GAVIN & DOHERTY GEOSOLUTIONS

Illaunbaun Wind Farm - Environmental Impact Assessment Report

Chapter 14: Shadow Flicker

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ACRONYMS

AOD	Above Ordnance Datum
DEHLG	Department of the Environment, Heritage and Local Government
DHPLG	Department of Housing, Planning and Local Government
EPA	Environmental Protection Agency
GIS	Geographic Information System
Hz	Hertz (unit of frequency)
ITM	Irish Transverse Mercator
IWEA	Irish Wind Energy Association
OSI	Ordnance Survey Ireland
SEAI	Sustainable Energy Authority of Ireland
UK	United Kingdom

GLOSSARY OF TERMS

Baseline	The existing environmental conditions before the Proposed Development, used as a reference for assessing potential changes.
Construction Phase	The period during which physical works to build the wind farm are undertaken.
Cumulative Impacts	'The addition of many minor or significant effects, including effects of other projects, to create larger, more significant effects' (EPA, 2022a).
Curtailment	The reduction or cessation of wind turbine operation, often for environmental, technical, or safety reasons.
Digital Elevation Model	A digital representation of ground surface topography or terrain.
Hub Height	The distance from the ground to the centre of the wind turbine rotor.
Indirect Impact	'Impacts on the environment, which are not a direct result of the project, often produced away from (the site) or as a result of a complex pathway' (EPA, 2022a).
Mitigation	Measure or action which would avoid, reduce, or remediate an impact.
Operational Phase	The period during which the wind farm is generating electricity.
Photosensitive Epilepsy	A condition in which seizures can be triggered by visual stimuli such as flickering light.
Receptor	A location or feature that may be affected by an environmental change (e.g., a dwelling).
Residual Effects	Impacts remaining after mitigation measures have been implemented.
Rotor Diameter	The distance across the circular area swept by the turbine blades.
Shadow Detection System	A turbine control feature that can shut down operation to prevent shadow flicker impacts.
Study Area	The geographical area defined for the purposes of assessment.
Sunshine Probability	The likelihood of sunshine occurrence at a location over a defined period.
Tip Height	The maximum height reached by a turbine blade tip at its highest point.
Topography	The arrangement of natural and artificial physical features of an area.

14 SHADOW FLICKER

14.1 INTRODUCTION

This Shadow Flicker Assessment has been produced in respect of the proposed Illaunbaun Wind Farm (hereinafter the 'Proposed Development'), in order to quantify the potential for shadow flicker occurrence at nearby residences as a result of the Proposed Development.

The Proposed Development comprises 6 wind turbines with an overall tip height of 150 m, and rotor diameter of up to 117 m, located in the townlands of Drumbaun, Slievenalicka, Illaunbaun and Tooreen, County Clare.

14.1.1 SCOPE OF ASSESSMENT

Shadow flicker is defined as the alternating light intensity produced by a wind turbine as the rotating blade casts shadows on the ground and stationary objects, such as the window of a residence, which may have the potential to cause disturbance or annoyance. This chapter considers the potential impact to human beings from shadow flicker generated by the Proposed Development during the operational stage only, as the potential impact can only occur when the turbines are in operation.

The 2019 Draft Revision of the 2006 Wind Energy Development Guidelines reiterate 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."
>
> "This effect lasts only for a short period and happens only in certain specific combined circumstances. The circumstances require that:
>
> 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."

According to the 2006 guidelines (DEHLG, 2006), if any one of the conditions outlined above is absent, shadow flicker cannot occur. The recently published 2019 Draft Revision of the Wind Energy Development Guidelines (DHPLG, 2019), hereafter refer to as the Draft 2019 Guidelines, added that another condition required for shadow flicker to occur is that:

> "there is sufficient direct sunlight to cause shadows (cloud, mist, fog or air pollution could limit solar energy levels)".

and notes 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".

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 changes such that the shadow cast by a turbine is constantly changing. Notwithstanding, 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. Furthermore, generally shadow flicker is more likely to occur where turbines are sited to the east, south-east, west or south-west of nearby properties. On balance, careful site selection, design and planning, and good use of relevant software to control the turbine operation can reduce the possibility of shadow flicker.

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

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

It should be noted that in modern wind turbines, an embedded shadow flicker mitigation is typically installed during manufacture, in the form of an automated shadow detection system which has the ability to measure sunlight levels and stop turbine rotation during conditions that would result in shadow flicker being experienced at any neighbouring property. Where residual negative effects are predicted, this chapter identifies appropriate mitigation strategies.

14.1.1.1 HUMAN HEALTH

Regarding the potential for health impacts resulting from shadow flicker, persons with photosensitive epilepsy tend to be sensitive to flickering light between 3 and 60 flashes per second (Hertz (Hz)) (Epilepsy Action, 2012), with sensitivity under 3 Hz deemed uncommon (Epilepsy Society, n.d.). 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 commercial wind turbines are typically less than 1 Hz (Harding, Harding, & Wilkins, 2008), at between 0.3 and 1 Hz, therefore well below the frequencies known to trigger effects in these individuals. Therefore, any potential shadow flicker effect from the Proposed Development is considered an effect on residential amenity, rather than having the potential to affect the health of residents.

14.2 RELEVANT LEGISLATION AND GUIDELINES

The relevant Irish guidance for shadow flicker is derived from the *Wind Energy Development Guidelines for Planning Authorities* (DEHLG, 2006) (“the 2006 Guidelines”) and the *Best Practice Guidelines for the Irish Wind Energy Industry* (Irish Wind Energy Association, 2012)

The 2006 Guidelines considers that:

> “At distances greater than 10 rotor diameters from a turbine, the potential for shadow flicker is very low. Where shadow flicker could be a problem, developers should provide calculations to quantify the effect and where appropriate take

> measures to prevent or ameliorate the potential effect, such as by turning off a particular turbine at certain times".

The 2006 Guidelines also state that:

> "It is recommended that shadow flicker at neighbouring offices and dwellings within 500 m should not exceed 30 hours per year or 30 minutes per day".

A minimum separation distance from all other occupied dwellings of 600 m (4 x 150 m (tip height) has been achieved through project design, with the nearest residence to any of the turbines located at 603 m. There are 156 occupied dwellings within 2 km of any proposed wind turbine location.

Although the DEHLG 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. assumed at 1,170 metres as the widest potential rotor diameter for this project (117 m) and 2,000 metres for completeness) of the proposed turbines within the Site (as per IWEA guidelines, 2012). The DEHLG Guidelines state that at distances greater than 10 rotor diameters from a turbine, the potential for shadow flicker is very low.

The adopted 2006 DEHLG guidelines are currently under review. The DHPLG 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 at any existing relevant receptors:

> "A condition should be attached to all planning permissions for wind energy development to ensure that there will be no shadow flicker at any existing nearby dwelling or other relevant existing affected sensitive property and that the necessary measures outlined in the shadow flicker assessment submitted with the application, such as turbine shut down during the associated time periods, should be taken by the wind energy developer or operator to eliminate the shadow flicker".

Shadow flicker is generally not regulated explicitly by planning authorities.

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 DEHLG Guidelines (2006). Thresholds of 30 hours per year or 30 minutes per day have been applied to all properties located within ten rotor diameters (i.e., assumed at 1,170 metres as the widest potential rotor diameter for the Proposed Development, extended to 2 km for completeness). However, it should also be noted the Proposed Development will be 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.

14.3 ASSESSMENT METHODOLOGY

An industry standard wind farm assessment software package, WindPRO Version 4.0 from EMD International 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 residential receptors. 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 then assessed.

Turbine dimensions of 117 m rotor diameter and 91.5 m hub height resulting in an overall tip height of 150 m were used to conduct the assessment.

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

- There are no clouds, and sunlight is always bright and direct;
- The turbines are always rotating, whereas this might not be the case due to curtailment, maintenance works or break downs;
- Dwelling receptors have windows on all sides;
- There is no intervening structures or vegetation (other than topography) that may restrict the visibility of a turbine, preventing or reducing the effect i.e. bare-earth scenario; and
- 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'.

14.3.1 DEFINITION OF STUDY AREA

As outlined in Section 14.2 above, the 2019 DEHLG Guidelines state that at distances greater than 10 rotor diameters from a turbine, the potential for shadow flicker is very low, thus it is considered that the minimum study area for shadow flicker is 10 times the rotor diameter of the proposed turbines (10 x 117 m = 1,170 m). In the interest of compiling a robust and complete assessment, a study area of 2,000 m is used in this instance.

14.3.2 STATEMENT OF COMPETENCE

This technical assessment was undertaken by Peter Connell (BA, MPhil, MSc), of Macro Works Ltd., a specialist landscape and visual assessment company with over 20-years' experience in the appraisal of visual effects from a variety of energy, infrastructure and commercial developments, including landscape and visual impact assessments, and glint and glare assessments. Peter has prepared several shadow flicker impact models and assessments for inclusion in Environmental Impact Assessment Reports.

14.3.3 CONSULTATION

Consultation undertaken as part of the EIA process is described in detail in Chapter 6: Project Scoping and Consultation. As recorded in that chapter, shadow flicker was raised as a concern by some residents living in proximity to the Proposed Development during the public consultation event held at Miltown Malbay Community Centre on 11 December 2024. Feedback received related to potential shadow flicker effects during turbine operation. This topic will be assessed in detail in Section 14.5.3 of this chapter, with proposed mitigation measures set out in Section 14.6. No further topic-specific consultation on shadow flicker was recorded outside of the general project consultation activities.

14.3.4 DATA SOURCES

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

- Ordnance Survey Ireland Raster base map;
- Digital elevation model of the Proposed Development and areas around all properties within the model (10 m resolution – OS X, Y, and Z data points);

- Turbine locations;
- Turbine dimensions (rotor diameter and hub height);
- Receptor locations (GeoDirectory);
- Bottom line height above ground 'window' (0.5 m above ground level) applied to each side of dwellings i.e. 'greenhouse mode'; and
- Long-term sunshine probability data from the Met Éireann synoptic station in Shannon Airport (as the closest monitoring station); and
- Wind data as provided by the SEAI wind data extract tool. This tool allows users to view wind direction for a given height for any specific point in the country. Information is based on 2006 wind direction data.

14.4 BASELINE: SHADOW FLICKER IN RECEIVING ENVIRONMENT

Taking the above into consideration, maps were examined to identify residential receptors (dwellings) within a study area, a distance ten times the maximum proposed rotor diameter of the proposed turbines (10 x 117 m = 1,170 m). A rotor diameter of 117 m was used to calculate this distance which was then rounded up to 2 km to allow for a robust assessment. The properties within the shadow flicker study area were identified using a combination of Ordnance Survey of Ireland (OSI) Maps and GIS and from internet mapping resources including Eircode Finder, Google Street View, Google Earth, Bing Maps, a planning permission search using the Clare County Council web resource and from a visit to the Study Area. There are 156 properties within the shadow flicker study area radius. The coordinates of each dwelling and its distance to the closest proposed turbine are listed in Table 14-1 and are shown in Figure 14-1.

Table 14-1 Properties within the shadow flicker study area

House ID	Easting (ITM)	Northing (ITM)	Elevation (m AOD)	Nearest Turbine	Distance to nearest turbine (m)
H1	508632	680244	143	T05	1505
H2	509084	682541	144	T06	634
H3	508326	680267	151	T05	1635
H4	509228	683830	111	T06	1929
H5	511430	682538	105	T02	1409
H6	508351	681477	106	T06	751
H7	509026	679746	144	T03	1837
H8	508393	680616	133	T05	1317
H9	509301	679892	164	T03	1583

House ID	Easting (ITM)	Northing (ITM)	Elevation (m AOD)	Nearest Turbine	Distance to nearest turbine (m)
H10	507319	681392	88	T06	1722
H11	510885	682752	135	T02	1232
H12	510603	682685	160	T02	1071
H13	508633	680825	146	T05	1003
H14	511947	681473	132	T02	1618
H15	510316	680500	180	T01	676
H16	508983	681075	162	T05	603
H17	511498	681770	128	T02	1166
H18	509161	679898	155	T03	1639
H19	508247	679785	132	T05	2088
H20	508631	680768	147	T05	1050
H21	511347	683347	85	T02	1976
H22	509557	680037	171	T03	1362
H23	508064	681690	99	T06	922
H24	508698	680796	155	T05	988
H25	509041	680417	169	T05	1218
H26	510655	679499	143	T01	1712
H27	507190	681828	84	T06	1770
H28	508096	679765	132	T05	2181
H29	510938	681006	154	T01	651
H30	510580	682615	154	T02	997
H31	510987	683607	83	T02	2064
H32	509325	680288	162	T03	1218
H33	509678	680112	171	T01	1237
H34	508896	679897	139	T05	1755
H35	507475	682004	104	T06	1485
H36	509504	680520	185	T03	928
H37	509153	680404	173	T05	1217

House ID	Easting (ITM)	Northing (ITM)	Elevation (m AOD)	Nearest Turbine	Distance to nearest turbine (m)
H38	510014	680366	177	T01	862
H39	509784	683537	107	T04	1761
H40	508618	683551	124	T06	1666
H41	511520	682641	96	T02	1543
H42	508686	683575	124	T06	1678
H43	508634	680271	145	T05	1479
H44	510219	682951	152	T04	1256
H45	507816	682980	115	T06	1558
H46	508877	679851	140	T05	1805
H47	507866	680083	128	T05	2065
H48	508781	679942	133	T05	1739
H49	510371	682606	181	T02	959
H50	508051	681312	93	T06	1091
H51	509478	679960	168	T03	1458
H52	509478	679960	168	T03	1458
H53	510325	682586	180	T02	939
H54	509264	682451	151	T06	613
H55	508373	680777	114	T05	1213
H56	508373	680777	114	T05	1213
H57	510719	683290	106	T02	1686
H58	510644	682692	156	T02	1088
H59	511473	681721	126	T02	1137
H60	509485	680450	180	T03	1000
H61	511046	682767	118	T02	1324
H62	508186	679783	134	T05	2120
H63	510930	683299	97	T02	1755
H64	510863	682745	136	T02	1217
H65	510182	682625	178	T04	942

House ID	Easting (ITM)	Northing (ITM)	Elevation (m AOD)	Nearest Turbine	Distance to nearest turbine (m)
H66	509917	680334	174	T01	929
H67	508464	679839	131	T05	1944
H68	510900	679953	163	T01	1358
H69	508667	679635	125	T05	2066
H70	508471	681454	107	T06	674
H71	512121	681532	128	T02	1787
H72	508413	679816	132	T05	1986
H73	510888	683298	100	T02	1740
H74	510356	680257	160	T01	920
H75	510151	682935	154	T04	1219
H76	509433	679952	167	T03	1480
H77	507781	682954	114	T06	1566
H78	508706	682667	143	T06	788
H79	508775	680828	161	T05	920
H80	508394	682223	138	T06	640
H81	507872	680682	102	T06	1647
H82	509212	683830	112	T06	1927
H83	509391	679883	163	T03	1560
H84	508383	682127	129	T06	610
H85	509541	680471	183	T03	957
H86	508798	680846	162	T05	893
H87	508516	680741	135	T05	1142
H88	507470	681510	100	T06	1543
H89	508598	683525	125	T06	1645
H90	508745	681228	143	T05	636
H91	508000	680817	105	T06	1461
H92	509292	680609	188	T03	973
H93	512018	681562	130	T02	1682

House ID	Easting (ITM)	Northing (ITM)	Elevation (m AOD)	Nearest Turbine	Distance to nearest turbine (m)
H94	510269	683405	112	T04	1702
H95	509674	680427	181	T03	954
H96	509467	683200	153	T06	1378
H97	507364	681478	97	T06	1653
H98	510770	680743	169	T01	632
H99	508850	680887	164	T05	832
H100	509423	683234	149	T06	1394
H101	510467	682626	172	T02	986
H102	509182	683842	115	T06	1936
H103	508542	680735	138	T05	1130
H104	509459	680471	181	T03	992
H105	510216	679245	112	T01	1934
H106	509446	680029	169	T03	1403
H107	511000	683279	95	T02	1761
H108	508132	679771	132	T05	2158
H109	508150	681697	99	T06	838
H110	511290	682552	105	T02	1313
H111	509362	683220	146	T06	1362
H112	507936	681631	97	T06	1061
H113	509980	680331	172	T01	907
H114	509696	680051	168	T01	1281
H115	510330	682700	176	T02	1052
H116	511879	681582	130	T02	1542
H117	510247	682661	177	T04	1004
H118	509572	680455	182	T03	960
H119	509615	680069	171	T01	1307
H120	511977	681591	131	T02	1639
H121	508314	679808	131	T05	2036

House ID	Easting (ITM)	Northing (ITM)	Elevation (m AOD)	Nearest Turbine	Distance to nearest turbine (m)
H122	508946	682856	144	T06	936
H123	509173	683830	115	T06	1923
H124	509427	680496	181	T03	986
H125	507593	681531	98	T06	1419
H126	509955	683474	113	T04	1708
H127	510947	681400	157	T02	657
H128	509724	680070	167	T01	1251
H129	510885	681380	169	T02	609
H130	511286	681320	138	T01	987
H131	510375	683825	85	T04	2135
H132	508999	683013	136	T06	1094
H133	509631	679917	164	T01	1430
H134	508932	680836	172	T05	842
H135	508819	680864	163	T05	867
H136	509131	679893	154	T03	1657
H137	511486	681803	128	T02	1158
H138	511271	682545	107	T02	1295
H139	508139	680139	137	T05	1849
H140	508139	680139	137	T05	1849
H141	512144	682310	112	T02	1923
H142	511914	681606	130	T02	1576
H143	509704	679161	98	T01	2104
H144	507277	682339	117	T06	1732
H145	508895	680171	143	T05	1489
H146	509418	679874	162	T03	1559
H147	508080	681801	106	T06	886
H148	511656	682715	91	T02	1695
H149	509403	680517	181	T03	981

House ID	Easting (ITM)	Northing (ITM)	Elevation (m AOD)	Nearest Turbine	Distance to nearest turbine (m)
H150	507478	681972	102	T06	1481
H151	511216	682745	107	T02	1405
H152	508637	683574	123	T06	1685
H153	510328	683452	108	T04	1765
H154	510037	680382	177	T01	839
H155	507953	680772	104	T06	1525
H156	508239	682230	134	T06	783
H157	511101	683605	81	T02	2101
H158	510219	683412	113	T04	1696
H159	510383	683344	110	T04	1682
H160	512261	681992	110	T02	1953
H161	510402	679351	127	T01	1827
H162	510038	679233	109	T01	1962
H163	509802	679984	160	T01	1296
H164	509665	679887	159	T01	1441
H165	509312	679994	162	T03	1486
H166	509198	679090	96	T01	2363
H167	509187	679412	111	T03	2072
H168	508833	679702	133	T05	1959
H169	508012	679751	128	T05	2239
H170	508060	679761	131	T05	2204
H171	507450	681004	89	T06	1764
H172	507325	681872	91	T06	1633
H173	507461	682818	118	T06	1745
H174	507631	683005	115	T06	1714
H175	507605	682985	115	T06	1721
H176	510696	682054	153	T02	541
H177	510483	680398	173	T01	797

House ID	Easting (ITM)	Northing (ITM)	Elevation (m AOD)	Nearest Turbine	Distance to nearest turbine (m)
H178	510729	680609	164	T01	705
H179	510315	680348	167	T01	828
H180	509874	680216	168	T01	1054
H181	509831	680151	166	T01	1131
H182	508969	680902	169	T05	768
H183	507690	682061	109	T06	1275
H184	509429	682352	168	T06	639
H185	509819	682632	175	T04	857
H186	510126	682551	177	T04	852
H187	510546	682559	152	T02	935
H188	507686	681509	92	T06	1337

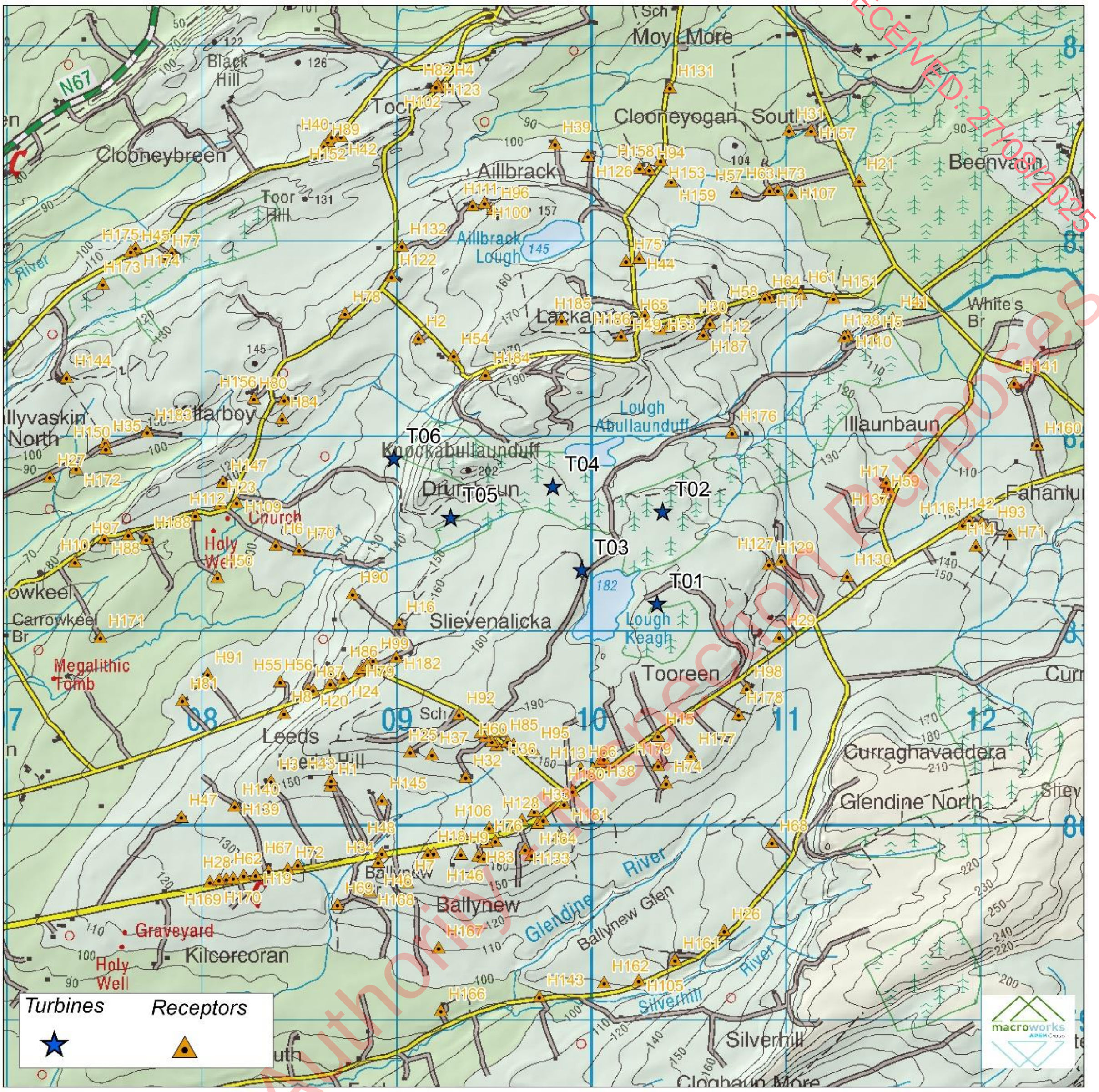

Figure 14-1: Map indicating locations of dwellings in relation to the Proposed Turbines.

No shadow flicker is experienced at 85 receptors, due to the orientation and distance of these dwellings with respect to the proposed turbines. Table 14-2 refers.

Table 14-2 Properties with no potential to experience shadow flicker

Dwellings with no shadow flicker experienced	
H4	H7
H9	H15
H18	H19
H21	H22
H26	H28

Dwellings with no shadow flicker experienced	
H31	H32
H33	H34
H36	H38
H39	H40
H42	H46
H47	H48
H51	H52
H57	H60
H62	H66
H67	H68
H69	H72
H74	H76
H82	H83
H85	H89
H94	H95
H96	H100
H102	H104
H105	H106
H108	H111
H113	H114
H118	H119
H121	H123
H124	H126
H128	H131
H133	H136
H139	H140
H143	H146
H152	H153

Dwellings with no shadow flicker experienced	
H154	H157
H158	H159
H161	H162
H163	H164
H165	H166
H167	H168
H169	H170
H177	H178
H179	H180
H181	

14.5 ASSESSMENT OF EFFECTS

14.5.1 "DO-NOTHING" SCENARIO

In the do-nothing scenario, the Proposed Development would not be constructed. Therefore, no shadow flicker effects would occur.

14.5.2 CONSTRUCTION PHASE IMPACTS

During the construction phase the turbine blades will not be moving. As such the shadow flicker effect is only linked to the operational phase of the proposed wind farm and has been excluded from the construction phase. Thus, there will be no shadow flicker effects during the construction phase of the proposed Project.

14.5.3 OPERATIONAL PHASE IMPACTS

Table 14-3 outlines the potential total hours of shadow flicker per year, the number of days per year that shadow flicker is possible, and the maximum hours of shadow flicker per day for each receptor, in the worst-case scenario. The entire modelling has been undertaken on WindPRO software, including a predicted shadow flicker contour map for both the worst-case and expected scenarios. The assessment results are included in Appendix A14-01. The assessment file was prepared when Illaunbaun Wind Farm was known as Clare 4N Wind Farm.

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

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

14.5.4 POTENTIAL IMPACTS (WORST-CASE)

The calculation of the days of shadow flicker per year and the maximum hours per year of shadow flicker experience, in the worst-case scenario, are as calculated by the computer software.

The calculated worst-case shadow flicker occurrences as outlined in Table 14-3 assumes that the sun is always shining, there is never any cloud cover and the dwelling is always occupied. Figure 14-2 below provides a visual representation of the worst-case predicted shadow impacts. As previously stated, this calculation is based on topography alone and excludes vegetation, buildings and other man-made structures which, in real life may act as a buffer between the turbines and receptors. The worst-case scenario models the information without considering embedded mitigations, such as automatic shadow detection systems, which will be incorporated into the design of the turbine during manufacture.

As can be seen from Table 14-3, in the worst-case, 103 of the 188 properties within 2 km of the Proposed Development could potentially experience an impact from shadow flicker, with 22 of the properties (H2, H6, H16, H23, H29, H54, H70, H80, H84, H90, H109, H127, H129, H130, H134, H147, H151, H156, H176, H182, H184, H187) theoretically experiencing greater than 30 hours of shadow flicker per year. H176 has the potential to experience a worst case of 94:58 hours of shadow flicker per year. However, as previously stated, modern turbines are typically fitted with an automatic shadow detection system which will shut down the turbine if it calculates the possibility of shadow reception on any of the surrounding houses. Thus, the real-case, expected shadow flicker prior to applying mitigation measures is assessed below.

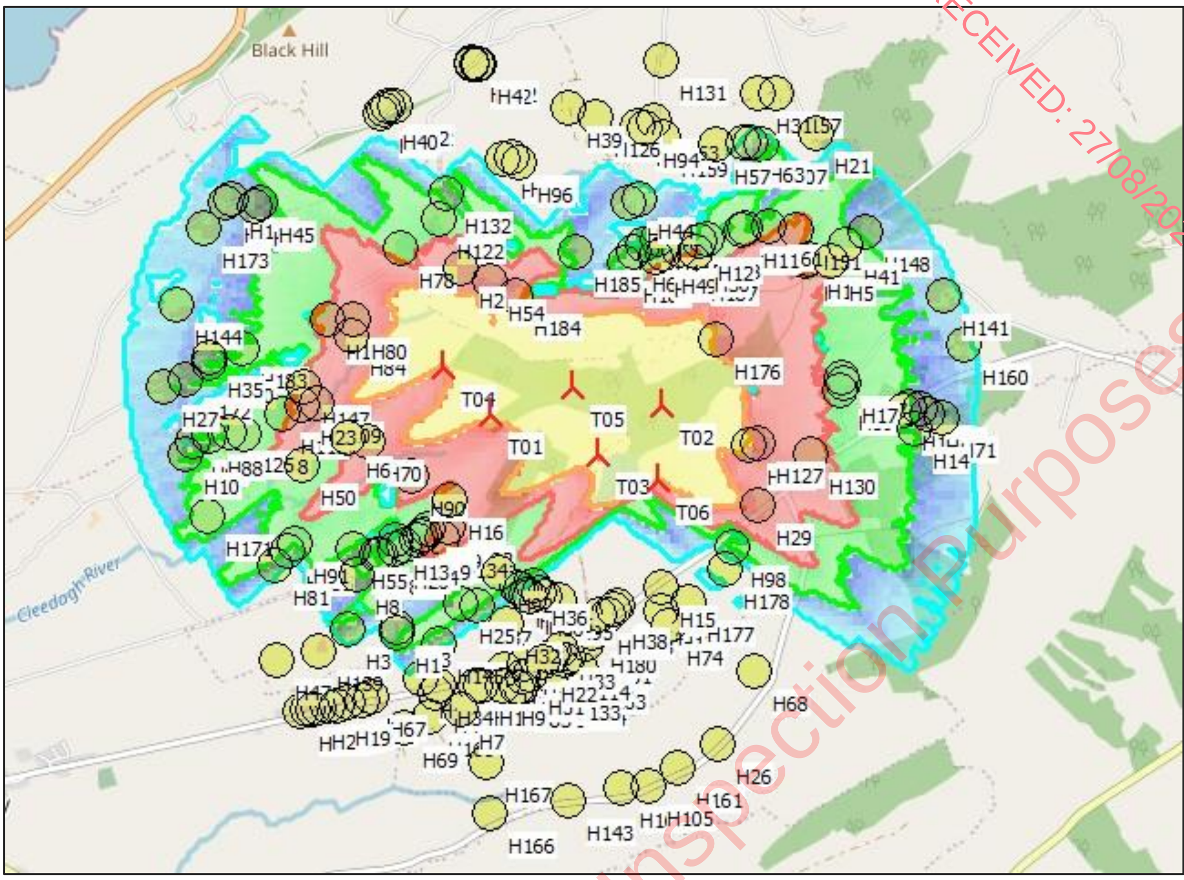

Figure 14-2: Extract from *Shadow Flicker Results*, outlining shadow flicker potential in the worst-case shadow scenario.

14.5.5 EXPECTED IMPACTS (REAL-CASE)

In order to calculate more realistic 'real world' occurrences of shadow flicker for the receptors that are identified as potentially vulnerable to shadow flicker (Table 14-1), 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, meteorological data from Met Éireann outlining 30-year climate averages for the synoptic station at Shannon Airport was used (Met Éireann, 2023). This was the closest weather monitoring station to the Site with available sunshine data. 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. Figure 14-3 below provides a visual representation of the expected or 'real-case' predicted shadow impacts.

As can be seen from Table 14-3, in the real-case, 103 of the 188 properties within 2 km of the Proposed Development will still have the potential to experience an impact from shadow flicker; however, none of the properties have the theoretical potential to experience greater than 30 hours of shadow flicker per year. H129 has the potential to experience a worst case of 19:44 hours of shadow flicker per year.

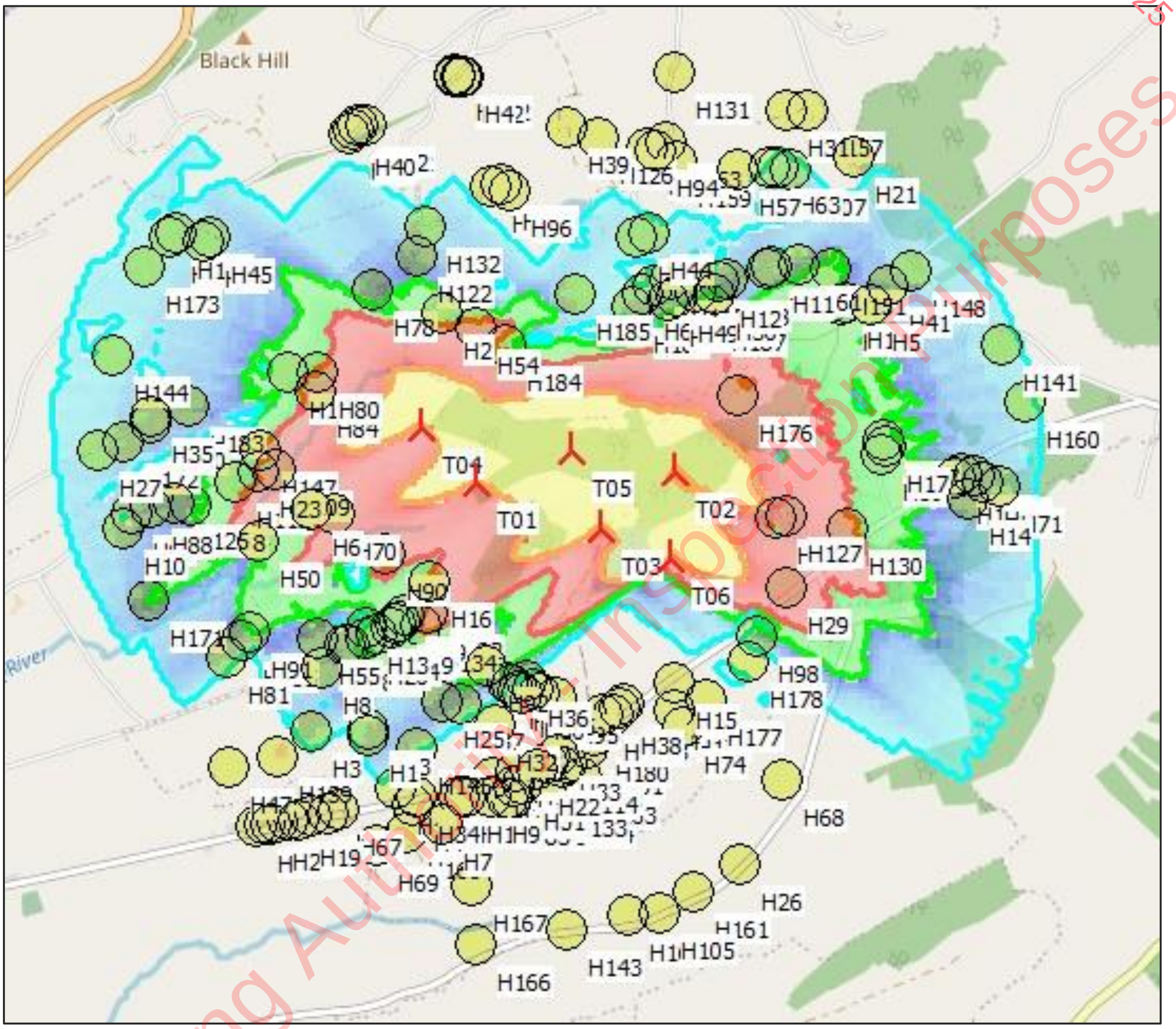

Figure 14-3: Extract from *Shadow Flicker Results*, outlining shadow flicker potential in the expected-shadow scenario.

Table 14-3 shows the potential (worst-case) and the expected (real-case) shadow flicker values per year which are likely to be experienced by each receptor. Although the projected durations of shadow flicker are substantially reduced for each dwelling, they are not eliminated entirely for all of the 188 receptors within the shadow flicker study area.

The Draft Revised Wind Energy Development Guidelines, published in December 2019, recommend that shadow flicker should not impact any dwelling, therefore where applicable, the relevant turbine or turbines must be shut down on a temporary basis until the potential for shadow flicker ceases.

Table 14-3 Summary of Projected Shadow Flicker Analysis for all properties

House ID	Easting (ITM)	Northing (ITM)	Worst Case Shadow [h/year]	Expected Shadow [h/year]
H1	508632	680244	7:33	1:35
H2	509084	682541	47:03	6:12
H3	508326	680267	6:21	1:18
H4	509228	683830	0:00	0:00
H5	511430	682538	27:34	3:55
H6	508351	681477	34:45	8:12
H7	509026	679746	0:00	0:00
H8	508393	680616	12:21	2:47
H9	509301	679892	0:00	0:00
H10	507319	681392	9:01	2:10
H11	510885	682752	13:01	1:53
H12	510603	682685	24:55	3:15
H13	508633	680825	20:21	4:39
H14	511947	681473	9:26	2:07
H15	510316	680500	0:00	0:00
H16	508983	681075	33:50	7:59
H17	511498	681770	25:26	5:07
H18	509161	679898	0:00	0:00
H19	508247	679785	0:00	0:00
H20	508631	680768	20:42	4:40
H21	511347	683347	0:00	0:00
H22	509557	680037	0:00	0:00
H23	508064	681690	37:00	8:39
H24	508698	680796	22:21	5:02
H25	509041	680417	16:47	3:29
H26	510655	679499	0:00	0:00
H27	507190	681828	3:58	0:57

House ID	Easting (ITM)	Northing (ITM)	Worst Case Shadow [h/year]	Expected Shadow [h/year]
H28	508096	679765	0:00	0:00
H29	510938	681006	73:05	16:11
H30	510580	682615	29:30	4:01
H31	510987	683607	0:00	0:00
H32	509325	680288	0:00	0:00
H33	509678	680112	0:00	0:00
H34	508896	679897	0:00	0:00
H35	507475	682004	8:56	1:52
H36	509504	680520	0:00	0:00
H37	509153	680404	10:27	2:09
H38	510014	680366	0:00	0:00
H39	509784	683537	0:00	0:00
H40	508618	683551	0:00	0:00
H41	511520	682641	22:16	3:08
H42	508686	683575	0:00	0:00
H43	508634	680271	6:49	1:27
H44	510219	682951	3:04	0:26
H45	507816	682980	7:50	1:05
H46	508877	679851	0:00	0:00
H47	507866	680083	0:00	0:00
H48	508781	679942	0:00	0:00
H49	510371	682606	16:13	2:04
H50	508051	681312	20:35	4:49
H51	509478	679960	0:00	0:00
H52	509478	679960	0:00	0:00
H53	510325	682586	15:44	2:01
H54	509264	682451	84:43	10:31

House ID	Easting (ITM)	Northing (ITM)	Worst Case Shadow [h/year]	Expected Shadow [h/year]
H55	508373	680777	8:16	1:54
H56	508373	680777	8:16	1:54
H57	510719	683290	0:00	0:00
H58	510644	682692	25:12	3:23
H59	511473	681721	26:37	5:29
H60	509485	680450	0:00	0:00
H61	511046	682767	23:51	3:03
H62	508186	679783	0:00	0:00
H63	510930	683299	3:22	0:24
H64	510863	682745	13:32	1:57
H65	510182	682625	12:27	1:36
H66	509917	680334	0:00	0:00
H67	508464	679839	0:00	0:00
H68	510900	679953	0:00	0:00
H69	508667	679635	0:00	0:00
H70	508471	681454	45:25	10:37
H71	512121	681532	7:37	1:41
H72	508413	679816	0:00	0:00
H73	510888	683298	1:16	0:08
H74	510356	680257	0:00	0:00
H75	510151	682935	3:44	0:32
H76	509433	679952	0:00	0:00
H77	507781	682954	7:41	1:04
H78	508706	682667	24:32	3:25
H79	508775	680828	25:02	5:37
H80	508394	682223	50:12	8:45
H81	507872	680682	5:59	1:14

House ID	Easting (ITM)	Northing (ITM)	Worst Case Shadow [h/year]	Expected Shadow [h/year]
H82	509212	683830	0:00	0:00
H83	509391	679883	0:00	0:00
H84	508383	682127	55:29	10:35
H85	509541	680471	0:00	0:00
H86	508798	680846	25:19	5:42
H87	508516	680741	13:47	3:10
H88	507470	681510	10:17	2:29
H89	508598	683525	0:00	0:00
H90	508745	681228	47:13	10:31
H91	508000	680817	14:07	3:02
H92	509292	680609	24:19	5:06
H93	512018	681562	8:28	1:51
H94	510269	683405	0:00	0:00
H95	509674	680427	0:00	0:00
H96	509467	683200	0:00	0:00
H97	507364	681478	8:39	2:06
H98	510770	680743	13:58	2:46
H99	508850	680887	28:27	6:26
H100	509423	683234	0:00	0:00
H101	510467	682626	23:25	3:00
H102	509182	683842	0:00	0:00
H103	508542	680735	14:34	3:19
H104	509459	680471	0:00	0:00
H105	510216	679245	0:00	0:00
H106	509446	680029	0:00	0:00
H107	511000	683279	7:37	0:55
H108	508132	679771	0:00	0:00

House ID	Easting (ITM)	Northing (ITM)	Worst Case Shadow [h/year]	Expected Shadow [h/year]
H109	508150	681697	45:40	10:34
H110	511290	682552	28:07	4:02
H111	509362	683220	0:00	0:00
H112	507936	681631	26:51	6:25
H113	509980	680331	0:00	0:00
H114	509696	680051	0:00	0:00
H115	510330	682700	9:20	1:14
H116	511879	681582	13:10	2:52
H117	510247	682661	12:02	1:34
H118	509572	680455	0:00	0:00
H119	509615	680069	0:00	0:00
H120	511977	681591	8:56	1:56
H121	508314	679808	0:00	0:00
H122	508946	682856	21:14	2:40
H123	509173	683830	0:00	0:00
H124	509427	680496	0:00	0:00
H125	507593	681531	12:29	3:01
H126	509955	683474	0:00	0:00
H127	510947	681400	89:37	19:01
H128	509724	680070	0:00	0:00
H129	510885	681380	94:51	19:44
H130	511286	681320	42:01	9:28
H131	510375	683825	0:00	0:00
H132	508999	683013	7:12	0:58
H133	509631	679917	0:00	0:00
H134	508932	680836	40:07	8:40
H135	508819	680864	26:25	5:57

House ID	Easting (ITM)	Northing (ITM)	Worst Case Shadow [h/year]	Expected Shadow [h/year]
H136	509131	679893	0:00	0:00
H137	511486	681803	25:49	5:10
H138	511271	682545	28:17	4:04
H139	508139	680139	0:00	0:00
H140	508139	680139	0:00	0:00
H141	512144	682310	3:33	0:39
H142	511914	681606	9:43	2:06
H143	509704	679161	0:00	0:00
H144	507277	682339	2:51	0:34
H145	508895	680171	2:33	0:32
H146	509418	679874	0:00	0:00
H147	508080	681801	35:07	8:04
H148	511656	682715	6:36	0:59
H149	509403	680517	3:44	0:46
H150	507478	681972	9:10	1:58
H151	511216	682745	36:26	4:47
H152	508637	683574	0:00	0:00
H153	510328	683452	0:00	0:00
H154	510037	680382	0:00	0:00
H155	507953	680772	9:03	1:51
H156	508239	682230	37:08	6:45
H157	511101	683605	0:00	0:00
H158	510219	683412	0:00	0:00
H159	510383	683344	0:00	0:00
H160	512261	681992	3:17	0:41
H161	510402	679351	0:00	0:00
H162	510038	679233	0:00	0:00

House ID	Easting (ITM)	Northing (ITM)	Worst Case Shadow [h/year]	Expected Shadow [h/year]
H163	509802	679984	0:00	0:00
H164	509665	679887	0:00	0:00
H165	509312	679994	0:00	0:00
H166	509198	679090	0:00	0:00
H167	509187	679412	0:00	0:00
H168	508833	679702	0:00	0:00
H169	508012	679751	0:00	0:00
H170	508060	679761	0:00	0:00
H171	507450	681004	18:23	3:57
H172	507325	681872	7:56	1:48
H173	507461	682818	3:29	0:34
H174	507631	683005	5:01	0:43
H175	507605	682985	4:47	0:41
H176	510696	682054	94:58	14:44
H177	510483	680398	0:00	0:00
H178	510729	680609	0:00	0:00
H179	510315	680348	0:00	0:00
H180	509874	680216	0:00	0:00
H181	509831	680151	0:00	0:00
H182	508969	680902	42:31	9:19
H183	507690	682061	12:03	2:29
H184	509429	682352	44:31	6:18
H185	509819	682632	6:40	0:57
H186	510126	682551	16:04	2:07
H187	510546	682559	31:49	4:25
H188	507686	681509	15:13	3:39

14.5.6 CUMULATIVE EFFECTS AND OTHER INTERACTIONS

Cumulative shadow flicker impacts may arise in instances where dwellings are at risk from potential shadow flicker impacts as a result of more than one windfarm. While separate windfarms are not likely to cause effects simultaneously, they could increase the cumulative total hours where a receptor has the potential for impacts.

In this Instance, there are no consented nor constructed wind farms within a 2 km range of the Proposed Development. On the basis of shadow flicker being deemed unlikely at distances over 10 rotor diameters from a property, it is considered that there is no potential for cumulative shadow flicker impacts resulting from the Proposed Development. The nearest operational wind farm is Boolinrudda Wind Farm, whose nearest turbine is located c. 3.9 km from the nearest proposed turbine (T6). Furthermore, should another windfarm be constructed within 2 km of the Proposed Development in the future, the installation of a shadow control system on the turbine will eliminate shadow flicker impacts from the Proposed Development, thus removing the potential for cumulative shadow flicker impacts.

14.6 MITIGATION MEASURES FOR SHADOW FLICKER

In line with guidance as outlined in Section 14.2, it is proposed that each turbine is fitted with an automatic shadow detection system during turbine manufacturing. This is an embedded mitigation measure that will see that the turbines shut down during periods where shadow flicker is predicted at any of the identified receptors, until the potential for shadow flicker ceases. 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, which 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 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. In the event that complaints of shadow flicker are received by the Developer / Site Operator or by Clare 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 may result in the shutting off turbines at specific times of day.

14.7 ASSESSMENT OF RESIDUAL EFFECTS

This assessment has identified the potential for shadow flicker to affect up to 85 out of 188 receptors within the shadow flicker study area. Of these, in the real-case or expected shadow scenario where realistic meteorological conditions are applied, no receptors are expected to exceed the limit set out in the guidelines of 30 hours or flicker per year.

It is proposed that a shadow control system be installed to eliminate the potential for shadow flicker from the Proposed Development. 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 (Parsons Brinckerhoff, 2011).

14.8 SUMMARY

Table 14-4: Summary of Potential Effects, Significance, Mitigation Measures, and Residual Effects for the Proposed Development

Potential Effect	Construction /Operation	Beneficial /Adverse/ Neutral	Extent (Site/Local/ National/ Transboundary)	Short term/ Long term	Direct/ Indirect	Permanent / Temporary	Reversible /Irreversible	Significance of Effect	Proposed mitigation	Residual Effects
Shadow flicker at sensitive receptors due to rotating turbine blades	Operation	Adverse	Local	Long term (occurring during operation al life of turbines)	Direct	Temporary (only during specific sunlight/tur bine operation conditions)	Reversible (effect ceases when turbine stops or mitigation is applied)	Not significant with mitigation (as per compliance with DEHLG Guidelines)	Use of an automated shadow detection/c ontrol system to shut down turbines when predicted shadow flicker exceeds guideline limits	No significant residual effects anticipated following mitigation

14.9 REFERENCES

Department of Housing, Planning and Local Government. (2019). *Draft revised wind energy development guidelines*. https://www.gov.ie/en/publication/dfb4c-draft-revised-wind-energy-development-guidelines/

Department of the Environment, Heritage and Local Government. (2006). *Wind energy development guidelines*. https://assets.gov.ie/static/documents/wind-energy-development-guidelines-2006.pdf

Epilepsy Action. (2012). *Other possible triggers of photosensitive epilepsy*. https://www.epilepsy.org.uk/info/photosensitive-epilepsy

Epilepsy Society. (n.d.). *Photosensitive epilepsy*. https://epilepsysociety.org.uk/about-epilepsy/epileptic-seizures/seizure-triggers/photosensitive-epilepsy

Harding, G., Harding, P., & Wilkins, A. (2008). Wind turbines, flicker, and photosensitive epilepsy. *Epilepsia, 49*(6), 1095–1098. https://doi.org/10.1111/j.1528-1167.2008.01523.x

Irish Wind Energy Association. (2012). *Best practice guidelines for the Irish wind energy industry* (2nd ed.). https://windenergyireland.com/images/files/Best_Practice_Guidelines.pdf

Parsons Brinckerhoff. (2011). *Update of UK Shadow Flicker Evidence Base*. Department of Energy and Climate Change. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/48052/1416-update-uk-shadow-flicker-evidence-base.pdf

EMD International (2023). windPRO. windPRO - Modules

Met Éireann (2023). Ireland's 30-year Climate Averages. https://www.met.ie/cms/assets/uploads/2023/08/shannon_airport_9120.htm

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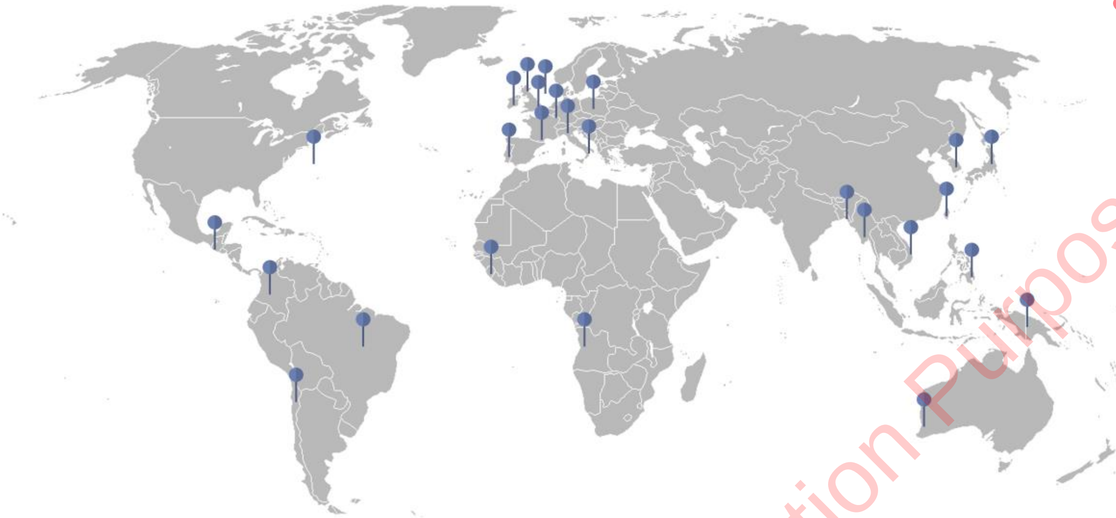

Offices

Dublin (Head Office)
Gavin & Doherty Geosolutions
Unit A2, Nutgrove Office Park
Rathfarnham
Dublin 14, D14 X627
Phone: +353 1 207 1000

Cork
Gavin & Doherty Geosolutions
First Floor, 12 South Mall
Cork
T12 RD43

London
Gavin & Doherty Geosolutions (UK) Limited
85 Great Portland Street, First Floor
London
W1W 7LT

Utrecht
Gavin & Doherty Geosolutions
WTC Utrecht, Stadsplateau 7
3521 AZ Utrecht
The Netherlands

Belfast
Gavin & Doherty Geosolutions (UK) Limited
Scottish Provident Building
7 Donegall Square West
Belfast
BT1 6JH

Edinburgh
Gavin & Doherty Geosolutions (UK) Limited
22 Northumberland Street SW Lane
Edinburgh
EH3 6JD

Rhode Island
Gavin & Doherty Geosolutions Inc.
225 Dyer St, 2nd Floor
Providence, RI 02903
USA

GDG
GAVIN & DOHERTY
GEOSOLUTIONS

Website: www.gdgeo.com
Email: info@gdgeo.com

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