6. SHADOW FLICKER

6.1 Introduction

This section of the Environmental Impact Assessment Report (EIAR) describes the potential impacts of shadow flicker on human beings and human health and has been completed in accordance with the guidance set out by the Environmental Protection Agency (EPA), in particular the *'Draft Guidelines on the Information to be Contained in Environmental Impact Assessment Reports'* (EPA, August 2017). The full description of the proposed development is provided in Chapter 4 of this EIAR.

6.1.1 Statement of Authority

This section of the EIAR has been prepared by Stephen Corrigan and reviewed by Eoin O'Sullivan and Michael Watson, all of MKO. Stephen is an Environmental Scientist with over three years' experience in private practice; where he has completed numerous assessments for shadow flicker. Stephen holds a BSc (Hons) in Environmental Science. Eoin is an experienced geo-environmental scientist and has over ten years' experience in the assessment of a wide range of energy and infrastructure related projects and working in the fields of environmental and human health risk assessment, waste management, waste policy and permitting. Eoin has also got extensive experience in the completion and review of shadow flicker assessments for wind farm projects. Eoin has wide experience in the project management of large scale infrastructural projects and brownfield developments and has routinely undertaken detailed quantitative risk assessment for the protection of controlled waters and ground gas risk assessments. Eoin holds an MSc in Environmental Engineering and is a Chartered Member of the Chartered Institute of Water and Environmental Management (CWEM) and Chartered Environmentalist (CEnv) with the Society of Environment. Michael has over seventeen years' experience in the environmental sector and had worked for the Geological Survey of Ireland and then a prominent private environmental & hydrogeological consultancy prior to joining MKO in 2014. Michael completed an MA in Environmental Management at NUI, Maynooth in 1999. Michael is a professional geologist (PGeo) and full member of IEMA (MIEMA) as well as a Chartered Environmentalist (CEnv) and also has extensive experience in the completion and review of shadow flicker assessments for wind energy projects.

6.2 Receiving Environment

The site of the proposed development is located in a number of townlands as listed in Table 1.1 of Section 1.1 of this EIAR. The proposed wind farm site is located approximately 5 kilometres to the north of Kilmihil and 25 kilometres southwest of Ennis, Co. Clare. The site located in county Clare, comprises lands at Mullagh, Creegh and Cahermurphy. The site location is shown in Figure 1.1 of Chapter 1 of this EIAR.

The study area for the shadow flicker assessment is ten times the rotor diameter from each turbine as set out in the *'Wind Energy Development Guidelines for Planning Authorities*', DoEHLG, 2006. All properties located within ten rotor diameters which is assumed to be 1.4 kilometres have been included in the assessment. The closest residential property is located approximately 700 metres from the nearest proposed turbine location.

6.3 Shadow Flicker

6.3.1 Background

Shadow flicker is an effect that occurs when rotating wind turbine blades cast shadows over a window in a nearby property. Shadow flicker is an indoor phenomenon, which may be experienced by an occupant sitting in an enclosed room when sunlight reaching the window is momentarily interrupted by a shadow of a wind turbine's blade. Outside in the open, light reaches a viewer (person) from a much less focused source than it would through a window of an enclosed room, and therefore shadow flicker assessments are typically undertaken for the nearby adjacent properties around a proposed wind farm site (*Wind Energy Development Guidelines for Planning Authorities*', DoEHLG, 2006).

The frequency of occurrence and the strength of any potential shadow flicker impact depends on several factors, each of which is outlined below.

1. ***Whether the sunlight is direct and unobstructed or diffused by clouds:***

If the sun is not shining, shadow flicker cannot occur. Reduced visibility conditions such as clouds, haze, and fog greatly reduce the chance of shadow flicker occurring.

Cloud amounts are reported as the number of eights (okta) of the sky covered. Irish skies are completely covered by cloud for well over 50% of the time. The mean cloud amount for each hour is between five and six okta. This is due to our geographical position off the northwest of Europe, close to the path of Atlantic low-pressure systems which tend to keep us in humid, cloudy airflows for much of the time. A study of mean cloud amounts at 12 stations over a 25-year period showed that the mean cloud amounts were at their minimum in April and their maximum in July. Cloud amounts were less by night than by day, with the mean minimum occurring roughly between 2100 and 0100 GMT and the mean maximum between 1000 and 1500 GMT at most stations. (Source: Met Éireann, www.met.ie)

2. ***The presence of intervening obstructions between the turbine and the observer:***

For shadow flicker to occur, the windows of a potentially affected property must have direct visibility of a wind turbine, with no physical obstructions such as buildings, trees and hedgerows, hills or other structures located on the intervening land between the window and the turbine.

Any obstacles such as trees or buildings located between a property and the wind turbine will reduce or eliminate the occurrence and/or intensity of the shadow flicker.

3. ***How high the sun is in the sky at a given time:***

At distances of greater than approximately 500 metres between a turbine and a receptor, shadow flicker generally occurs only at sunrise or sunset when the shadow cast by the turbine is longer. At distances greater than ten rotor diameters from a turbine, the potential for shadow flicker is very low ('*Wind Energy Development Guidelines for Planning Authorities*', DoEHLG, 2006). Figure 6-1 illustrates the shadow cast by a turbine at various times during the day, where the red shading represents the area where shadow flicker may occur. When the sun is high in the sky, the length of the shadow cast by the turbine is significantly shorter.

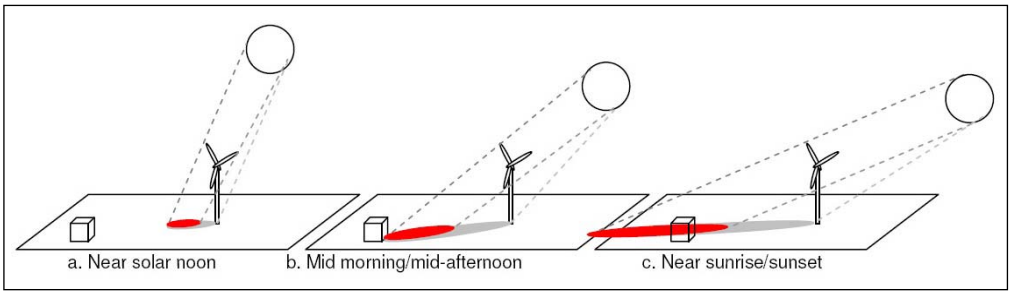

Figure 6-1 Shadow-Prone Area as a Function of Time of Day (Source: Shadow Flicker Report, Helimax Energy, December 2008)

4. ***Distance and bearing, i.e. where the property is located relative to a turbine and the sun:***

The further a property is from the turbine the less pronounced the impact will be. There are several reasons for this: there are fewer times when the sun is low enough to cast a long shadow; when the sun is low it is more likely to be obscured by either cloud on the horizon or intervening buildings and vegetation; and, the centre of the rotor's shadow passes more quickly over the land reducing the duration of the impact.

At distance, the turbine blades do not cover the sun but only partly mask it, substantially weakening the shadow. This impact occurs first with the shadow from the blade tip, the tips being thinner in section than the rest of the blade. The shadows from the tips extend the furthest and so only a very weak impact is observed at distance from the turbines. (Source: *Update of Shadow Flicker Evidence Base, UK Department of Energy and Climate Change, 2010*)

5. ***Property usage and occupancy:***

Where shadow flicker is predicted to occur at a specific location, this does not imply that it will be witnessed. Potential occupants of a property may be sleeping or occupying a room on another side of the property that is not subject to shadow flicker, or completely absent from the location during the time of shadow flicker events. As shadow flicker usually occurs only when the sun is at a low angle in the sky, i.e. very early in the morning after sunrise or late in the evening before sunset, even if there is a bedroom on the side of the property affected, the shadow flicker may not be witnessed if curtains or blinds in the bedroom are closed.

6. ***Wind direction, i.e. position of the turbine blades:***

The direction of wind turbine blades changes according to wind direction, as the turbine rotor turns to face the wind. In order to cast a shadow, the turbine blades have to be facing directly toward or away from the sun (ie. perpendicual to it), so they are moving across the source of the light relative to the observer. This is demonstrated in Figure 6-2.

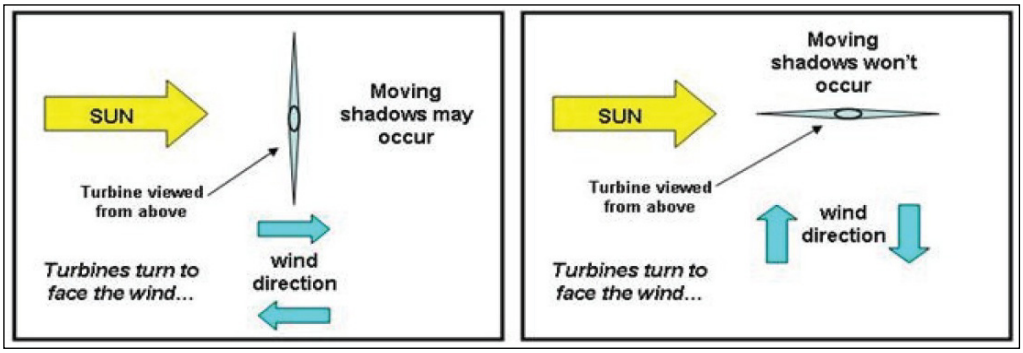

Figure 6-2 Turbine Blade Position and Shadow Flicker Impact (Source: Wind Fact Sheet: Shadow Flicker, Noise Environment Power LLC)

7. ***Rotation of turbine blades:***

Shadow flicker occurs only if there is sufficient wind for the turbine blades to be continually rotating. Wind turbines begin operating at a specific wind speed referred to as the 'cut-in speed', i.e. the speed at which the turbine produces a net power output, and they cease operating at a specific 'cut-out speed'. Therefore, even during the sunlight hours when shadow flicker has been predicted to occur, if the turbine blades are not turning due to insufficient wind speed, no shadow flicker will occur.

6.3.2 Guidance

The current, adopted guidance for shadow flicker in Ireland is derived from the *'Wind Energy Development Guidelines for Planning Authorities 2006'* (DoEHLG), and the *'Best Practice Guidelines for the Irish Wind Energy Industry'* (Irish Wind Energy Association, 2012). The 2006 DoEHLG Guidelines state that at distances greater than 10 rotor diameters from a turbine, the potential for shadow flicker is very low.

The DoEHLG 2006 wind energy guidelines recommend that shadow flicker at dwellings within 500 metres of a proposed turbine location should not exceed a total of 30 hours per year or 30 minutes per day. The closest residential property is located approximately 700 metres from the nearest turbine location. Refer to Section 6.2.

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.

Although the DoEHLG thresholds apply to properties 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 1.4 kilometres as a worst-case scenario) of the proposed turbines within the proposed development 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 for public consultation. The Draft 2019 guidelines recommend local planning authorities and/or An Bord Pleanála impose conditions to ensure that:

> *"no existing dwelling or other affected property will experience shadow flicker as a result of the wind energy development subject of the planning application and the wind energy development shall be installed and operated in accordance with the shadow flicker study submitted to accompany the planning application, including any mitigation measures required."*

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).

At time of writing, the Draft Guidelines have not yet been adopted, and the relevant guidelines remain those published in 2006. Notwithstanding this, however, due to the timelines associated with the planning process for renewable energy projects, it is possible that a version of the draft guidelines may be finalised during the consideration period for the current proposed development. Towards this end it

is anticipated that Cahermurphy Two Wind Farm will be capable of adhering to the relevant shadow flicker standards, and is in accordance with the set back requirements. The assessment herein is based on compliance with the current DoEHLG Guidelines limit (30 hours per year or 30 minutes per day).

6.3.3 Scoping

Section 2.6 in Chapter 2 of this EIAR describes the scoping and consultation exercise undertaken for the proposed Cahermurphy Two Wind Farm. No comments were received in relation to Shadow Flicker in response to scoping requests as of July 2020.

6.3.4 Shadow Flicker Prediction Methodology

Shadow flicker occurs only under certain, combined circumstances, as detailed above. Where shadow flicker does occur, it is generally short-lived. The Department of the Environment, Heritage and Local Government (DoEHLG) guidelines state that careful site selection, design and planning, and good use of relevant software can help avoid the possibility of shadow flicker in the first instance, all of which have been employed at the site of the proposed development. Proper siting of wind turbines is key to reducing or eliminating shadow flicker.

The occurrence of shadow flicker can be precisely predicted using specialist computer software programmes specifically developed for the wind energy industry, such as WindFarm (ReSoft) or WindFarmer (DNV.GL) or AWS OpenWind. The computer modelling of the occurrence and magnitude of shadow flicker is made possible by the fact that the sun rises and sets in the same position in the sky on the same day each year.

For the purposes of this shadow flicker assessment, the software package WindFarm Version 4.1.2.3 has been used to predict the level of shadow flicker associated with the proposed wind farm development. WindFarm is a commercially available software tool that enables developers to analyse, design and optimise proposed wind farms. It allows proposed turbine layouts to be optimised for maximum energy yield whilst taking account of environmental, planning and engineering constraints.

Any potential shadow flicker impact can be precisely modelled to give the start and end time (accurate to the second) of any incidence of shadow flicker, at any location, on any day or all days of the year when it might occur. Where a shadow flicker impact is predicted to occur, the total maximum daily and annual durations can be predicted, along with the total number of days. Any incidence of predicted shadow flicker can be attributed to a particular turbine or group of turbines to allow effective mitigation strategies to be planned and proposed if the model indicates that an exceedance of the shadow flicker guideline limit might occur, as detailed further below.

6.3.5 Shadow Flicker Assessment Criteria

6.3.5.1 Turbine Dimensions

Planning permission is being sought for a turbine size envelope with a maximum tip height of up to 170 metres. For the purposes of this assessment, a turbine with a rotor diameter of 140 metres and a hub height of 100 metres was modelled in order to complete the assessment. While these dimensions have been used for the purposes of this assessment, the actual turbine to be installed on the site will be the subject of a competitive tender process, and could include turbines of a different rotor diameter and hub height configuration (within the 170-metre tip height envelope) considered as part of this assessment.

Regardless of the make or model of the turbine eventually selected for installation on site, it will have a maximum tip height of up to 170 metres and the potential shadow flicker impact it will give rise to will be no more than the residual amount set out in this assessment. With the benefit of the mitigation

measures outlined in this section, any turbine to be installed onsite will be able to comply with the DoEHLG 2006 guidelines thresholds of 30 minutes per day or 30 hours per year, or with any revised guidelines if required, through the use of turbine control software.

Any references to the turbine dimensions in this shadow flicker assessment should be considered in the context of the above, and should not be construed as pre-determining the dimensions of the wind turbine to be used on the site.

6.3.5.2 Study Area

There is a total of 100 No. properties including occupied, unoccupied/derelict, within a distance of 10 rotor diameters (assumed at 1,400 metres) from the proposed turbine locations.

The area was also the subject of a planning history search, to identify properties that may have been granted planning permission, but not yet been constructed however there are none within the study area. Of the 100 No. buildings, 96 are dwellings, 1 is Cahermurphy National School and 3 are derelict (formerly residential). The locations of the buildings are shown in Figure 6.3 below, with all buildings detailed in Table 6.1 in Section 6.3.6 below. Former residential dwellings termed as "derelict" within this assessment are defined as properties that are currently unoccupied and in an uninhabitable condition, but which may have the potential to be restored to their former use.

6.3.5.3 Assumptions and Limitations

At each property, shadow flicker calculations were carried out based on 4 no. notional windows facing north, east, south and west, labelled Windows 1, 2, 3 and 4 respectively. The degrees from north value for each window is:

- Window 1: 0 degrees from North
- Window 2: 90 degrees from North
- Window 3: 180 degrees from North
- Window 4: 270 degrees from North

Each window measures one-metre-high by one-metre-wide, and tilt angle is assumed to be zero. The centre height of each window is assumed to be two metres above ground level and no screening due to trees or other buildings or vegetation is assumed. It was not considered necessary or practical to measure the dimensions of every window on every property in the study area. While the actual size of a window will marginally influence the incidence and duration of any potential shadow flicker impact, with larger windows resulting in slightly longer shadow flicker durations, any additional incidences or durations or shadow flicker over and above those predicted in this assessment can be countered by extending the mitigation strategies outlined further below.

The use of computer models to predict the amount of shadow flicker that will occur is known to produce an over-estimate of possible impact, referred to as the 'worst-case impact', due to the following limitations:

- The sun is assumed to be shining during all daylight hours such that a noticeable shadow is cast. This will not occur in reality.
- The wind is always assumed to be within the operating range of the turbines such that the turbine rotor is turning at all times, thus enabling a periodic shadow flicker. Wind turbines only begin operating at a specific 'cut-in speed', and cease operating at a specific 'cut-out speed'. In periods where the wind is blowing at medium to high speeds, the probability of there being clear or partially clear skies where the sun is shining and could cast a shadow, is low.

Map Legend

- EIAR Study Boundary
- Proposed Turbine Location
- Shadow Flicker Study Area - 1,400m (10 x 140m Rotor Diameter) Distance from Turbines
- Dwelling Location

Creevagh Lough
Treanmanagh
Garrownagry
Cragbeg Br
Doolough Br
Sch
Illaunfreega Br
Drummin Br
Cillín
Boleybeg Lough
Drummin
Burial Ground
Knocknahila
Knocknadrummin
Lough Nacrag
Cragnashingaun
Cloghaun
Caheraghacullin
Gortaheera
Cahermurphy
Cahermurphy Hill
Creegh North Br
Cloonwhite North
Knockbrack
Clooneenagh
Clooneenagh Cross
Graveyard
Castlepark
Cairn
Holy Well
Kiltumper
Mound
Cloonwhite South
Caher Lo
un East

05 06 07 08 09 10 11 12 71 70 69 68 67

MAP TITLE: **Shadow Flicker Study Area**		MAP NO.: **Figure 6.3**	SCALE: **1:20,000**
PROJECT TITLE: **Cahermurphy Two Wind Farm**			DATE: **13-07-2020**
DRAWING BY: **Eoin O'Sullivan**	CHECKED BY: **Michael Watson**		ISSUE NO.: **170238-2020.07.13-D4**

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- The wind turbines are assumed to be available to operate, i.e. turned on at all times. In reality, turbines may be switched off during maintenance or for other technical or environmental reasons.
- The turbine rotor is considered (as a sphere) to present its maximum aspect to observers in all directions. In reality, the wind direction and relative position of the turbine rotor would result in a changing aspect being presented by the turbine. The rotor will actually present as ellipses of varying sizes to observers from different directions. The time taken for the sun to pass across the sky behind a highly elliptical rotor aspect will be shorter than the modelled maximum aspect.

The total annual shadow flicker calculated for each property assumes 100% sunshine during daytime hours, as referred to above. However, weather data for this region shows that the sun shines on average for 28.3% of the daylight hours per year. This percentage is based on Met Eireann data recorded at Shannon Airport over the 30-year period from 1981 to 2010 (www.met.ie). The actual sunshine hours at the proposed development site and therefore the percentage of time shadow flicker could actually occur is 28.3% of daylight hours. Table 6.1 below therefore lists the annual shadow flicker calculated for each property when the regional average of 28.3% sunshine is taken into account, to give a more accurate annual average shadow flicker prediction.

6.3.6 Shadow Flicker Assessment Results

6.3.6.1 Daily and Annual Shadow Flicker

The WindFarm computer software was used to model the predicted daily and annual shadow flicker levels in significant detail, identifying the predicted daily start and end times, maximum daily duration and the individual turbines predicted to give rise to shadow flicker.

The model results assume worst-case conditions, including

- 100% sunshine during all daylight hours throughout the year,
- An absence of any screening (vegetation or other buildings),
- That the sun is behind the turbine blades,
- That the turbine blades are facing the property, and
- That the turbine blades are moving.

The maximum daily shadow flicker model is based on the assumption that daylight hours consist of 100% sunshine. This is a conservative assumption which represents a worst-case scenario. Following the detail provided above on sunshine hours, a sunshine factor of 28.3% has been applied.

The predicted maximum daily and annual shadow flicker levels are then considered in the context of the DoEHLG's guideline daily threshold of 30 minutes per day and annual threshold of 30 hours per year. If there is a predicted exceedance of the threshold limits at any property, the turbines that contribute to the exceedance are also identified.

The DoEHLG Wind Energy Guidelines recommend that shadow flicker at dwellings within 500 metres of a proposed turbine location should not exceed a total of 30 minutes per day or 30 hours per year. As detailed in Section 6.1 there are no residential properties within 700 metres of the proposed turbine locations. However, for the purposes of this assessment, the guideline threshold has been applied to all properties within 1,400 metres of the proposed turbine locations.

Note a total of 100 No. buildings have been modelled as part of the shadow flicker assessment, the results of which are presented in Table 6.1. Former residential dwellings termed as "derelict" within this assessment are defined as properties that are currently unoccupied and in an uninhabitable condition, but which may have the potential to be restored to their former use.

Table 6-1 Maximum Potential Daily and Annual Shadow Flicker

Building No.	ITM Coordinates (Easting)	ITM Coordinates (Northing)	Distance to Nearest Turbine (metres)	Nearest Turbine	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Turbine(s) Giving Rise to Shadow Flicker Exceedance	Mitigation Strategy Required (for Potential Day Exceedance)?
1	509369	670139	700	6	01:13:48	113:36:00	32:08:56	3, 5, 6	Yes
2	509257	670291	767	6	01:04:48	103:42:00	29:20:50	3, 5, 6	Yes
3	509182	670334	774	3	01:09:00	109:42:00	31:02:42	2, 3, 5, 6	Yes
4	509020	670420	705	3	01:18:00	109:06:00	30:52:31	2, 3, 5, 6	Yes
5	509006	670480	741	3	01:06:00	83:48:00	23:42:55	2, 3, 5	Yes
6	509155	670491	851	3	00:55:48	71:18:00	20:10:40	3, 5, 6	Yes
7 (derelict)	508942	670546	756	3	01:02:24	69:24:00	19:38:25	2, 3	Yes
8	508817	671291	1408	3	00:00:00	00:00:00	0:00:00	-	No
9	508009	671016	1221	3	00:00:00	00:00:00	0:00:00	-	No
10	508188	670827	978	3	00:12:36	02:36:00	0:44:09	3	No
11	508432	671019	1112	3	00:00:00	00:00:00	0:00:00	-	No
12	509842	667929	1027	10	00:32:24	22:18:00	6:18:39	10	Yes

Building No.	ITM Coordinates (Easting)	ITM Coordinates (Northing)	Distance to Nearest Turbine (metres)	Nearest Turbine	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Turbine(s) Giving Rise to Shadow Flicker Exceedance	Mitigation Strategy Required (for Potential Day Exceedance)?
13	510010	667945	1158	10	00:31:48	38:30:00	10:53:44	10	Yes
14 (derelict)	509849	667870	1069	10	00:21:36	08:54:00	2:31:07	10	No
15	509678	667839	964	10	00:00:00	00:00:00	0:00:00	-	No
16	509394	667682	936	10	00:27:36	11:36:00	3:16:58	9	No
17	509471	667575	1066	10	00:19:48	08:54:00	2:31:07	9	No
18	509382	667626	983	10	00:24:00	11:54:00	3:22:04	9	No
19	509244	667569	996	10	00:00:00	00:00:00	0:00:00	-	No
20	509338	667431	1154	10	00:00:00	00:00:00	0:00:00	-	No
21	509639	667356	1337	10	00:00:00	00:00:00	0:00:00	-	No
22	508905	667729	747	9	00:37:48	24:36:00	6:57:42	9	Yes
23	507564	668323	746	7	00:47:24	80:12:00	22:41:48	7, 9	Yes
24	507943	670573	802	2	00:48:36	56:48:00	16:04:28	3, 6	Yes
25	508042	670523	758	2	00:56:24	72:36:00	20:32:45	3, 6	Yes

Building No.	ITM Coordinates (Easting)	ITM Coordinates (Northing)	Distance to Nearest Turbine (metres)	Nearest Turbine	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Turbine(s) Giving Rise to Shadow Flicker Exceedance	Mitigation Strategy Required (for Potential Day Exceedance)?
26	508016	670483	715	2	00:53:24	74:48:00	21:10:06	2, 3, 6	Yes
27	507960	670563	792	2	00:50:24	59:00:00	16:41:49	3, 6	Yes
28	508100	670495	725	3	01:21:36	95:54:00	27:08:23	1, 2, 3, 6	Yes
29	509696	668726	707	10	00:47:24	95:54:00	27:08:23	8, 10	Yes
30	509765	668730	775	10	00:43:12	74:06:00	20:58:13	8, 10	Yes
31	509804	668771	824	10	00:41:24	63:54:00	18:05:01	8, 10	Yes
32	509838	668861	848	8	00:40:12	71:54:00	20:20:52	6, 8, 10	Yes
33	509905	668819	921	8	00:37:12	65:48:00	18:37:17	6, 8, 10	Yes
34	509961	668863	968	8	00:35:24	71:42:00	20:17:28	6, 8, 10	Yes
35	510057	668847	1066	8	00:32:24	66:48:00	18:54:16	6, 8, 10	Yes
36	509579	667556	1133	10	00:00:00	00:00:00	0:00:00	-	No
37	508526	667475	742	9	00:00:00	00:00:00	0:00:00	-	No
38	508379	667449	739	9	00:00:00	00:00:00	0:00:00	-	No

Building No.	ITM Coordinates (Easting)	ITM Coordinates (Northing)	Distance to Nearest Turbine (metres)	Nearest Turbine	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Turbine(s) Giving Rise to Shadow Flicker Exceedance	Mitigation Strategy Required (for Potential Day Exceedance)?
39	508559	667510	719	9	00:00:00	00:00:00	0:00:00	-	No
40	508702	667461	822	9	00:00:00	00:00:00	0:00:00	-	No
41	508973	667089	1279	9	00:00:00	00:00:00	0:00:00	-	No
42	509002	667115	1273	9	00:00:00	00:00:00	0:00:00	-	No
43	508298	667456	729	9	00:00:00	00:00:00	0:00:00	-	No
44	508275	667450	736	9	00:00:00	00:00:00	0:00:00	-	No
45	508204	667432	762	9	00:00:00	00:00:00	0:00:00	-	No
46	508117	667436	775	9	00:00:00	00:00:00	0:00:00	-	No
47	508162	667237	960	9	00:00:00	00:00:00	0:00:00	-	No
48	507578	667354	1108	9	00:00:00	00:00:00	0:00:00	-	No
49	507616	667411	1040	9	00:00:00	00:00:00	0:00:00	-	No
50	507712	667416	975	9	00:00:00	00:00:00	0:00:00	-	No
51	507762	667420	942	9	00:00:00	00:00:00	0:00:00	-	No

Building No.	ITM Coordinates (Easting)	ITM Coordinates (Northing)	Distance to Nearest Turbine (metres)	Nearest Turbine	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Turbine(s) Giving Rise to Shadow Flicker Exceedance	Mitigation Strategy Required (for Potential Day Exceedance)?
52	507871	667414	888	9	00:00:00	00:00:00	0:00:00	-	No
53	507178	667859	1177	9	00:30:36	19:18:00	5:27:43	9	Yes
54	507181	667828	1182	9	00:30:36	20:00:00	5:39:36	9	Yes
55	507174	668003	1150	9	00:30:36	35:54:00	10:09:35	7, 9	Yes
56	507168	668123	1112	4	00:31:48	51:54:00	14:41:16	7, 9	Yes
57	507532	668235	779	9	00:43:12	53:06:00	15:01:38	7, 9	Yes
58 (derelict)	506984	668590	881	1	00:40:12	67:30:00	19:06:09	4, 7, 9	Yes
59	506900	668687	842	1	00:37:48	56:36:00	16:01:04	4, 7	Yes
60	506930	668696	817	1	00:39:00	63:24:00	17:56:32	4, 7	Yes
61	506920	668708	813	1	00:38:24	56:06:00	15:52:35	4, 7	Yes
62	506903	668759	782	1	00:37:48	46:12:00	13:04:29	4, 7	Yes
63	506827	668845	769	1	00:35:24	24:54:00	7:02:48	4	Yes
64	506824	668794	807	1	00:35:24	36:36:00	10:21:28	4, 7	Yes

Building No.	ITM Coordinates (Easting)	ITM Coordinates (Northing)	Distance to Nearest Turbine (metres)	Nearest Turbine	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Turbine(s) Giving Rise to Shadow Flicker Exceedance	Mitigation Strategy Required (for Potential Day Exceedance)?
65 (school)	506168	668768	1356	1	00:27:36	30:06:00	8:31:06	1	No
66	506141	668759	1384	1	00:27:00	27:48:00	7:52:03	1	No
67	506204	668729	1343	1	00:28:12	31:54:00	9:01:40	1	No
68	506181	668729	1363	1	00:27:36	31:36:00	8:56:34	1	No
69	506235	668785	1289	1	00:28:48	34:06:00	9:39:01	1	No
70	506450	668783	1105	1	00:32:24	37:18:00	10:33:21	1, 4	Yes
71	506153	669205	1239	1	00:28:12	14:42:00	4:09:36	1	No
72	506302	669182	1096	1	00:31:48	19:24:00	5:29:25	1	Yes
73	506337	669172	1063	1	00:33:00	21:00:00	5:56:35	1	Yes
74	506376	669192	1022	1	00:34:12	22:24:00	6:20:21	1	Yes
75	506751	669073	700	1	01:07:12	107:42:00	30:28:45	1, 2, 4	Yes
76	506713	669161	703	1	01:16:12	114:06:00	32:17:25	1, 2, 4	Yes
77	506682	669253	711	1	01:09:00	81:00:00	22:55:23	1, 2, 4	Yes

Building No.	ITM Coordinates (Easting)	ITM Coordinates (Northing)	Distance to Nearest Turbine (metres)	Nearest Turbine	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Turbine(s) Giving Rise to Shadow Flicker Exceedance	Mitigation Strategy Required (for Potential Day Exceedance)?
78	506534	669661	894	1	00:37:48	24:12:00	6:50:55	1	Yes
79	506490	669691	944	1	00:36:00	22:00:00	6:13:34	1	Yes
80	506478	669736	972	1	00:35:24	21:12:00	5:59:59	1	Yes
81	506473	669790	998	1	00:34:48	20:36:00	5:49:47	1	Yes
82	506475	669872	1033	1	00:33:36	20:24:00	5:46:24	1	Yes
83	506260	669699	1166	1	00:30:00	14:48:00	4:11:18	1	No
84	507292	670370	882	2	00:40:12	52:30:00	14:51:27	2, 3, 5	Yes
85	508206	670885	1026	3	00:00:00	00:00:00	0:00:00	-	No
86	506720	669853	815	1	00:42:00	52:00:00	14:42:58	1, 2, 4	Yes
87	507340	670366	845	2	00:42:00	57:36:00	16:18:03	2, 3, 5	Yes
88	508025	670503	736	2	00:54:00	72:36:00	20:32:45	2, 3, 6	Yes
89	509263	670401	870	6	00:58:48	83:12:00	23:32:44	3, 5, 6	Yes
90	509133	670426	791	3	01:05:24	93:30:00	26:27:38	2, 3, 5, 6	Yes

Building No.	ITM Coordinates (Easting)	ITM Coordinates (Northing)	Distance to Nearest Turbine (metres)	Nearest Turbine	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Turbine(s) Giving Rise to Shadow Flicker Exceedance	Mitigation Strategy Required (for Potential Day Exceedance)?
91	508416	667476	717	9	00:00:00	00:00:00	0:00:00	-	No
92	509346	667917	705	10	00:33:00	48:36:00	13:45:14	7, 9	Yes
93	508930	671251	1398	3	00:00:00	00:00:00	0:00:00	-	No
94	507208	667332	1393	9	00:10:12	02:06:00	0:35:39	9	No
95	507331	667337	1294	9	00:00:00	00:00:00	0:00:00	-	No
96	507423	667356	1214	9	00:00:00	00:00:00	0:00:00	-	No
97	507452	667358	1191	9	00:00:00	00:00:00	0:00:00	-	No
98	507502	667354	1159	9	00:00:00	00:00:00	0:00:00	-	No
99	507548	667189	1254	9	00:00:00	00:00:00	0:00:00	-	No
100	508816	666916	1365	9	00:00:00	00:00:00	0:00:00	-	No

6.3.6.1.1 *Proposed Cahermurphy Two Wind Farm*

Of the 100 No. properties modelled, it is predicted that 54 No. properties may experience daily shadow flicker in excess of the DoEHLG guideline threshold of 30 minutes per day. This prediction is assuming worst-case conditions (i.e. 100% sunshine on all days where the shadow of the turbines passes over a house, wind blowing in the correct direction, no screening present, etc.) and in the absence of any turbine control measures. Of these 54 No. properties:

- 52 No. properties are occupied/vacant dwellings; and
- 2 No. properties are derelict dwellings

Of the 100 No. residential properties modelled, when the regional sunshine average (i.e. the mean amount of sunshine hours throughout the year) of 28.3%, the DoEHLG total annual guideline limit of 30 hours is predicted as being exceeded at five of the modelled properties.

It is worth nothing that in reality, the 'estimated actual' shadow flicker is considered conservative and likely to be significantly less than predicted in Table 6-1 as the following items are not considered by the model:

- Receivers may be screened by cloud cover and/or vegetation/built form i.e. adjacent buildings, farm buildings, garages or barns;
- Each receiver will not have windows facing in all directions onto the wind farm;
- At distances, greater than 500-1000m '*the rotor blade of a wind turbine will not appear to be chopping the light but the turbine will be regarded as an object with the sun behind it. Therefore, it is generally not necessary to consider shadow casting at such distances*'.

Section 6.4.3.1 outlines the mitigation strategies which will be employed at the potentially affected properties to ensure the daily shadow flicker threshold will not be exceeded.

6.3.6.2 Cumulative Shadow Flicker

For the assessment of cumulative shadow flicker, any other existing, permitted or proposed wind farms are considered where they are located within ten rotor diameters of the proposed turbines. In this case, a cumulative shadow flicker assessment was carried out to include both the permitted Cahermurphy Wind Farm (comprising 4 wind turbines 3 of which are constructed) and the proposed Cahermurphy Two Wind Farm. There were no other existing, permitted or proposed wind farms that were applicable. The permitted Cahermurphy Wind is located directly to the east of the proposed development (see Section 2.5 of Chapter 2 of this EIAR for further details).

Table 6-2 Maximum Potential Cumulative Daily and Annual Shadow Flicker

Building No.	ITM Coordinates (Easting)	ITM Coordinates (Northing)	Distance to Nearest Turbine (metres)	Nearest Turbine	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Turbine(s) Giving Rise to Shadow Flicker Exceedance	Mitigation Strategy Required (for Potential Day Exceedance)?
1	509369	670139	670	11[1]	01:55:48	182:42:00	51:42:15	3, 5, 6, 12, 13, 14	Yes
2	509257	670291	767	6	01:04:48	103:42:00	29:20:50	3, 5, 6	Yes
3	509182	670334	774	3	01:09:00	109:42:00	31:02:42	2, 3, 5, 6	Yes
4	509020	670420	705	3	01:18:00	109:06:00	30:52:31	2, 3, 5, 6	Yes
5	509006	670480	741	3	01:06:00	83:48:00	23:42:55	2, 3, 5	Yes
6	509155	670491	851	3	00:55:48	71:18:00	20:10:40	3, 5, 6	Yes
7 (derelict)	508942	670546	756	3	01:02:24	69:24:00	19:38:25	2, 3	Yes
8	508817	671291	1408	3	00:00:00	00:00:00	00:00:00	-	No
9	508009	671016	1221	3	00:00:00	00:00:00	00:00:00	-	No
10	508188	670827	978	3	00:12:36	02:36:00	00:44:09	3	No
11	508432	671019	1112	3	00:00:00	00:00:00	00:00:00	-	No
12	509842	667929	1027	10	00:32:24	22:18:00	06:18:39	10	Yes

Building No.	ITM Coordinates (Easting)	ITM Coordinates (Northing)	Distance to Nearest Turbine (metres)	Nearest Turbine	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Turbine(s) Giving Rise to Shadow Flicker Exceedance	Mitigation Strategy Required (for Potential Day Exceedance)?
13	510010	667945	1158	10	00:31:48	38:30:00	10:53:44	10	Yes
14 (derelict)	509849	667870	1069	10	00:21:36	08:54:00	02:31:07	10	No
15	509678	667839	964	10	00:00:00	00:00:00	00:00:00	-	No
16	509394	667682	936	10	00:27:36	11:36:00	03:16:58	9	No
17	509471	667575	1066	10	00:19:48	08:54:00	02:31:07	9	No
18	509382	667626	983	10	00:24:00	11:54:00	03:22:04	9	No
19	509244	667569	996	10	00:00:00	00:00:00	00:00:00	-	No
20	509338	667431	1154	10	00:00:00	00:00:00	00:00:00	-	No
21	509639	667356	1337	10	00:00:00	00:00:00	00:00:00	-	No
22	508905	667729	747	9	00:37:48	24:36:00	06:57:42	9	Yes
23	507564	668323	746	7	00:47:24	80:12:00	22:41:48	7, 9	Yes
24	507943	670573	802	2	00:48:36	56:48:00	16:04:28	3, 6	Yes
25	508042	670523	758	2	00:56:24	72:36:00	20:32:45	3, 6	Yes

Building No.	ITM Coordinates (Easting)	ITM Coordinates (Northing)	Distance to Nearest Turbine (metres)	Nearest Turbine	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Turbine(s) Giving Rise to Shadow Flicker Exceedance	Mitigation Strategy Required (for Potential Day Exceedance)?
26	508016	670483	715	2	00:53:24	74:48:00	21:10:06	2, 3, 6	Yes
27	507960	670563	792	2	00:50:24	59:00:00	16:41:49	3, 6	Yes
28	508100	670495	725	3	01:21:36	95:54:00	27:08:23	1, 2, 3, 6	Yes
29	509696	668726	707	10	00:47:24	95:54:00	27:08:23	8, 10	Yes
30	509765	668730	775	10	00:43:12	74:06:00	20:58:13	8, 10	Yes
31	509804	668771	660	14[1]	00:41:24	63:54:00	18:05:01	8, 10	Yes
32	509838	668861	560	14[1]	00:40:12	71:54:00	20:20:52	6, 8, 10	Yes
33	509905	668819	570	14[1]	00:37:12	65:48:00	18:37:17	6, 8, 10	Yes
34	509961	668863	510	14[1]	00:35:24	71:42:00	20:17:28	6, 8, 10	Yes
35	510057	668847	490	14[1]	00:32:24	66:48:00	18:54:16	6, 8, 10	Yes
36	509579	667556	1133	10	00:00:00	00:00:00	00:00:00	-	No
37	508526	667475	742	9	00:00:00	00:00:00	00:00:00	-	No
38	508379	667449	739	9	00:00:00	00:00:00	00:00:00	-	No

Building No.	ITM Coordinates (Easting)	ITM Coordinates (Northing)	Distance to Nearest Turbine (metres)	Nearest Turbine	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Turbine(s) Giving Rise to Shadow Flicker Exceedance	Mitigation Strategy Required (for Potential Day Exceedance)?
39	508559	667510	719	9	00:00:00	00:00:00	00:00:00	-	No
40	508702	667461	822	9	00:00:00	00:00:00	00:00:00	-	No
41	508973	667089	1279	9	00:00:00	00:00:00	00:00:00	-	No
42	509002	667115	1273	9	00:00:00	00:00:00	00:00:00	-	No
43	508298	667456	729	9	00:00:00	00:00:00	00:00:00	-	No
44	508275	667450	736	9	00:00:00	00:00:00	00:00:00	-	No
45	508204	667432	762	9	00:00:00	00:00:00	00:00:00	-	No
46	508117	667436	775	9	00:00:00	00:00:00	00:00:00	-	No
47	508162	667237	960	9	00:00:00	00:00:00	00:00:00	-	No
48	507578	667354	1108	9	00:00:00	00:00:00	00:00:00	-	No
49	507616	667411	1040	9	00:00:00	00:00:00	00:00:00	-	No
50	507712	667416	975	9	00:00:00	00:00:00	00:00:00	-	No
51	507762	667420	942	9	00:00:00	00:00:00	00:00:00	-	No

Building No.	ITM Coordinates (Easting)	ITM Coordinates (Northing)	Distance to Nearest Turbine (metres)	Nearest Turbine	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Turbine(s) Giving Rise to Shadow Flicker Exceedance	Mitigation Strategy Required (for Potential Day Exceedance)?
52	507871	667414	888	9	00:00:00	00:00:00	00:00:00	-	No
53	507178	667859	1177	9	00:30:36	19:18:00	05:27:43	9	Yes
54	507181	667828	1182	9	00:30:36	20:00:00	05:39:36	9	Yes
55	507174	668003	1150	9	00:30:36	35:54:00	10:09:35	7, 9	Yes
56	507168	668123	1112	4	00:31:48	51:54:00	14:41:16	7, 9	Yes
57	507532	668235	779	9	00:43:12	53:06:00	15:01:38	7, 9	Yes
58 (derelict)	506984	668590	881	1	00:40:12	67:30:00	19:06:09	4, 7, 9	Yes
59	506900	668687	842	1	00:37:48	56:36:00	16:01:04	4, 7	Yes
60	506930	668696	817	1	00:39:00	63:24:00	17:56:32	4, 7	Yes
61	506920	668708	813	1	00:38:24	56:06:00	15:52:35	4, 7	Yes
62	506903	668759	782	1	00:37:48	46:12:00	13:04:29	4, 7	Yes
63	506827	668845	769	1	00:35:24	24:54:00	07:02:48	4	Yes
64	506824	668794	807	1	00:35:24	36:36:00	10:21:28	4, 7	Yes

Building No.	ITM Coordinates (Easting)	ITM Coordinates (Northing)	Distance to Nearest Turbine (metres)	Nearest Turbine	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Turbine(s) Giving Rise to Shadow Flicker Exceedance	Mitigation Strategy Required (for Potential Day Exceedance)?
65 (school)	506168	668768	1356	1	00:27:36	30:06:00	08:31:06	1	No
66	506141	668759	1384	1	00:27:00	27:48:00	07:52:03	1	No
67	506204	668729	1343	1	00:28:12	31:54:00	09:01:40	1	No
68	506181	668729	1363	1	00:27:36	31:36:00	08:56:34	1	No
69	506235	668785	1289	1	00:28:48	34:06:00	09:39:01	1	No
70	506450	668783	1105	1	00:32:24	37:18:00	10:33:21	1, 4	Yes
71	506153	669205	1239	1	00:28:12	14:42:00	04:09:36	1	No
72	506302	669182	1096	1	00:31:48	19:24:00	05:29:25	1	Yes
73	506337	669172	1063	1	00:33:00	21:00:00	05:56:35	1	Yes
74	506376	669192	1022	1	00:34:12	22:24:00	06:20:21	1	Yes
75	506751	669073	700	1	01:07:12	107:42:00	30:28:45	1, 2, 4	Yes
76	506713	669161	703	1	01:16:12	114:06:00	32:17:25	1, 2, 4	Yes
77	506682	669253	711	1	01:09:00	81:00:00	22:55:23	1, 2, 4	Yes

Building No.	ITM Coordinates (Easting)	ITM Coordinates (Northing)	Distance to Nearest Turbine (metres)	Nearest Turbine	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Turbine(s) Giving Rise to Shadow Flicker Exceedance	Mitigation Strategy Required (for Potential Day Exceedance)?
78	506534	669661	894	1	00:37:48	24:12:00	06:50:55	1	Yes
79	506490	669691	944	1	00:36:00	22:00:00	06:13:34	1	Yes
80	506478	669736	972	1	00:35:24	21:12:00	05:59:59	1	Yes
81	506473	669790	998	1	00:34:48	20:36:00	05:49:47	1	Yes
82	506475	669872	1033	1	00:33:36	20:24:00	05:46:24	1	Yes
83	506260	669699	1166	1	00:30:00	14:48:00	04:11:18	1	No
84	507292	670370	882	2	00:40:12	52:30:00	14:51:27	2, 3, 5	Yes
85	508206	670885	1026	3	00:00:00	00:00:00	00:00:00	-	No
86	506720	669853	815	1	00:42:00	52:00:00	14:42:58	1, 2, 4	Yes
87	507340	670366	845	2	00:42:00	57:36:00	16:18:03	2, 3, 5	Yes
88	508025	670503	736	2	00:54:00	72:36:00	20:32:45	2, 3, 6	Yes
89	509263	670401	870	6	00:58:48	83:12:00	23:32:44	3, 5, 6	Yes
90	509133	670426	791	3	01:05:24	93:30:00	26:27:38	2, 3, 5, 6	Yes

Building No.	ITM Coordinates (Easting)	ITM Coordinates (Northing)	Distance to Nearest Turbine (metres)	Nearest Turbine	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Turbine(s) Giving Rise to Shadow Flicker Exceedance	Mitigation Strategy Required (for Potential Day Exceedance)?
91	508416	667476	717	9	00:00:00	00:00:00	00:00:00	-	No
92	509346	667917	705	10	00:33:00	48:36:00	13:45:14	7, 9	Yes
93	508930	671251	1398	3	00:00:00	00:00:00	00:00:00	-	No
94	507208	667332	1393	9	00:10:12	02:06:00	00:35:39	9	No
95	507331	667337	1294	9	00:00:00	00:00:00	00:00:00	-	No
96	507423	667356	1214	9	00:00:00	00:00:00	00:00:00	-	No
97	507452	667358	1191	9	00:00:00	00:00:00	00:00:00	-	No
98	507502	667354	1159	9	00:00:00	00:00:00	00:00:00	-	No
99	507548	667189	1254	9	00:00:00	00:00:00	00:00:00	-	No
100	508816	666916	1365	9	00:00:00	00:00:00	00:00:00	-	No

Notes
1. Turbine located at the permitted Cahermurphy Wind Farm site.

The cumulative model results (see Table 6-2) show that there are no additional properties where the guideline limits are exceeded due to cumulative shadow flicker from the proposed Cahermurphy Wind Farm Two in conjunction with the permitted Cahermurphy Wind Farm. However building no. 1 experiences an increase in potential shadow flicker due to the presence of both the permitted Cahermurphy Wind Farm and the proposed Cahermurphy Two Wind Farm. Section 6.4.3.1 outlines the mitigation strategies which will be employed at the potentially affected properties to ensure the daily shadow flicker threshold will not be exceeded for the houses in question.

6.4 Likely Significant Impacts and Associated Mitigation Measures

6.4.1 'Do-Nothing' Scenario

If the proposed development were not to proceed there would be no shadow flicker impacts other than the existing Cahermurphy Wind Farm project.

6.4.2 Construction Phase

6.4.2.1 Shadow Flicker

Shadow flicker, which occurs during certain conditions due to the movement of wind turbine blades, as described in this chapter of the EIAR, occurs only during the operational phase of a wind energy development. There are therefore no shadow flicker impacts associated with the construction phase of the proposed development.

6.4.3 Operational Phase

The effects set out below relate to the operational phase of the proposed wind farm.

6.4.3.1 Shadow Flicker

Pre-Mitigation Impacts

Assuming worst-case conditions, a total of 54 residential properties may experience daily shadow flicker in excess of the current DoEHLG guideline threshold of 30 minutes per day. The DoEHLG total annual guideline limit of 30 hours is predicted to be exceeded at 5 of the residential properties when the regional sunshine average of 28.3% is taken into account. Also, as described in detail above, there are a number of other additional reasons why this exceedance may not occur.

Proposed Mitigation Measures

In the event that shadow flicker exceedances are predicted to occur at buildings, a site visit will be undertaken firstly to determine the level of occurrence, existing screening and window orientation. The shadow flicker prediction data will be used to select dates on which a shadow flicker event could be observed at one or multiple affected properties and the following process will be adhered to.

1. *Recording the weather conditions at the time of the site visit, including wind speeds and direction (i.e. blue sky, intermittent clouds, overcast, moderate breeze, light breeze, still etc.).*

2. *Recording the house number, time and duration of site visit and the observation point GPS coordinates.*
3. *Recording the nature of the sensitive receptor, its orientation, windows, landscaping in the vicinity, any elements of the built environment in the vicinity, vegetation.*
4. *In the event of shadow flicker being noted as occurring the details of the duration (times) of the occurrence will be recorded.*

Screening Measures

In the event of an occurrence of shadow flicker exceeding guideline threshold values of 30 hours per annum or 30 minutes per day at residential receptor locations post operation, mitigation options will be discussed with the affected homeowner, including:

- Installation of appropriate window blinds in the affected rooms of the residence;
- Planting of screening vegetation;
- Other site-specific measures which might be agreeable to the affected party and may lead to the desired mitigation.

If agreement can be reached with the home owner then it would be arranged for the required mitigation to be implemented in cooperation with the affected party as soon as practically possible and for the full costs to be borne by the wind farm operator.

Wind Turbine Control Measures

If it is not possible to mitigate any identified shadow flicker limit exceedance locally using the measures detailed above, wind turbine control measures will be implemented.

Wind turbines will be fitted with shadow flicker control units to allow the turbines to be controlled to prevent the occurrence of shadow flicker at properties surrounding the wind farm. The shadow flicker control units will be added to any required turbines and are not cost prohibitive.

A shadow flicker control unit allows a wind farm's turbines to be programmed and controlled using the wind farm's SCADA control system to change a particular turbine's operating mode during certain conditions or times, or even turn the turbine off if necessary.

The model will be re-run at the time of construction. Where exceedances are shown to occur at house locations in the vincity of the proposed wind farm, the windfarms SCADA system will be programmed to ensure limits are not exceeded.

All predicted incidents of shadow flicker can be pre-programmed into the wind farm's control software. The wind farm's SCADA control system can be programmed to shut down any particular turbine at any particular time on any given day to ensure that shadow flickers occurrences at properties which are not naturally screened or cannot be screened with measures outlined above. Where such wind turbine control measures are to be utilised, they need only be implemented when the specific combined circumstances occur that are necessary to give rise to the shadow flicker effect in the first instance. Therefore, if the sun is not shining on a particular day that shadow flicker was predicted to occur at a nearby property, there would be no need to shut down the relevant turbines that would have given rise to the shadow flicker at the property. Similarly, if the wind speed was below the cut-in speed that caused the turbine rotor to rotate and give rise to a shadow flicker effect at a nearby property, there would be no need to shut down the relevant turbines that otherwise would have caused shadow flicker.

The atmospheric variables that determine whether shadow flicker will occur or not, are continuously monitored at the wind farm site and the data fed into the wind farm's SCADA control system. The strength of direct sunlight is measured by way of photocells, and if the sunlight is of sufficient strength to cast a shadow, the shadow flicker control mechanisms come into effect. Wind speed and direction are measured by anemometers and wind vanes on each turbine and on the wind farm's met mast, and

similarly, and if wind speed and direction is such that a shadow will be cast, the shadow flicker control mechanisms come into effect. The moving blades of the turbine will require a short period of time to cease rotating and as such there may be a very short period (less than 3 to 5 minutes) during which the blades are slowed to a complete halt. The turbines giving rise to shadow flicker may be turned off on different days to prevent excessive wear and tear on any single turbine. This method of shadow flicker mitigation has been technically well-proven at wind farms in areas outside Ireland that experience significantly longer periods of direct sunlight.

This measure can be utilised at the site of the proposed development to prevent incidences of shadow flicker values at any house. Therefore, the proposed wind farm are anticipated to be capable of adhering to the requirements of the Draft Revised Wind Energy Development Guidelines 2019 should they be adopted during the planning application process for this development.

Should a complaint be received within 12 months of commissioning of the wind farm, field investigation/monitoring will be carried out by the wind farm operator at the affected property. With the permission of the homeowner, the wind farm developer will log the date, time and duration of shadow flicker events occurring on at least five different days from within the dwelling. The provided log will be compared with the predicted occurrence of shadow flicker at the residence, and if necessary, a field investigation will be carried out.

Residual Impact

Shadow flicker could potentially have a long-term slight negative impact. However, as the applicant has committed to a curtailment strategy for all turbines that have the potential to cause an exceedance in the existing daily and annual shadow flicker limits at residential properties up to a distance of 10 rotor diameters from the proposed development, there will be an imperceptible impact from shadow flicker on human beings.

Significance of Effects

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

6.4.4 Cumulative Effects

For the assessment of cumulative shadow flicker, any other existing, permitted or proposed wind farms are considered where they are located within ten rotor diameters of the proposed turbines. In this case, a cumulative shadow flicker assessment was carried out to include both the permitted Cahermurphy Wind Farm (comprising 4 wind turbines 3 of which are constructed) and the proposed Cahermurphy Two Wind Farm. There were no other existing, permitted or proposed wind farms that were applicable.

6.4.4.1 Shadow Flicker

As discussed in Section 6.3.6.2 above, the cumulative model results show that there are no additional properties where the guideline limits are exceeded due to cumulative shadow flicker from the proposed Cahermurphy Two Wind Farm in conjunction with the permitted Cahermurphy Wind Farm.