15 SHADOW FLICKER AND ELECTROMAGNETIC INTERFERENCE

15.1 INTRODUCTION

This chapter assesses the impacts of the Development (**Figure 1.2**) on shadow flicker and electromagnetic interference. The Development refers to all elements of the application for planning permission for Dyrick Hill Wind Farm (**Chapter 2: Development Description**). Where negative effects are predicted, the chapter identifies appropriate mitigation strategies therein. The assessment considers the potential effects during the following phases of the Development:

- Construction of the Development
- Operation of the Development
- Decommissioning of the Development

Common acronyms used throughout this EIAR can be found in **Appendix 1.2.** This chapter of the EIAR is supported by Figures provided in Volume III and by the following Appendix documents provided in Volume IV of this EIAR:

- **Appendix 15.1Shadow Flicker Analysis**

15.1.1 Statement of Authority

This section has been prepared by Mr. Ryan Mitchell and Mr. Justin Lohan of Jennings O'Donovan & Partners Ltd. Mr. Mitchell has a Bachelor's Degree in Animal conservation and Biodiversity, has a strong proven background in ecology with 5 years' of experience working in the sector. He is experienced in report writing, EIAR chapter writing and project management working on EIARs for wind farm developments in Ireland.

Mr. Lohan has a Bachelor's Degree in Environmental Science and Technology. He also has almost 20 years' experience working in the construction and environmental sectors. He is experienced in report writing, EIAR chapter writing and project management working on EIARs for wind farm developments in Ireland.

The chapter has been reviewed by Mr. David Kiely of Jennings O'Donovan & Partners Ltd. Mr. Kiely has 35 years' experience in the civil engineering and environmental sector. He has obtained a Bachelor's Degree in Civil Engineering and a Master's Degree in Environmental Protection, has overseen the construction of over 40 wind farms and has carried out numerous soils and geology assessments for EIARs. He has been responsible for the overall preparation of more than 20 EIA Reports (EIARs).

15.1.2 Assessment Structure

In line with the revised EIA Directive and current EPA guidelines listed in **Chapter 1**, **Section 1.6** the structure of this Shadow Flicker and Electromagnetic Interference chapter is as follows:

- Assessment Methodology and Significance Criteria
- Description of baseline conditions at the Site
- Identification and assessment of impacts of shadow flicker and electromagnetic interference associated with the Development, during the construction, operational and decommissioning phases of the Development
- Mitigation measures to avoid or reduce the impacts identified
- Identification and assessment of residual impact of the Development considering mitigation measures
- Identification and assessment of cumulative impacts if and where applicable

The desktop study as outlined in Section 15.2 is considered adequate to allow Waterford City and County Council to carry out an adequate assessment of the Development.

15.2 SHADOW FLICKER

This section comprehensively assesses the potential shadow flicker impacts of the Development. No shadow flicker will occur during the construction or decommissioning phases. Therefore, the only potential shadow flicker impacts that could arise from the Development would be during the operational phase.

15.2.1 Assessment Methodology

This assessment of shadow flicker involved the following:

- A desk study of the shadow flicker baseline in the area of the Development
- Evaluation of potential effects
- Evaluation of the significance of effects
- Identification of measures to avoid and mitigate potential effects

The study area is defined as 10 times the widest potential rotor diameter within the range (10 x 162m = 1,620m). A study area of 2,000m is used for completeness. A shadow flicker computer model (WindPRO 3.6) was used to calculate the occurrence of shadow flicker at relevant receptors to the Development. The output from the calculations was analysed to identify and assess potential shadow flicker impacts. Wind turbines, like other tall structures, can cast long shadows when the sun is low in the sky.

The 2019 draft review of the 2006 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."

In order to ensure the full extent of the moving shadow which would be created by the turning turbines is considered in the assessment the following scenario was modelled:

- Twelve 6.0 – 7.2 MW wind turbines,
- Overall ground to blade tip height of 185m,
- A rotor diameter of 162m, and
- A hub height of 104m.

This scenario was included in the assessment along with the cumulative impacts of nearby wind farms (within 2km) in order to fully assess the impact of the Development. Tierney Single Turbine which is located 3.5km northeast of the site boundary. Due to the proximity of this wind turbine to the site (Further than 2km), it was not evaluated in the Shadow Flicker Analysis as there will be no cumulative impacts.

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

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

Shadow flicker lasts only for a short period and happens only in certain specific combined circumstances. The circumstances required for shadow flicker to occur are:

- the sun is shining
- the turbine is directly between the sun and the affected property, and
- there is enough wind energy to ensure that the turbine blades are moving.

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

The recently published 2019 Draft Revision of the 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 may have the potential to cause disturbance and annoyance to residents if it affects occupied rooms of a house.

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

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

- The duration of the shadow will be shorter the greater the distance (i.e., it will pass by quicker)
- The shadow flicker cast by rotating wind turbine blades will be reduced, the further a dwelling is from an operating turbine.

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

Persons with photosensitive epilepsy can be sensitive to flickering light between 3 and 60 Hertz (Hz)[1]. 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[2], and are well below the frequencies known to trigger effects in these individuals. Therefore, any potential shadow flicker effect from the Development is

[1] Epilepsy Action (2012) *Other Possible Triggers of Photosensitive Epilepsy*. Available online at: http://www.epilepsy.org.uk/info/photosensitive-epilepsy [Accessed on 09/03/2023]
[2] Harding, G., Harding, P., & Wilkins, A. (2008). *Wind turbines, flicker, and photosensitive epilepsy*. *Epilepsia* (49) 6, pp. 1095-1098.

considered an effect on residential amenity, rather than having the potential to affect the health of residents.

15.3 RELEVANT LEGISLATION AND GUIDANCE

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

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 DoEHLG guidelines state that shadow flicker lasts only for a short period of time and occurs only during certain specific combined circumstances, as follows:

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

A significant minimum separation distance from all occupied dwellings of 740m has been achieved with the Project design. With the exception of H92 which is in ownership of a financially involved third party which is located 710m from T09. The impact of Shadow Flicker on building 320m from turbine 10 has not been assessed. A Deed of the covenant from the landowner confirming that the property will not be used as a residential dwelling form the start of construction of the Wind Farm has been included in **Appendix 2.3**. There are currently 111 No. occupied dwellings located between 740m and 2km of any proposed wind turbine location.

Although the DoEHLG thresholds apply to dwellings located within 500 metres of a proposed turbine location, for the purposes of this assessment, the guideline thresholds of 30 hours per year or 30 minutes per day have been applied to all properties located within ten rotor diameters (i.e.,1,620 metres (162m) and 2,000 metres for completeness) of the proposed turbines within the Site (as per IWEA guidelines, 2012). The DoEHLG 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 DoHPLG released the 'Draft Revised Wind Energy Development Guidelines' in December 2019. The revised draft of Wind Energy Development Guidelines 2019 provides for zero shadow flicker.

The Draft 2019 Guidelines are based on the recommendations set out in the 'Proposed Revisions to Wind Energy Development Guidelines 2006 – Targeted Review' (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 Development can be brought in line with the requirements of the 2019 draft guidelines, should they be adopted while this application is in the planning system, through the implementation of the mitigation measures outlined herein.

Taking the above into consideration, JOD examined maps and aerial photographs to identify receptors (dwellings) up to 2km to include the ten rotor diameters guidance (1,620m) (all turbines will have a maximum rotor diameter of 162m of the Development). A total of 116 dwellings were originally identified in the desktop study. A house survey was conducted to confirm the dwellings in the study. The following dwellings H10, H12, H97 and H106 were incorrectly identified as a dwelling and have been removed from the shadow flicker study. These properties were not evaluated as part of the Shadow Flicker Analysis. It was it was confirmed there are a total of 112 dwellings within 2km of any turbine, as seen in **Figure 15.1**.

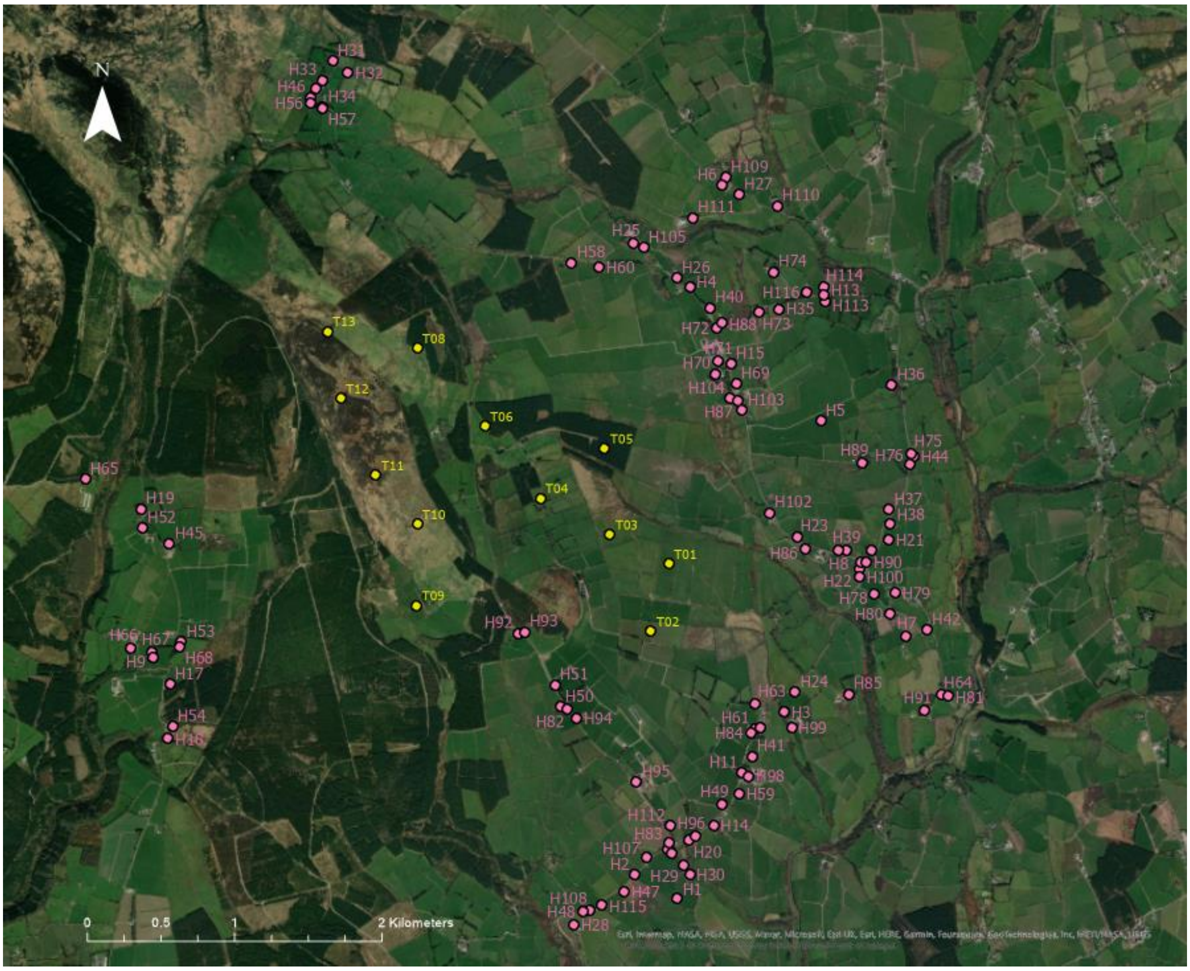

Figure 15.1. Shadow Flicker receptors within 2km of any turbine.

A distance of 2km was used to assess the effects of shadow flicker for completeness. Wind farms within 2km of the Development were also included in the assessment to determine the cumulative impacts.

15.3.1 Shadow Flicker Modelling

An industry standard wind farm assessment software package, WindPRO from EMD International Version 3.6 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 2m width, 2m height and 0.5m 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 properties within the model (10m resolution – OS X, Y, and Z data points)
- Turbine locations
- Turbine dimensions (rotor diameter and hub height)
- Receptor locations (i.e., property locations)
- Bottom line height above ground 'window' (0.5m 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 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 or break downs
- there is no intervening structures or vegetation (other than topography) that may restrict the visibility of a turbine, preventing or reducing the effect
- a limit to human perception of shadow flicker is not considered by the model

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

The model also outputs a more realistic scenario, or "expected values". In this scenario, the only change in assumptions is that the statistically likely monthly sunshine frequency and wind direction frequency data is assessed. This assessment only changes the annual hours per year 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 Kilkenny
- Long-term wind rose data from the onsite met mast

15.3.2 Baseline Description

Taking the above into consideration, JOD examined maps to identify receptors (dwellings) in the local area within a study area, a distance ten times the maximum proposed rotor diameter of the proposed turbines (10 x 162m = 1620m). This was rounded up to 2km to allow for a complete assessment. This dimension will give the most significant outcome as smaller rotor diameters will cast less shadow. The properties 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 Waterford City and County Council web resource and from a visit to the Study Area. There are 112 properties within the shadow flicker study area radius. The majority of houses are located to the south and south-west of the Development. The coordinates of each dwelling and its distance to the closest proposed turbine are listed in **Table 15.1** and are shown in **Figure 15.1.**

Table 15.1: Properties within the shadow flicker study area

Current House ID	ITM – EAST	ITM – NORTH	Closest Turbine	Closest Distance to Turbine (m)
H1	616566	602601	2	1912
H2	616278	602765	2	1657
H3	617295	603868	2	1058
H4	616652	606760	5	1242
H5	617543	605846	1	1415
H6	616872	607448	5	1957
H7	618120	604387	1	1679
H8	617665	604966	1	1155
H9	613008	604243	9	1824

Current House ID	ITM – EAST	ITM – NORTH	Closest Turbine	Closest Distance to Turbine (m)
H11	617011	603458	2	1143
H13	617566	606705	5	1819
H14	616814	603102	2	1382
H15	616934	606235	5	1032
H16	616505	602938	2	1485
H17	613123	604057	9	1760
H18	613112	603691	9	1913
H19	612926	605250	12	1550
H20	616644	602996	2	1445
H21	618004	605037	1	1499
H22	617803	604792	1	1292
H23	617384	605055	1	889
H24	617368	604005	2	1060
H25	616269	607055	5	1409
H26	616566	606816	5	1256
H27	616990	607385	5	1952
H28	615866	602423	2	2063
H29	616613	602830	2	1604
H30	616652	602768	2	1671
H31	614227	608291	13	1831
H32	614334	608208	13	1754
H33	614155	608159	13	1699
H34	614162	607979	13	1519
H35	617258	606607	5	1514
H36	618024	606092	1	1939
H37	618006	605242	1	1537
H38	618016	605148	1	1527
H39	617718	604971	1	1208
H40	616792	606615	5	1193
H41	617075	603568	2	1091
H42	618266	604429	1	1808
H43	616534	602910	2	1515
H44	618172	605603	1	1811
H45	613121	605013	11	1475
H46	614078	608043	13	1587
H47	616206	602650	2	1778
H48	615926	602514	2	1960
H49	616870	603242	2	1270
H50	615775	603904	2	803
H51	615737	604053	2	749

Current House ID	ITM – EAST	ITM – NORTH	Closest Turbine	Closest Distance to Turbine (m)
H52	612936	605123	12	1607
H53	613201	604344	9	1618
H54	613140	603773	9	1857
H55	614116	608101	13	1642
H56	614078	608005	13	1549
H57	614161	607969	13	1509
H58	615852	606919	8	1198
H59	616989	603312	2	1257
H60	616039	606888	5	1229
H61	617093	603758	2	963
H62	617135	603768	2	988
H63	617097	603926	2	860
H64	618362	603988	2	2017
H65	612547	605452	12	1820
H66	612857	604306	9	1963
H67	613003	604279	9	1824
H68	613191	604315	9	1632
H69	616969	606101	5	995
H70	616831	606165	5	908
H71	616849	606253	5	974
H72	616835	606478	5	1110
H73	617127	606589	5	1402
H74	617223	606859	5	1659
H75	618157	605625	1	1806
H76	618151	605556	1	1773
H77	617886	604972	1	1376
H78	617909	604674	1	1410
H79	618046	604676	1	1545
H80	618015	604537	1	1539
H81	618411	603978	2	2067
H82	615819	603889	2	779
H83	616514	602985	2	1439
H84	617066	603729	2	964
H85	617732	603992	2	1406
H86	617437	604978	1	929
H87	616980	605982	5	959
H88	616869	606514	5	1165
H89	617820	605561	1	1475
H90	617855	604887	1	1341
H91	618248	603879	2	1933

Current House ID	ITM – EAST	ITM – NORTH	Closest Turbine	Closest Distance to Turbine (m)
H92	615485	604405	9	710
H93	615533	604415	9	754
H94	615887	603829	2	776
H95	616292	603396	2	1027
H96	616688	603029	2	1421
H98	617056	603436	2	1186
H99	617344	603761	2	1157
H100	617808	604843	1	1295
H101	617811	604891	1	1297
H102	617196	605224	1	766
H103	617011	605919	5	969
H104	616927	605998	5	915
H105	616341	607024	5	1390
H107	616358	602886	2	1533
H108	615976	602525	2	1938
H109	616900	607502	5	2018
H110	617248	607307	5	2021
H111	616675	607227	5	1678
H112	616519	603099	2	1325
H113	617570	606656	5	1795
H114	617562	606755	5	1845
H115	616059	602556	2	1892
H116	617449	606718	5	1733

No shadow flicker is experienced at 39 No. dwellings, (**Table 15.2**) 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.

Table 15.2: Dwellings with no shadow flicker experienced

Dwellings with no shadow flicker experienced		
H1	**H32**	**H62**
H2	**H33**	**H81**
H6	**H34**	**H83**
H11	**H41**	**H84**
H14	**H43**	**H95**
H16	**H46**	**H96**
H19	**H47**	**H98**
H20	**H48**	**H107**
H27	**H49**	**H108**
H28	**H55**	**H109**
H29	**H56**	**H110**
H30	**H57**	**H112**

Dwellings with no shadow flicker experienced		
H31	H61	H115

15.3.3 Assessment of Potential Effects

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

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

Currently, there are no other wind farm developments within 2km to assess the cumulative effects of the development. The closest wind farm development is Tierney Single Turbine which is located 3.5km northeast of the site boundary.

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

Receptor ID	Dyrick Hill Wind Farm	
	Worst Case Shadow [h/year]	Expected Shadow [h/year]
H1	00:00	00:00
H2	00:00	00:00
H3	31:30	6:01
H4	20:04	2:39
H5	44:17	5:47
H6	00:00	00:00
H7	17:20	3:15
H8	47:33	8:04
H9	17:32	3:02
H11	00:00	00:00
H13	8:05	1:00
H14	00:00	00:00
H15	45:08	5:39
H16	00:00	00:00
H17	22:23	3:40
H18	10:58	1:51
H19	00:00	00:00
H20	00:00	00:00
H21	25:22	4:11
H22	41:25	7:29
H23	88:14	14:29
H24	47:29	9:11
H25	33:16	3:59
H26	19:07	2:36
H27	00:00	00:00
H28	00:00	00:00
H29	00:00	00:00
H30	00:00	00:00
H31	00:00	00:00
H32	00:00	00:00
H33	00:00	00:00
H34	00:00	00:00
H35	12:59	1:37
H36	7:22	0:54
H37	22:06	3:25
H38	22:52	3:37
H39	42:50	7:14
H40	54:43	6:27
H41	00:00	00:00
H42	14:48	2:43
H43	00:00	00:00

Receptor ID	Dyrick Hill Wind Farm	
	Worst Case Shadow [h/year]	Expected Shadow [h/year]
H44	5:44	0:45
H45	24:06	4:15
H46	**00:00**	**00:00**
H47	**00:00**	**00:00**
H48	**00:00**	**00:00**
H49	**00:00**	**00:00**
H50	12:12	2:16
H51	98:44	17:13
H52	23:41	4:00
H53	21:21	3:42
H54	10:09	1:44
H55	**00:00**	**00:00**
H56	**00:00**	**00:00**
H57	**00:00**	**00:00**
H58	59:44	7:35
H59	**00:00**	**00:00**
H60	52:40	6:44
H61	**00:00**	**00:00**
H62	**00:00**	**00:00**
H63	16:58	3:13
H64	6:26	1:12
H65	10:09	1:48
H66	5:04	0:55
H67	16:25	2:52
H68	22:26	3:51
H69	66:24	8:24
H70	53:57	6:50
H71	41:27	5:26
H72	54:16	6:30
H73	24:51	3:09
H74	20:55	2:21
H75	5:51	0:46
H76	5:58	0:47
H77	31:40	5:21
H78	26:36	4:44
H79	21:44	3:52
H80	22:43	4:06
H81	**00:00**	**00:00**
H82	12:32	2:22
H83	**00:00**	**00:00**
H84	**00:00**	**00:00**
H85	26:51	5:11
H86	85:41	14:38
H87	77:46	10:16

Receptor ID	Dyrick Hill Wind Farm	
	Worst Case Shadow [h/year]	Expected Shadow [h/year]
H88	49:44	5:55
H89	27:02	3:51
H90	35:00	6:08
H91	26:30	5:06
H92	83:40	15:45
H93	69:25	12:56
H94	9:16	1:45
H95	**00:00**	**00:00**
H96	**00:00**	**00:00**
H98	**00:00**	**00:00**
H99	12:20	2:20
H100	39:16	6:59
H101	37:54	6:38
H102	140:33	21:14
H103	70:54	9:52
H104	82:40	10:45
H105	32:53	4:02
H107	**00:00**	**00:00**
H108	**00:00**	**00:00**
H109	**00:00**	**00:00**
H110	**00:00**	**00:00**
H111	13:17	1:37
H112	**00:00**	**00:00**
H113	7:44	0:57
H114	8:23	1:02
H115	**00:00**	**00:00**
H116	9:37	1:11

It is demonstrated in **Table 15.3**, there will be potential for up to 73 receptors out of 112 to experience some degree of theoretical shadow flicker impact. 39 receptors will experience no theoretical shadow flicker impact.

None of the evaluated receptors are modelled to receive more than 30 hours of Shadow flicker per year. Property H102, is predicted to be the worst affected receptor with a total of 21 hours and 14 minutes per year modelled in the theoretical shadow flicker scenario.

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

15.3.4 Assessment of Expected Shadow Flicker Impact

In order to calculate more realistic and 'real world' occurrences of shadow flicker for the receptors that are identified as potentially vulnerable to shadow flicker (**Table 15.3**), 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 is automatically uploaded by the software. Data from Kilkenny Meteorological Observatory was used as this Met Éireann observatory is the closest to the Site and also measures multiple environmental parameters. 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.

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 15.3 shows the potential and the expected shadow flicker values per year which are likely to be experienced by each receptor. 'Potential sunshine hours' refers to the intervening time period between modelled sunrise and sunset. Although the projected duration of shadow flicker is reduced substantially for each dwelling, they are not eliminated entirely for all of the 112 receptors within the shadow flicker study area of the Development. The Draft Revised Wind Energy Development Guidelines, December 2019, recommend that shadow flicker should not impact any dwelling, therefore the relevant turbine or turbines must be shut down on a temporary basis until the potential for shadow flicker ceases.

15.3.5 Cumulative Effects

The closest wind farm is Tierney Single Turbine which is located 3.5km northeast of the site boundary. If the proposed Dyrick Hill Wind Farm development is consented, it is anticipated that there will be no cumulative impact since the respective potential shadow flicker extent areas will not overlap. The cumulative impact of both projects on the local receptors identified is predicted to have a **neutral/ imperceptible impact.**

15.3.3 Mitigation Measures & Residual Effects

Due to the potential for shadow flicker to affect receptors within the shadow flicker study area, it is proposed that a shadow control system will be installed on each of the wind turbines. The control system will calculate, in real-time:

- Whether shadow flicker has the potential to affect nearby properties, based on pre-programmed co-ordinates for the properties and turbines
- Wind speed (can effect how fast the turbine will turn and how quickly the flicker will occur)
- Wind direction
- The intensity of the sunlight
- When the control system detects that the sunlight is strong enough to cast a shadow, and the shadow falls on a property or properties, then the turbine will automatically shut down; and will restart when the potential for shadow flicker ceases at the affected properties.

It is intended that the measures outlined above, subject to safe shut down time of approximately 60 seconds, will eliminate the potential for shadow flicker to affect any of the properties within the study area, this will be the case regardless of which turbine is selected within the turbine range. In the event that complaints of shadow flicker are received by the Developer / Site Operator or by Waterford City and County Council, an investigation will take place and the complaints frequency, duration and time of complaints will be considered and specialist modelling software will be used to confirm the occurrence(s). Should the complaint persist, a shadow flicker survey involving the collection of light data will also be carried out at the property in which the complaint was made. Further refinement of the blade shadow control system will be conducted to eliminate the shadow flicker occurrence. This could result in the shutting off turbines at specific times of day.

15.4 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 an information booklet published by ESB in 2017 called "EMF & You" which provides information about Electric & Magnetic Fields and the electricity network in Ireland[3].

In 2014 a study was undertaken in Canada[4], 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.

15.4.1 Assessment of Potential Impacts

Electromagnetic fields from wind farm infrastructure, including the grid connection and substation, are very localised and are considered to be an imperceptible, long-term impact.

15.4.2 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 are not expected.

[3] EMF & You, ESB, 2017 - https://esb.ie/docs/default-source/default-document-library/emf-public-information_booklet_v9.pdf?sfvrsn=0, [Accessed Online: 09/03/2023]
[4] Lindsay C McCallum, *et al*. (2014) *Measuring electromagnetic fields (EMF) around wind turbines in Canada: is there a human health concern?*

15.5 SUMMARY OF SIGNIFICANT EFFECTS

This assessment has identified the potential for shadow flicker to affect 73 No. out of 112 No. receptors within the shadow flicker study area. It is proposed that a shadow control system will be installed to eliminate the potential for shadow flicker from the Development at all of the 73 receptors modelled as having theoretical exposure to shadow flicker impacts. 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 assessment has not identified any likely significant Electromagnetic Interference effects from the Development.

15.6 STATEMENT OF SIGNIFICANCE

This chapter has assessed the significance of potential effects of the Development on shadow flicker and electromagnetic interference.

This assessment has identified that by installing a blade shadow control system on the proposed turbines, there will be no significant impacts. Given that only effects of significant impact or greater are considered "significant" in terms of the EIA Regulations, the potential effects of the Development as a result of shadow flicker, when mitigated, are considered to be not significant.

The Development has been assessed as having the potential to result in effects of **imperceptible, long-term impact** overall with regards to electromagnetic interference. Cumulative effects are predicted as unlikely.

This assessment has identified that cumulative impact of the closest surrounding wind farms Tierney Single Turbine which is situated 3.5km east of the site boundary, will have an **Neutral / imperceptible cumulative impact** to the dwellings identified in the Shadow Flicker study.

[5] Update of UK Shadow Flicker Evidence Base, Parsons Brinckerhoff for Department of Energy and Climate Change, United Kingdom. [Accessed Online: 09/03/2023] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/48052/1416-update-uk-shadow-flicker-evidence-base.pdf