H15	555304	625667	T1	891
H16	555349	625612	T1	956
H17	555310	625539	T1	957
H18	555384	625532	T1	1025
H19	554912	625134	T1	998
H20	553714	625349	T1	1042
H21	553722	625387	T1	1011
H22	553714	625434	T1	988
H23	553661	625440	T1	1027
H24	553566	625907	T3	884
H25	553552	626017	T3	804
H26	553518	626038	T3	811
H27	553445	626008	T3	883
H28	553834	626159	T3	529
H29**	553532	626131	T3	735
H30**	553379	626762	T3	703
H31	553252	626932	T8	807
H32	553094	627829	T8	774
H33	553426	628112	T8	702
H34	553451	628146	T9	709
H35	553575	628329	T9	722
H36	553486	628892	T9	1234
H37	553408	628905	T9	1284
H38	553398	628993	T9	1365
H39	553295	628921	T9	1359
H40	553221	628934	T9	1413
H41	553175	628924	T9	1434
H42	553052	628901	T9	1496
H46	553161	628986	T9	1492
H47	553189	628997	T9	1483

House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H48	553229	629001	T9	1463
H49	553285	629011	T9	1440
H50	553325	629016	T9	1423
H51	553376	629036	T9	1413
H62	554895	629036	T9	1480
H63	554864	629031	T9	1458
H64	554899	628995	T9	1448
H65	554860	628961	T9	1398
H66	554900	628954	T9	1415
H67	554861	628927	T9	1370
H68	554901	628917	T9	1386
H69	554902	628908	T9	1379
H70	554904	628867	T9	1348
H71	554904	628858	T9	1341
H72	554862	628836	T9	1297
H73	554860	628794	T9	1264
H74	554885	628752	T9	1247
H75	554876	628695	T9	1198
H76	554879	628657	T9	1172
H77	554953	628657	T9	1224
H78	554941	628622	T9	1192
H79	554942	628591	T9	1171
H80	554870	628575	T9	1107
H81	554948	628565	T9	1159
H82	554951	628528	T9	1137
H83	555536	627030	T6	1096
H84	555700	626885	T6	1287
H85	555514	625336	T1	1239
H86*	555754	625366	T1	1429
H87	555303	625256	T1	1126
H88	555298	625212	T1	1155
H89	555222	625276	T1	1056

House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H90	555135	625094	T1	1143
H91	555175	624909	T1	1321
H92	555131	624919	T1	1290
H93	555091	624842	T1	1338
H94	555157	624807	T1	1400
H95	555181	624733	T1	1477
H96	555168	624715	T1	1487
H122	553948	624658	T1	1486
H123	553926	624708	T1	1448
H124	553915	624753	T1	1411
H125	553882	624769	T1	1411
H126	553768	624877	T1	1372
H127	553809	624982	T1	1261
H128	553578	625279	T1	1191
H129	553546	625258	T1	1229
H130	553597	625237	T1	1204
H131	553527	625219	T1	1268
H132	553580	624855	T1	1497
H141	553519	625617	T1	1740
H142	553516	625637	T1	1058
H143	553302	625898	T3	1063
H144	553081	625833	T3	1272
H145	553035	625813	T3	1320
H146	552972	625807	T3	1373
H147	552937	625803	T3	1404
H148	552905	625800	T3	1432
H149	552872	625797	T3	1461
H150	552836	625790	T3	1494
H170	552903	625855	T3	1403
H171	552953	625860	T3	1358
H172	553003	625872	T3	1310
H173	553034	625878	T3	1282

House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H174	553057	625881	T3	1261
H177	552817	626710	T3	1256
H178**	553652	624809	T6	931
H179**	555336	626905	T1	876
H180	554207	625213	T1	1411

*Commercial

**Derelict

14.2.5 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. Therefore, the assessment represents a 'worst-case' scenario.

14.2.6 Assessment of Expected Shadow Flicker Impact

In order to calculate more realistic and '*real world'* occurrences of shadow flicker for the sensitive receptors that are identified as potentially vulnerable to shadow flicker (**Table 14.2**), 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 Cork Airport Weather Station was used as this Met Éireann observatory is the closest to the Site and also measures multiple environmental parameters (**Table 14.3**). This gives a good representation of data for the Project. This data was utilised to consider the probability of sunshine occurrence and thus allow the determination of '*projected*' values for shadow flicker occurrence.

Table 14.3. Average daily sunshine hours from Cork Airport Weather Station

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.8	2.4	3.3	5.3	6.2	5.8	5.4	5.2	4.3	3	2.3	1.7

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 14.4 shows the potential 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 sensitive receptor, they are not eliminated entirely for all of the 113 sensitive receptors within the shadow flicker Study Area of the Project.

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 analysis indicated that, under the assessed scenario, 41 sensitive receptors (36.28%) could experience a maximum of more than 30 minutes of shadow flicker per day, while 5 sensitive receptors (4.42%) could be exposed to over 30 hours of shadow flicker per year. This exceeds the 2006 Guidelines recommendation of 30 minutes per day/ 30 hours per year and the Draft 2019 Guidelines which aim to eliminate negative shadow flicker.

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 the 2019 Guideline's thresholds is outlined in **Section 14.2.9**.

14.2.7 Assessment of Potential Effects

This assessment considers the potential shadow flicker effect of the Project 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.

The maximum expected daily shadow flicker for each sensitive receptor is outlined in the table below, displayed in hours and minutes. 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 2km of a proposed development should be considered in a cumulative shadow flicker assessment. There are no wind farms within 2km of the Project to be considered with the Project for cumulative effects.

Table 14.4: Summary of Worst (Daily)- and Expected (Annual)-Case Shadow Flicker Exceedance Under 2006 Guidelines

Dwelling ID	'Worst Case' Daily Shadow Flicker			'Expected' Annual Shadow Flicker		
	Garrane Wind Farm Flicker Levels – Daily Compliance Threshold [h/day] (hrs:mins)	Garrane Wind Farm Flicker Levels Max. Shadow [h/day] (hrs:mins)	Level of Exceedance 2006 WEDGS	Predicted Shadow Flicker Levels – Annual Compliance Threshold [h/year] (hrs:mins)	Predicted Shadow Flicker Expected Shadow [h/year] (hrs:mins)	Level of Exceedance 2006 Guidelines
H1	00:30	00:42	**00:12**	30:00	09:47	0:00
H2	00:30	00:47	**00:17**	30:00	14:39	0:00
H3	00:30	00:49	**00:19**	30:00	15:46	0:00
H4	00:30	00:57	**00:27**	30:00	18:19	0:00
H5	00:30	00:47	**00:17**	30:00	25:49	0:00
H6	00:30	00:57	**00:27**	30:00	33:03	**03:03**
H7	00:30	01:04	**00:34**	30:00	34:00	**04:00**
H8*	00:30	01:10	**00:40**	30:00	40:57	**10:57**
H9	00:30	01:05	**00:35**	30:00	37:38	**07:38**
H10	00:30	00:53	**00:23**	30:00	28:11	0:00
H11	00:30	00:52	**00:22**	30:00	27:13	0:00
H12	00:30	00:42	**00:12**	30:00	12:35	0:00
H13	00:30	00:48	**00:18**	30:00	14:54	0:00
H14	00:30	00:41	**00:11**	30:00	14:57	0:00
H15	00:30	00:41	**00:11**	30:00	12:54	0:00
H16	00:30	00:38	**00:08**	30:00	11:14	0:00

Dwelling ID	'Worst Case' Daily Shadow Flicker			'Expected' Annual Shadow Flicker		
	Garrane Wind Farm Flicker Levels – Daily Compliance Threshold [h/day] (hrs:mins)	Garrane Wind Farm Flicker Levels Max. Shadow [h/day] (hrs:mins)	Level of Exceedance 2006 WEDGS	Predicted Shadow Flicker Levels – Annual Compliance Threshold [h/year] (hrs:mins)	Predicted Shadow Flicker Expected Shadow [h/year] (hrs:mins)	Level of Exceedance 2006 Guidelines
H17	00:30	00:40	**00:10**	30:00	08:14	0:00
H18	00:30	00:36	**00:06**	30:00	08:42	0:00
H19	00:30	00:00	0:00	30:00	00:00	0:00
H20	00:30	00:00	0:00	30:00	00:00	0:00
H21	00:30	00:00	0:00	30:00	00:00	0:00
H22	00:30	00:09	0:00	30:00	00:34	0:00
H23	00:30	00:19	0:00	30:00	02:06	0:00
H24	00:30	00:41	**00:11**	30:00	13:09	0:00
H25	00:30	00:42	**00:12**	30:00	15:06	0:00
H26	00:30	00:41	**00:11**	30:00	11:43	0:00
H27	00:30	00:37	**00:07**	30:00	09:18	0:00
H28	00:30	01:06	**00:36**	30:00	30:38	**00:38**
H29**	00:30	00:42	**00:12**	30:00	10:40	0:00
H30**	00:30	00:50	**00:20**	30:00	29:23	0:00
H31	00:30	00:44	**00:14**	30:00	20:24	0:00
H32	00:30	00:49	**00:19**	30:00	13:40	0:00
H33	00:30	01:03	**00:33**	30:00	18:26	0:00
H34	00:30	01:00	**00:30**	30:00	16:47	0:00
H35	00:30	00:53	**00:23**	30:00	10:55	0:00
H36	00:30	00:00	0:00	30:00	00:00	0:00
H37	00:30	00:00	0:00	30:00	00:00	0:00
H38	00:30	00:00	0:00	30:00	00:00	0:00

Dwelling ID	'Worst Case' Daily Shadow Flicker			'Expected' Annual Shadow Flicker		
	Garrane Wind Farm Flicker Levels – Daily Compliance Threshold [h/day] (hrs:mins)	Garrane Wind Farm Flicker Levels Max. Shadow [h/day] (hrs:mins)	Level of Exceedance 2006 WEDGS	Predicted Shadow Flicker Levels – Annual Compliance Threshold [h/year] (hrs:mins)	Predicted Shadow Flicker Expected Shadow [h/year] (hrs:mins)	Level of Exceedance 2006 Guidelines
H39	00:30	00:00	0:00	30:00	00:00	0:00
H40	00:30	00:24	0:00	30:00	00:58	0:00
H41	00:30	00:28	0:00	30:00	01:51	0:00
H42	00:30	00:24	0:00	30:00	02:24	0:00
H46	00:30	00:23	0:00	30:00	00:59	0:00
H47	00:30	00:09	0:00	30:00	00:13	0:00
H48	00:30	00:00	0:00	30:00	00:00	0:00
H49	00:30	00:00	0:00	30:00	00:00	0:00
H50	00:30	00:00	0:00	30:00	00:00	0:00
H51	00:30	00:00	0:00	30:00	00:00	0:00
H62	00:30	00:00	0:00	30:00	00:00	0:00
H63	00:30	00:00	0:00	30:00	00:00	0:00
H64	00:30	00:00	0:00	30:00	00:00	0:00
H65	00:30	00:00	0:00	30:00	00:00	0:00
H66	00:30	00:00	0:00	30:00	00:00	0:00
H67	00:30	00:00	0:00	30:00	00:00	0:00
H68	00:30	00:11	0:00	30:00	00:18	0:00
H69	00:30	00:13	0:00	30:00	00:27	0:00
H70	00:30	00:21	0:00	30:00	01:08	0:00
H71	00:30	00:21	0:00	30:00	01:17	0:00
H72	00:30	00:21	0:00	30:00	01:10	0:00
H73	00:30	00:26	0:00	30:00	01:54	0:00

Dwelling ID	'Worst Case' Daily Shadow Flicker			'Expected' Annual Shadow Flicker		
	Garrane Wind Farm Flicker Levels – Daily Compliance Threshold [h/day] (hrs:mins)	Garrane Wind Farm Flicker Levels Max. Shadow [h/day] (hrs:mins)	Level of Exceedance 2006 WEDGS	Predicted Shadow Flicker Levels – Annual Compliance Threshold [h/year] (hrs:mins)	Predicted Shadow Flicker Expected Shadow [h/year] (hrs:mins)	Level of Exceedance 2006 Guidelines
H74	00:30	00:30	0:00	30:00	02:55	0:00
H75	00:30	00:31	**00:01**	30:00	03:41	0:00
H76	00:30	00:32	**00:02**	30:00	03:58	0:00
H77	00:30	00:30	0:00	30:00	03:21	0:00
H78	00:30	00:31	**00:01**	30:00	03:20	0:00
H79	00:30	00:31	**00:01**	30:00	03:11	0:00
H80	00:30	00:34	**00:04**	30:00	04:07	0:00
H81	00:30	00:31	**00:01**	30:00	03:01	0:00
H82	00:30	00:32	**00:02**	30:00	03:00	0:00
H83	00:30	00:31	**00:01**	30:00	15:19	0:00
H84	00:30	00:25	0:00	30:00	09:47	0:00
H85	00:30	00:23	0:00	30:00	03:18	0:00
H86*	00:30	00:22	0:00	30:00	03:54	0:00
H87	00:30	00:00	0:00	30:00	00:00	0:00
H88	00:30	00:00	0:00	30:00	00:00	0:00
H89	00:30	00:00	0:00	30:00	00:00	0:00
H90	00:30	00:00	0:00	30:00	00:00	0:00
H91	00:30	00:00	0:00	30:00	00:00	0:00
H92	00:30	00:00	0:00	30:00	00:00	0:00
H93	00:30	00:00	0:00	30:00	00:00	0:00
H94	00:30	00:00	0:00	30:00	00:00	0:00
H95	00:30	00:00	0:00	30:00	00:00	0:00

Dwelling ID	'Worst Case' Daily Shadow Flicker			'Expected' Annual Shadow Flicker		
	Garrane Wind Farm Flicker Levels – Daily Compliance Threshold [h/day] (hrs:mins)	Garrane Wind Farm Flicker Levels Max. Shadow [h/day] (hrs:mins)	Level of Exceedance 2006 WEDGS	Predicted Shadow Flicker Levels – Annual Compliance Threshold [h/year] (hrs:mins)	Predicted Shadow Flicker Expected Shadow [h/year] (hrs:mins)	Level of Exceedance 2006 Guidelines
H96	00:30	00:00	0:00	30:00	00:00	0:00
H122	00:30	00:00	0:00	30:00	00:00	0:00
H123	00:30	00:00	0:00	30:00	00:00	0:00
H124	00:30	00:00	0:00	30:00	00:00	0:00
H125	00:30	00:00	0:00	30:00	00:00	0:00
H126	00:30	00:00	0:00	30:00	00:00	0:00
H127	00:30	00:00	0:00	30:00	00:00	0:00
H128	00:30	00:00	0:00	30:00	00:00	0:00
H129	00:30	00:00	0:00	30:00	00:00	0:00
H130	00:30	00:00	0:00	30:00	00:00	0:00
H131	00:30	00:00	0:00	30:00	00:00	0:00
H132	00:30	00:00	0:00	30:00	00:00	0:00
H141	00:30	00:34	**00:04**	30:00	06:00	0:00
H142	00:30	00:35	**00:05**	30:00	05:37	0:00
H143	00:30	00:30	0:00	30:00	06:22	0:00
H144	00:30	00:23	0:00	30:00	03:30	0:00
H145	00:30	00:22	0:00	30:00	03:15	0:00
H146	00:30	00:20	0:00	30:00	03:13	0:00
H147	00:30	00:19	0:00	30:00	03:21	0:00
H148	00:30	00:19	0:00	30:00	03:34	0:00
H149	00:30	00:18	0:00	30:00	03:47	0:00
H150	00:30	00:17	0:00	30:00	03:55	0:00

Dwelling ID	'Worst Case' Daily Shadow Flicker			'Expected' Annual Shadow Flicker		
	Garrane Wind Farm Flicker Levels – Daily Compliance Threshold [h/day] (hrs:mins)	Garrane Wind Farm Flicker Levels Max. Shadow [h/day] (hrs:mins)	Level of Exceedance 2006 WEDGS	Predicted Shadow Flicker Levels – Annual Compliance Threshold [h/year] (hrs:mins)	Predicted Shadow Flicker Expected Shadow [h/year] (hrs:mins)	Level of Exceedance 2006 Guidelines
H170	00:30	00:20	0:00	30:00	04:48	0:00
H171	00:30	00:20	0:00	30:00	04:27	0:00
H172	00:30	00:21	0:00	30:00	04:18	0:00
H173	00:30	00:22	0:00	30:00	04:14	0:00
H174	00:30	00:22	0:00	30:00	04:07	0:00
H177	00:30	00:26	0:00	30:00	07:15	0:00
H178**	00:30	00:00	0:00	30:00	00:00	0:00
H179**	00:30	00:44	**00:14**	30:00	24:12	0:00
H180	00:30	00:00	0:00	30:00	00:00	0:00

*Commercial

**Derelict

It can be demonstrated from **Table 14.4**, there is the potential for 73 sensitive receptors out of 113 to experience some degree of shadow flicker and 40 sensitive receptors that will experience no shadow flicker. H8, which is a cluster of agricultural sheds, is expected to experience 33 hours 13 minutes of shadow flicker in a year, which is the worst affected occupied sensitive receptor. 40 sensitive receptors have the potential to exceed the 2006 Guidelines of a maximum 30 minutes of shadow flicker per day. The closest sensitive receptor, H28 who is involved with the Project, is within 529m of the closest turbine (T03). This has 24 hours 28 minutes of expected shadow flicker per year, and a maximum of 1 hour and 6 minutes of shadow flicker per day.

Five of the sensitive receptors are expected to exceed the 2006 Wind Energy Guidelines recommended threshold of 30 hours or more of shadow flicker per year, namely H6, H7, H8, H9 and H28. The worst effected of these sensitive receptors is H8, which is an agricultural shed, which experiences 40 hours 57 minutes of shadow flicker per year.

The calculated worst-case shadow flicker occurrences in the **Table 14.4** assumes the sun is always shining, that there is no cloud cover, the turbines are rotating and the sensitive receptor 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 14.1** all of the proposed turbines give rise to some degree of cumulative shadow flicker, if unmitigated.

14.2.8 Cumulative Effects

The IWEA Guidelines recommend that all existing and / or permitted wind farm developments within 2km of a proposed development should be considered in a cumulative shadow flicker assessment, however, the key factor to determine whether cumulative effects may occur is whether sensitive receptors are located within the Shadow Flicker Study Area of 10 times the rotor diameter for the Project.

Cumulative shadow flicker effects could arise if sensitive receptors 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 sensitive receptor is affected. In this instance, there are no proposed or operational wind farms within a 2km range of the turbines that may cause cumulative effects.

14.2.9 Mitigation Measures & Residual Effects

14.2.9.1 Likely Evolution of the Baseline

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

14.2.9.2 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.

14.2.9.3 Operational Phase

Shadow flicker control systems, consisting of light sensors and specialised software, 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 sensitive receptors, based on pre-programmed co-ordinates for the sensitive receptors and turbines;
- Wind speed (can affect how fast the turbine will turn and how quickly the flicker will occur);

- Wind direction; and
- 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 sensitive receptor or sensitive receptors, then the turbine will automatically shut down; and will restart when the potential for shadow flicker ceases at the effected sensitive receptors. 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[5].

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 14.1** 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 Limerick City and County Council, the Developer will conduct an investigation 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 sensitive receptor in which the complaint was made. Further refinement of the blade shadow control system will be conducted to mitigate negative shadow flicker occurrence.

14.2.9.4 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.

14.2.9.5 Residual Effects

This assessment has identified the potential for shadow flicker to affect 73 sensitive receptors. Of these, 40 sensitive receptors exceed 30 minutes within 24 hours according to the Worst-Case Scenario under the 2006 Guidelines, with 5 sensitive receptors also surpassing 30 hours of shadow flicker per year in the 'real case' scenario. The

[5] ClimateXChange, 2017. 'Review of Light and Shadow Effects from Wind Turbines in Scotland' [Available at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.climatexchange.org.uk/wp-content/uploads/2023/09/light_and_shadow_effects_from_wind_turbines_in_scotland_stages_1_and_2.pdf]

implementation of mitigation as detailed in **Section 14.2.9.3** to implement a shadow control system during periods of potential shadow flicker will ensure that negative shadow flicker effects experienced at any sensitive receptor within the Study Area (allowing for a short period of time for the rotor to come to a stop) are mitigated against. It is therefore considered that Garrane Green Energy Project will comply with Wind Energy Development Guidelines (2006) and has due regard to the Draft Revised Wind Energy Development Guidelines (2019).

Following implementation of mitigation measures described in **Section 14.2.9.3**, the residual impact as a result of shadow flicker will be a neutral, imperceptible, long-term effect. Accordingly, it is considered that there will be no residual impact as a result of shadow flicker.

14.3 SUMMARY OF SIGNIFICANT EFFECTS

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

This assessment has identified the potential for shadow flicker to affect 73 out of 113 sensitive receptors within the shadow flicker Study Area. Of these, 40 sensitive receptors exceed 30 minutes within 24 hours according to the Worst-Case Scenario under the 2006 Guidelines, with 5 sensitive receptors also surpassing 30 hours of shadow flicker per year in the 'real case' scenario. It is proposed that a shadow control system be installed to mitigate the potential for negative shadow flicker from the Project. 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 impact or greater are considered "significant" in terms of the EIA Directive the potential effects of the Project as a result of shadow flicker, when mitigated, are considered to be **not significant**. The Project has been assessed as having the potential to result in **negative, imperceptible, long-term effect** overall with regards to shadow flicker. There are no predicted cumulative effects.

14.4 REFERENCES

Department of Housing, Planning and Local Government, *Draft Revised Wind Energy Development Guidelines* (2019)

Department of the Environment, Heritage and Local Government, *Wind Energy Development Guidelines* (2006)

Irish Wind Energy Association & Wind Skillnet, *Best Practice Guidelines for the Irish Wind Energy Industry* (2012)