16 SHADOW FLICKER

16.1 INTRODUCTION

This chapter assesses the effects of the Proposed Development in terms of shadow flicker. The Proposed Development refers to elements of the application for the construction of Gortloughra Wind Farm as detailed in **Chapter 2: Project Description**. Where negative effects are predicted in relation to shadow flicker, the chapter identifies appropriate mitigation strategies therein. The assessment considers the potential effects during the operational phase of the Proposed Development.

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

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 16.1 Shadow Flicker Analysis**

Table 16.1: Glossary of Common Acronyms

Glossary of Common Acronyms	
BSc	Bachelor of Science
BSc Hons	Bachelor of Science (Honours)
EIAR	Environmental Impact Assessment
GIS	Geographical Information Systems
Hz	Hertz
m	Metre
MSc	Master of Science
MW	Megawatt
WEDGs	Wind Energy Development Guidelines

16.1.1 Statement of Authority

This chapter has been prepared by Kathlyn Feeney and reviewed by Andrew O'Grady and David Kiely of Jennings O'Donovan & Partners Limited.

Kathlyn Feeney is a Graduate Environmental Scientist with a First-Class Honours Degree (BSc. Hons) in Environmental Science. She forms part of the Environmental team responsible for preparing the EIAR Chapters. Kathlyn has experience writing EIARs, GIS, Feasibility Studies and Shadow Flicker analysis. She has a key interest in using software such as ArcGIS Pro and Wind PRO.

Andrew O'Grady is a Senior Environmental Consultant and holds a Bachelor (Hons.) Degree in Geography from University of Coventry and a MSc. in Environmental Resources Management from the Free University, Amsterdam. He has worked in environmental consultancy for over seventeen years and has prepared various Environmental Reports and EIARs. Andrew is the pre-planning stage project manager for the Gortloughra Wind Farm and has coordinated this EIAR.

David Kiely has 41 years' experience in the civil engineering and environmental sector. He has obtained a Bachelor's Degree in Civil Engineering and a Masters in Environmental Protection, has overseen the construction of over 60 wind farms and has carried out numerous soils and geology assessments for EIA's. He has been responsible in the overall preparation of in excess of 60 EIARs. David is the Project Director of this EIAR.

16.1.2 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 Development, during the construction, operational and decommissioning phases of the Development
- Mitigation measures to avoid or reduce the effects identified including shadow flicker control measures
- Identification and assessment of residual impact of the Proposed Development considering mitigation measures

- Identification and assessment of cumulative effects if and where applicable

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

16.2 SHADOW FLICKER

This chapter comprehensively assesses the potential shadow flicker effects of the operational stage of the Proposed Development. No shadow flicker will occur during the construction or decommissioning phases as shadow flicker occurs only when the rotating blades of a wind turbine cast a moving shadow over a building. The grid connection and turbine delivery route are not included in this assessment as shadow flicker relates to the turbines only, details on the grid connection and turbine delivery routes can be found in **Chapter 2: Project Description**.

16.2.1 Assessment Methodology

This assessment of shadow flicker involved the following:

- Evaluation of potential effects (see Section 16.2.6) 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 (2006)[1] limits of 30 hours per year and 30 minutes per day. The Proposed Development will commit to the zero-shadow flicker policy set out in 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.
- Evaluation of the significance of effects using the methodology set out in **Chapter 1: Introduction, Scoping and Consultation**, Section 1.10
- Identification of measures to avoid and mitigate potential effects

The Study Area is defined as 10 times the widest possible potential rotor diameter within the range (10 x 150 m = 1,500 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

[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]

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 for the inclusion of dwellings impacted in the cumulative assessment with the neighbouring Shehy More Wind Farm. Six receptors outside of the 2,000 m Study Area were also included in the analysis. Receptors H9, H8 and H63 were included due to the proximity of the Shehy More Wind Farm. Receptors H28, H62 and H64 were included due to their proximity to the 2,000 m range, for completeness. There are 73 No. receptors within the Study Area, six of these receptors fall outside the 2km but were included in the assessment due to reasons outlined above. All receptors can be viewed within **Appendix 16.1** and also in **Figure 1.3**.

A shadow flicker computer model (WindPRO 4.0) was used to calculate the occurrence of shadow flicker at relevant receptors to the Proposed Development. The sensitive receptors were identified using a combination of Tailte Éireann Maps, AutoCAD drawings and from internet mapping resources including *Eircode Finder*[3]*, Google Street View*[4], *Google Earth*[5], *Bing Maps*[6]*,* a planning permission search using the Cork County Council web resource[7] and from a site visit in May 2021 to the Study Area and subsequent door to door consultations carried out by the Developer. The desktop sensitive receptor search was originally completed in June 2021 with regular rechecks completed to see that no new receptors were identified within the Study Area. This was done virtually and in-person. The output from the calculations is analysed to identify and assess potential shadow flicker effects. Wind turbines, like other tall structures, can cast long shadows when the sun is low in the sky.

The 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*."

[3] Department of the Environment, Climate & Communications, 2024. Eircode. Available at: https://www.eircode.ie/
[4] Google, 2024. Google Maps. Available at: https://www.google.ie/maps/@54.2769152,-8.486912,5266m/data=!3m1!1e3?entry=ttu&g_ep=EgoyMDI0MTExMi4wIKXMDSoASAFQAw%3D%3D
[5] Google, 2024. Google Earth. Available at: https://earth.google.com/web/@52.04407517,-8.83588611,395.62363557a,240042.8536512d,35y,4.84029754h,0.24009708t,360r/data=CgRCAggBOgMKATBCAggASg0I_____ARAA
[6] Microsoft, 2024. Microsoft Bing. Available at: https://www.bing.com/maps?cp=51.600141%7E-8.647658&lvl=9.8
[7] Cork County Council, 2024. Planning Viewer. Available at: https://corkcocoeur.maps.arcgis.com/apps/webappviewer/index.html?id=254568bc8931492eb72ab5446c411cb9

The candidate turbine for the Proposed Development which was assessed in this Chapter is a Vestas V150 6.0 MW with dimensions:

- Hub height: 100 m
- Rotor diameter: 150 m
- Blade tip height 175 m

Cumulative effects are also assessed in Section 16.2.8.

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

A shadow flicker computer model (WindPRO 4.0) was used to calculate the occurrence of shadow flicker at relevant receptors to the Proposed Development, this is discussed further in Section 16.2.3. The output from the calculations is analysed to identify and assess potential shadow flicker effects. This is further detailed in **Appendix 16.1**.

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 positioned so as to cast a shadow on the receptor.

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

The 2019 Draft Revised Wind Energy Development Guidelines (WEDG) 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 will have the potential to cause disturbance and annoyance to sensitive receptors where sunlight and wind conditions are calculated to do so. 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. **Chapter 5: Population and Human Health**, Section 5.3.6.8, concludes that there are no specific health and safety considerations in relation to the operation of a wind turbine based on peer reviewed scientific research publications. Therefore, any potential shadow flicker effect from the Proposed Development is considered an effect on residential amenity, rather than having the potential to affect the health of residents.

The 2006 Guidelines state that; '*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 in the first instance'*.

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 receptors is of significance because:

- The duration of the shadow will be shorter the greater the distance (i.e., it will pass by quicker)
- The further a sensitive receptor is from an operating rotating turbine blades, the less shadow flicker will be experienced.

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 16.1**.

16.2.2 Relevant Guidance

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

Wind Energy Association, 2012), and the Draft Revised Wind Energy Development Guidelines (Department of Housing, Local Government and Heritage, 2019).

The 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.

Although the DoEHLG thresholds apply to dwellings located within 500 m 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, 2012[8]). The 2006 Guidelines state that at distances greater than 10 rotor diameters from a turbine, the potential for shadow flicker is very low. Despite this, all receptors within 2 km were included due to the potential cumulative impact of the Proposed Development and the existing Shehy More Wind Farm.

The adopted 2006 DoEHLG guidelines are currently under review, although the Draft 2019 WEDGs have not yet been adopted and the 2006 guidelines are still the adopted guidelines used. The Department of Housing, Local Government and Heritage released the 'Draft Revised Wind Energy Development Guidelines' in December 2019. The Draft Revised Wind Energy Development Guidelines (2019) provides for zero shadow flicker:

[8] 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]

"Computational models can be used to accurately predict the strength and duration of potential shadow flicker during daylight hours for every day of the year. A Shadow Flicker Study detailing the outcome of computational modelling for the potential for shadow flicker from the development should accompany all planning applications for wind energy development.

If a suitable shadow flicker prediction model indicates that there is potential for shadow flicker to occur at any particular dwelling or other potentially affected property, then a review of site design involving the possible relocation of one or more turbines to explore the possibility of eliminating the occurrence of potential flicker is required. Following such a review, if shadow flicker is not eliminated for any dwelling or other potentially affected property then clearly specified measures which provide for automated turbine shut down to eliminate shadow flicker should be required as a condition of a grant of permission."

The Draft 2019 Guidelines are based on the recommendations set out in the 'Proposed Revisions to Wind Energy Development Guidelines 2006 – Targeted Review in relation to Noise, Proximity and Shadow Flicker'[9] (December 2013) and the 'Review of the Wind Energy Development Guidelines 2006 – Preferred Draft Approach'[10] (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 Proposed Development will be brought in line with the requirements of the 2019 draft guidelines, which allows for no shadow flicker to impact an existing sensitive receptor, through effective implementation of the mitigation measures outlined herein.

16.2.3 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 Proposed Development. The programme facilitates the analysis of a wind farm for possible shadow flicker occurrence at nearby houses. It allows for the production of maps, and shadow flicker prediction. The data output from the programme has been analysed and the receptors potentially vulnerable to shadow flicker were identified (as detailed in section 16.2.1). The significance of shadow flicker effects was assessed.

[9] Environment, Community and Local Government, 2013. *Proposed Revisions to Wind Energy Development Guidelines 2006 – Targeted Review in relation to Noise, Proximity and Shadow Flicker. [Available online: file:///C:/Users/kfeeney/Downloads/132533_b946118f-d089-41b9-b15b-ae4266325ed6%20(1).pdf]*

[10] Environment, Community and Local Government, 2017. Review of the Wind Energy Development Guidelines 2006 – Preferred Draft Approach. [Available online: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://unece.org/DAM/env/pp/compliance/C2014-112_Ireland/frComm_03.09.2017/frCommC122_03.09.2017_update_att_1_Information_Note_on_Review_of_the_Wind_Energy_Development_Guidelines.pdf]

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 Proposed Development and areas around all sensitive receptors within the model (10m resolution – OS X, Y, and Z data points)
- Turbine locations
- Turbine dimensions (i.e. rotor diameter of 150 m and hub height of 100 m)
- Receptor locations
- Bottom line height above ground 'window' (0.5 m 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 Proposed Development 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 are 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. 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). Given the assumptions incorporated into the model, the calculations overestimate the duration of effects. 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 closest station to the Proposed Development: Met Éireann synoptic station in Valentia, Co. Cork
- Long-term wind rose data from the SEAI Wind Mapping System (Site Centre ITM co-ordinates 514000E, 56000N)

16.2.4 Baseline Description & Likely Evolution of the Baseline

The Site is located in a rural area, typically ribbon development with the majority of receptors located to the east of the Proposed Development. Should the Proposed Development not proceed, the surrounding areas will remain the same. Shadow flicker is directly associated with the operation of turbines.

Taking the above into consideration, JOD examined maps to identify sensitive receptors in the local area within a Study Area, a distance of 2 km, with 6 no. receptors outside of the 2 km also included, as outlined in **Section 16.2.1**. There are 73 no. 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 16.2** and are shown in **Figure 1.3**.

Table 16.2: Sensitive receptors within the shadow flicker study area

House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H1	512574	560249	T1	1459
H2	512548	560240	T1	1483
H3	512576	560296	T1	1467
H4	512607	560021	T1	1401
H5	513258	560218	T1	787
H6	513280	560045	T1	730
H7	514664	561741	T2	1643
H8	517491	561675	T6	2337
H9	517560	561620	T6	2351
H10	516223	559500	T6	697
H11	516345	559495	T6	780
H12	516426	559436	T6	879
H13	516455	559391	T6	931
H14	516453	559491	T6	860
H15	516742	559597	T6	1045
H17	516913	559519	T6	1232
H18	517205	559763	T6	1432
H19	517186	559907	T6	1390
H20	516995	559974	T6	1194
H21	517058	560064	T6	1254
H22	517237	560043	T6	1433
H23	517355	560026	T6	1551
H24	517505	560096	T6	1701
H25	517525	560068	T6	1721
H26	517602	560034	T6	1799
H27	517766	560044	T6	1962
H28	517833	560174	T6	2032
H29	517746	560332	T6	1961
H30	515967	558698	T9	806
H31	516071	558608	T9	942
H33	516831	558505	T9	1661

House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H34	516331	558002	T9	1544
H35	516489	557893	T9	1730
H36	516258	557871	T9	1599
H37	515815	557831	T8	1411
H38	512706	558535	T7	1543
H39	513035	558529	T7	1224
H40	512590	558155	T7	1767
H41	514019	558165	T7	703
H42	514606	558023	T8	868
H44	514826	557698	T8	1159
H45	514556	557258	T7	1616
H46	514715	557154	T8	1708
H47	514833	557430	T8	1427
H48	514870	557636	T8	1222
H49	515012	557597	T8	1272
H50	516168	557781	T9	1622
H60	512339	560424	T1	1727
H61	512089	560001	T1	1918
H62	511856	559964	T1	2152
H63	515138	562209	T2	2181
H64	511651	559779	T1	2364
H67*	514062	558379	T7	486
H68	517177	559907	T6	1381
H69	517375	560081	T6	1571
H70	517485	560120	T6	1682
H71	517582	560131	T6	1779
H72	517565	560150	T6	1764
H73	517665	560186	T6	1866
H74	517712	560152	T6	1910
H75	517770	560146	T6	1968
H76	517793	560211	T6	1995
H77	517724	560209	T6	1926

House ID	Easting ITM	Northing ITM	Closest Turbine	Closest Distance to Turbine (m)
H78	516185	558817	T9	945
H79	516326	559301	T6	919
H80	517061	559769	T6	1290
H81	516482	559447	T6	912
H82	517190	559916	T6	1393
H83	517202	560097	T6	1399
H84	517121	559978	T6	1319
H85	517638	560049	T6	1834
H86	517727	560072	T6	1923
H87	517677	560204	T6	1879

*Landowner has financial involvement in the Project.

16.2.5 Limitations of the Assessment

The Shadow Flicker 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. Vegetation, buildings and other structures may restrict the visibility of a turbine, preventing or reducing the effect of shadow flicker.

16.2.6 Assessment of Potential Effects

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

The maximum expected daily shadow flicker for each receptor is outlined in **Table 16.3**. 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.

Other developments within 2 km are considered in this assessment of the Proposed Development for cumulative effects. Shehy More Wind Farm is located 560 m from the nearest turbine. The IWEA Guidelines recommend that all existing and / or permitted wind farm developments within 2 km of a proposed development should be considered in a cumulative shadow flicker assessment.

The calculation of the potential total hours of shadow flicker per year, the number of days per year that shadow flicker is possible, the maximum hours of shadow flicker per day for each receptor from the Proposed Development and the Shehy More wind farm is shown in **Table 16.3** and discussed under cumulative effects in Section 16.2.8. Full assessment outputs are in **Appendix 16.1** of the EIAR.

Table 16.3: Summary of Potential Shadow Flicker Listing for All Sensitive Receptors

Receptor ID	Gorthloughra Turbines only			Gorthloughra Turbines and Cumulative Wind Farms*		
	Worst Case Shadow [h/year]	Max. Shadow [h/day]	Expected Shadow [h/year]	Worst Case Shadow [h/year]	Max. Shadow [h/day]	Expected Shadow [h/year]
H1	09:08	00:24	01:30	09:08	00:24	01:30
H2	08:52	00:23	01:29	08:52	00:23	01:29
H3	09:02	00:24	01:25	09:02	00:24	01:25
H4	10:36	00:24	02:12	10:36	00:24	02:12
H5	49:51	00:56	08:22	63:04	00:56	11:17
H6	63:10	01:11	12:20	76:45	01:11	15:06
H7*	00:00	00:00	00:00	**39:23**	**00:31**	**04:05**
H8*	00:00	00:00	00:00	**69:06**	**00:45**	**10:35**
H9*	00:00	00:00	00:00	**59:08**	**00:44**	**09:32**
H10	70:02	00:39	13:11	70:00	00:39	13:11
H11	54:00	00:34	10:14	54:00	00:34	10:14
H12	45:31	00:32	08:33	45:31	00:32	08:33
H13	46:32	00:31	08:45	46:32	00:31	08:45
H14	39:28	00:31	07:29	39:28	00:31	07:29
H15	19:26	00:25	03:44	19:26	00:25	03:44
H17	29:27	00:24	05:17	29:27	00:24	05:17
H18	13:11	00:25	02:36	13:11	00:25	02:36
H19	17:29	00:25	03:25	17:29	00:25	03:25
H20	21:42	00:29	04:09	21:42	00:29	04:09
H21	13:15	00:28	02:45	13:15	00:28	02:45
H22	10:09	00:24	02:06	10:09	00:24	02:06

Receptor ID	Gorthloughra Turbines only			Gorthloughra Turbines and Cumulative Wind Farms*		
	Worst Case Shadow [h/year]	Max. Shadow [h/day]	Expected Shadow [h/year]	Worst Case Shadow [h/year]	Max. Shadow [h/day]	Expected Shadow [h/year]
H23	08:42	00:22	01:48	08:42	00:22	01:48
H24	07:08	00:21	01:26	07:08	00:21	01:26
H25	06:58	00:20	01:25	06:58	00:20	01:25
H26	06:30	00:20	01:20	06:30	00:20	01:20
H27	00:00	00:00	00:00	00:00	00:00	00:00
H28	00:00	00:00	00:00	00:00	00:00	00:00
H29	00:00	00:00	00:00	00:00	00:00	00:00
H30	30:42	00:31	06:12	30:42	00:31	06:12
H31	28:21	00:28	05:33	28:21	00:28	05:33
H33	22:16	00:22	03:50	22:16	00:22	03:50
H34	00:00	00:00	00:00	00:00	00:00	00:00
H35	00:00	00:00	00:00	00:00	00:00	00:00
H36	00:00	00:00	00:00	00:00	00:00	00:00
H37	00:00	00:00	00:00	00:00	00:00	00:00
H38	10:26	00:24	02:18	10:26	00:24	02:18
H39	36:46	00:31	07:58	36:46	00:31	07:58
H40	12:54	00:21	02:52	12:54	00:21	02:52
H41	00:00	00:00	00:00	00:00	00:00	00:00
H42	00:00	00:00	00:00	00:00	00:00	00:00
H44	00:00	00:00	00:00	00:00	00:00	00:00
H45	00:00	00:00	00:00	00:00	00:00	00:00
H46	00:00	00:00	00:00	00:00	00:00	00:00

Receptor ID	Gorthloughra Turbines only			Gorthloughra Turbines and Cumulative Wind Farms*		
	Worst Case Shadow [h/year]	Max. Shadow [h/day]	Expected Shadow [h/year]	Worst Case Shadow [h/year]	Max. Shadow [h/day]	Expected Shadow [h/year]
H47	00:00	00:00	00:00	00:00	00:00	00:00
H48	00:00	00:00	00:00	00:00	00:00	00:00
H49	00:00	00:00	00:00	00:00	00:00	00:00
H50	00:00	00:00	00:00	00:00	00:00	00:00
H60	06:32	00:20	01:01	06:32	00:20	01:01
H61	00:00	00:00	00:00	00:00	00:00	00:00
H62	00:00	00:00	00:00	00:00	00:00	00:00
H63*	00:00	00:00	00:00	**19:17**	**00:40**	**03:09**
H64	00:00	00:00	00:00	00:00	00:00	00:00
H67	00:00	00:00	00:00	00:00	00:00	00:00
H68	17:52	00:26	03:29	17:52	00:26	03:29
H69	08:26	00:22	01:43	08:26	00:22	01:43
H70	07:08	00:21	01:24	07:08	00:21	01:24
H71	06:29	00:19	01:15	06:29	00:19	01:15
H72	06:35	00:20	01:15	06:35	00:20	01:15
H73	05:49	00:19	01:03	05:49	00:19	01:03
H74	00:00	00:00	00:00	00:00	00:00	00:00
H75	00:00	00:00	00:00	00:00	00:00	00:00
H76	00:00	00:00	00:00	00:00	00:00	00:00
H77	00:00	00:00	00:00	00:00	00:00	00:00
H78	34:49	00:33	06:24	34:49	00:33	06:24
H79	58:00	00:34	10:43	58:00	00:34	10:43

Receptor ID	Gorthloughra Turbines only			Gorthloughra Turbines and Cumulative Wind Farms*		
	Worst Case Shadow [h/year]	Max. Shadow [h/day]	Expected Shadow [h/year]	Worst Case Shadow [h/year]	Max. Shadow [h/day]	Expected Shadow [h/year]
H80	29:49	00:28	05:40	29:49	00:28	05:40
H81	39:39	00:30	07:28	39:39	00:30	07:28
H82	11:50	00:25	02:25	11:50	00:25	02:25
H83	10:28	00:25	02:07	10:28	00:25	02:07
H84	12:36	00:26	02:36	12:36	00:26	02:36
H85	06:07	00:19	01:15	06:07	00:19	01:15
H86	00:00	00:00	00:00	00:00	00:00	00:00
H87	05:44	00:19	01:01	05:44	00:19	01:01

***Impacted by Shehy More Wind Farm only**

It can be demonstrated from the cumulative scenario in **Table 16.3**, that in total there will be 51 receptors out of 73 that will experience some degree of shadow flicker and 22 receptors that will experience no shadow flicker. Three of these receptors, H4, H5 and H6, will be impacted cumulatively by the Proposed Development and Shehy More Wind Farm. Shadow flicker at the remaining receptors is caused by the Proposed Development. H6 is expected to experience 15 hours 06 minutes of shadow flicker in a year, which is the worst affected occupied receptor. Although, 03 hours and 26 minutes of the shadow flicker experienced at H6 is from the Shehy More Wind Farm only. The closest receptor, H67 (which is involved in the Project), is within 485 m of the closest turbine (T07), and experiences no shadow flicker. The closest receptor who is not involved, H10, is within 696 m of the closest turbine (T06).

There are four shadow flicker receptors, H7, H8, H9 and H63, which are impacted by the operational Shehy More Wind Farm only and these receptors will not experience shadow flicker from the Proposed Development.

None of the receptors are expected to experience more than the 2006 Guidelines recommended 30 hours or less of shadow flicker per year in any of the scenarios. However, 16 No. sensitive receptors exceed the 2006 Guidelines of a maximum 30 minutes of shadow flicker per day. 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 are outlined in Section 16.2.9.

As can be seen in the shadow flicker assessment attached as **Appendix 16.1** all of the proposed turbines give rise to some degree of cumulative shadow flicker, if unmitigated.

16.2.7 Assessment of Expected Shadow Flicker Impact

In order to calculate more realistic and '*real world*' occurrences of shadow flicker for the receptors that are identified as potentially vulnerable to shadow flicker (**Table 16.3**), 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[11] is automatically uploaded by the software. Data from Valentia Observatory Station was used as this Met Éireann observatory is the

[11] https://www.met.ie/climate/available-data/historical-data

closest to the Site and also measures multiple environmental parameters (**Table 16.3**). This gives a good representation of data for the Proposed Development. This data was utilised to consider the probability of sunshine occurrence, and thus allow the determination of '*projected*' values for shadow flicker occurrence.

Table 16.4: Average daily sunshine hours from Valentia Observatory Station

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.30	2.04	2.89	4.92	5.79	4.99	4.32	4.35	3.60	2.54	1.64	1.06

The worst-case predicted hours for shadow flicker are reduced by the average time the weather is cloudy annually. As discussed; 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 16.3 shows the potential and the expected shadow flicker values per year which are likely to be experienced by each receptor. '*Potential sunshine hours'* refers to the intervening time period between modelled sunrise and sunset. Although the projected duration of shadow flicker is reduced substantially for each sensitive receptor, they are not eliminated entirely for all of the 73 receptors within the shadow flicker Study Area of the Proposed Development.

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

16.2.8 Cumulative Effects

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 receptor is affected. In this instance, there is one operational wind farm (Shehy More Wind Farm) within a 2 km range of the turbines that may cause cumulative effects.

The assessment showed 4 no. receptors H7, H8, H9 and H63, are predicted to be affected by the operational Shehy More Wind Farm and not the Proposed Development (**Table 16.3**). There are 3 No. receptors that are predicted to be affected by cumulative shadow flicker effects, namely H4, H5 and H6. The installation of a blade shadow control system on all wind turbines will eliminate shadow flicker effects from the Proposed Development, therefore, removing cumulative shadow flicker effects. Mitigation of this shadow flicker is further discussed in section 16.2.9.

16.2.9 Mitigation Measures & Residual Effects

16.2.9.1 Likely Evolution of the Baseline

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

16.2.9.2 Construction Phase

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.

16.2.9.3 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 affect 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 receptors, then the turbine will automatically shut down; and will restart when the potential for shadow flicker ceases at the effected receptors. Such systems are common in many wind farm developments and the technology has been well established. A case study in Scotland, which carried out a review of how light and shadow effects from wind farms are considered in the development planning process in

Scotland, found that the use of turbine shut-down control modules for turbines which were causing shadow flicker at nearby offices was successful[12].

The Developer is committed to a zero-shadow flicker strategy which means that the turbines shadow flicker module will be programmed to shut down whenever the conditions for shadow flicker at a property are met, irrespective of which turbine in the range is installed Under this approach there would be no shadow flicker experienced at any property, and therefore no impacts on any receptors. **Appendix 16.1** 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 a complaint or complaints of shadow flicker are received by the Developer / site operator or by Cork County Council, the Developer will conduct an investigation, and the complaints frequency, duration and time of shadow flicker incident 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 receptor in which the complaint was made. Further refinement of the blade shadow control system will be conducted to eliminate the shadow flicker occurrence. This could result in the shutting off a turbine or turbines at specific times of day.

16.2.9.4 Decommissioning Phase

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.

16.2.9.5 Residual Effects

The results of the shadow flicker assessment predict that Gortloughra Wind Farm has the potential to result in shadow flicker at a maximum of 51 receptors surrounding the Site, as shown in **Table 16.3**. The implementation of mitigation to cease operation of the turbines during periods of potential shadow flicker will see that no shadow flicker effects are experienced at any sensitive receptor within the Study Area. It is therefore considered that Gortloughra Wind Farm will comply with Draft 2019 Guidelines (and therefore the 2006 Guidelines) of no shadow flicker at neighbouring sensitive receptors within the Study Area. Following implementation of mitigation measures described in Section 16.2.9.3, the residual impact as a result of shadow flicker will be a neutral, imperceptible, long-term effect.

[12] 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]

Accordingly, it is considered that there will be no residual impact as a result of shadow flicker.

16.3 SUMMARY OF SIGNIFICANT EFFECTS

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

This assessment has identified the potential for shadow flicker to affect 51 no. out of 73 no. receptors within the shadow flicker Study Area, as shown in **Table 16.3**. It is proposed that a shadow control system be installed to eliminate shadow flicker from the Proposed Development. 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 Proposed Development as a result of shadow flicker, when mitigated, are considered to be not significant. The Proposed Development has been assessed as having the potential to result in **neutral, imperceptible, long-term effects** overall with regards to shadow flicker.