STATKRAFT

ENVIRONMENTAL IMPACT ASSESSMENT REPORT (EIAR) FOR THE PROPOSED DERNACART WIND FARM, COUNTY LAOIS

VOLUME 2 – MAIN EIAR

CHAPTER 7 - SHADOW FLICKER

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30 YEARS

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7 SHADOW FLICKER

7.1 Introduction

This chapter considers potential shadow flicker effects at nearby buildings associated with the operation of Dernacart Wind Farm. The specific objectives of the chapter are to:

- describe the baseline;
- describe the assessment methodology and relevant guidance;
- describe the potential impacts;
- describe the need for any mitigation measures, if required; and
- assess the residual impacts remaining, following the implementation of any mitigation measures.

This assessment has been undertaken by TNEI Services Ltd.

7.1.1 Scope of Assessment

7.1.1.1 Conditions required for Shadow Flicker

Under certain combinations of geographical position, wind direction and times of day and year, the sun may pass behind the rotors of a wind turbine and cast a shadow over the windows of nearby buildings. When the blades rotate and the shadow passes a window, to a person within that room the shadow appears to 'flick' on and off; this effect is known as 'shadow flicker'. The phenomenon occurs only within buildings where shadows are cast across a window aperture, and the effects are typically considered up to a maximum distance of 10 times the rotor diameter from each wind turbine; at greater distances the effects are generally considered to be negligible.

7.1.1.2 Study Area

A study area of 1,700 m from each of the eight wind turbines was selected for this assessment. This is based upon ten times the maximum rotor diameter (170 m) that would be used within the proposed development, in order to present a worst-case scenario and define the largest possible study area. The assessment considers all identified potential shadow flicker sensitive receptors within and on the edge of the study area. The receptor locations are detailed on Figure 7.1 and presented in tabulated format in Appendix 7.1.

7.1.1.3 Effects to be Assessed

This chapter summarises the potential shadow flicker effects at all of the identified receptors and quantifies both the maximum and likely number of hours per annum that each property may be subjected to shadow flicker effects.

7.1.1.4 Effects Scoped Out of Assessment

Where moving shadows are cast over the ground, rather than through the windows of a building, this is known as 'shadow throw'. There are no guidelines to quantify this effect and no requirement to assess 'shadow throw'. Therefore, 'shadow throw' has not been considered further in this assessment.

7.2 Methodology

It is possible to predict the total theoretical number of hours per year that shadow flicker may occur in a building from the relative position of the turbines to the building, the geometry of the wind turbines, the latitude of the wind turbine site and the size & orientation of the windows potentially affected.

These predictions can then be used to determine the times necessary to apply curtailment to each turbine in order to mitigate the effects of shadow flicker.

The potential for shadow flicker to occur and the intensity and duration of any effects depend upon the following factors:

- the location of the window relative to the turbines;
- the distance of the building from the turbines;
- the turbine geometry;
- the time of year (which impacts the sun's trajectory across the sky);
- the frequency of cloudless skies (particularly at low elevations above the horizon); and,
- the wind direction (which impacts on turbine orientation).

Several specialist software packages are available that can take account of the variables listed above to determine the maximum theoretical number of shadow flicker hours that could occur at each window under worst-case conditions. For this assessment, predictions of shadow flicker effects have been undertaken using ReSoft WindFarm software, based on the proposed turbine locations and the maximum proposed turbine dimensions.

7.2.1 Relevant Guidance

In assessing the potential shadow flicker impacts of the development, the following guidance and policy documents have been considered:

Local Planning Policy
The Laois County Development Plan (2017)[1] state the following in relation to shadow flicker resulting from wind farms:

"6.3 Shadow Flicker
An assessment of the theoretical shadow flicker shall be prepared, further assessment shall indicate the likely level of shadow flicker based on anticipated meteorological constraints. If required, mitigating measures shall be proposed."

Wind Energy Development Guidelines (2006)
Guidance provided by the Department of the Environment, Heritage and Local Government (DoEHLG) [2] states that properties that are within 10 rotor diameters of the turbines are susceptible to the effects of shadow flicker and at distances greater than 10 rotor diameters from a turbine, the potential for shadow flicker is very low.

There is no standard for the assessment of shadow flicker in Ireland, although the Wind Energy Development Guidelines (WEDG) 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. It is recommended that shadow flicker at neighbouring offices and dwellings within 500m should not exceed 30 hours per year or 30 minutes per day.*

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 WEDG are currently under review. At the time of writing, the new guidelines have not been published.

IWEA Best Practice Guidelines

In March 2012, the Irish Wind Energy Association (IWEA)[3] issued a document detailing best practice guidance for wind farms.

The document provides a preferred methodology to predict the worst-case shadow flicker conditions in order to provide the most robust results from the assessment. With regards to shadow flicker, the IWEA guidelines support those given in the WEDG, stating:

> *"The assessment of potentially sensitive locations or receptors within a distance of ten rotor diameters from proposed turbine locations will normally be suitable for EIA purposes"*

7.2.2 Field Assessment

Building location data was supplied by Fehily Timoney & Company for use in this assessment, derived from a combination of site surveys and supplementary GIS data. The dataset was refined through the use of aerial imagery to identify building type and condition (habitable, derelict etc.), orientation from north and building dimensions; the building centre-point co-ordinates were also refined where required. Any building that was clearly identifiable as uninhabited (such as a farm outbuilding) or derelict was removed, however where this was not possible to confirm, the building was considered as part of the assessment.

In total, 98 potential shadow flicker receptors were identified within 10 rotor diameters of the turbines. No receptors were identified within 500 m of the turbines.

The locations of all of the receptors identified within the study area are shown on Figure 7.1 and Appendix 7.1 contains the model input data for all of the receptors and windows.

7.2.3 Extent of Shadow Flicker Assessment

The shadow flicker model calculates the total theoretical occurrence of shadow flicker at all receptors per year based on a worst-case scenario that 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 and the turbines (except where this is prevented due to topography). In reality this will not occur and for some of the time, turbines will not be orientated as described, whilst clouds will obscure the sun and line of sight may be obscured, for example, from leaves on trees.

In order to provide a more realistic prediction of shadow flicker effects, historical weather data can be used to apply a correction factor, which considers the frequency of clear skies when shadows may be cast. Data compiled by Met Éireann from the nearest long-term weather station to Dernacart Wind Farm (Birr) has been used to determine the average sunshine hours over a 30 year period (1979 to 2008); this data is presented in Table 7-1.

Table 7-1: Average Monthly Sunshine Hours at Birr (1979-2008)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean Daily Duration[i]	1.5	2.2	2.9	4.5	5.1	4.3	3.9	4	3.5	2.9	1.9	1.4	3.2
Daylight Hours[ii]	8.2	9.8	11.9	14.0	15.8	16.8	16.3	14.6	12.6	10.5	8.6	7.6	12.2
% Sunshine	18%	22%	24%	32%	32%	26%	24%	27%	28%	28%	22%	18%	26%

i Based on meteorological data from Birr 1979-2008 (https://www.met.ie/climate-ireland/1981-2010/birr.html)
ii Based on sunrise and sunset times for Mountmellick 2020 (https://www.sunrise-and-sunset.com)

The average annual number of sunshine hours (when clear skies allow for the casting of strong shadows) is approximately 26% of the average annual daylight hours, as shown in Table 7-1 above. It can therefore be assumed that shadow flicker effects are only likely to occur for around 26% of the Total Theoretical predicted shadow flicker levels, when considering typical sunshine hours. It is worth noting that this correction does not account for additional reductions that would occur as a result of variations in wind speed, wind direction, or by determining whether there is line of sight between a turbine and receiver. The 'likely' levels of shadow flicker are, therefore, still considered to be a conservative estimate.

7.2.4 Modelling Parameters

The levels of shadow flicker at each receptor have been calculated based on a 'greenhouse' modelling approach, where the full length of each façade of a building is modelled as a window (and is therefore sensitive to shadow flicker). Each modelled window is assumed to have a height of 2 m. This approach has been taken in order to present a worst case estimate of shadow flicker, in the absence of any detailed window location data.

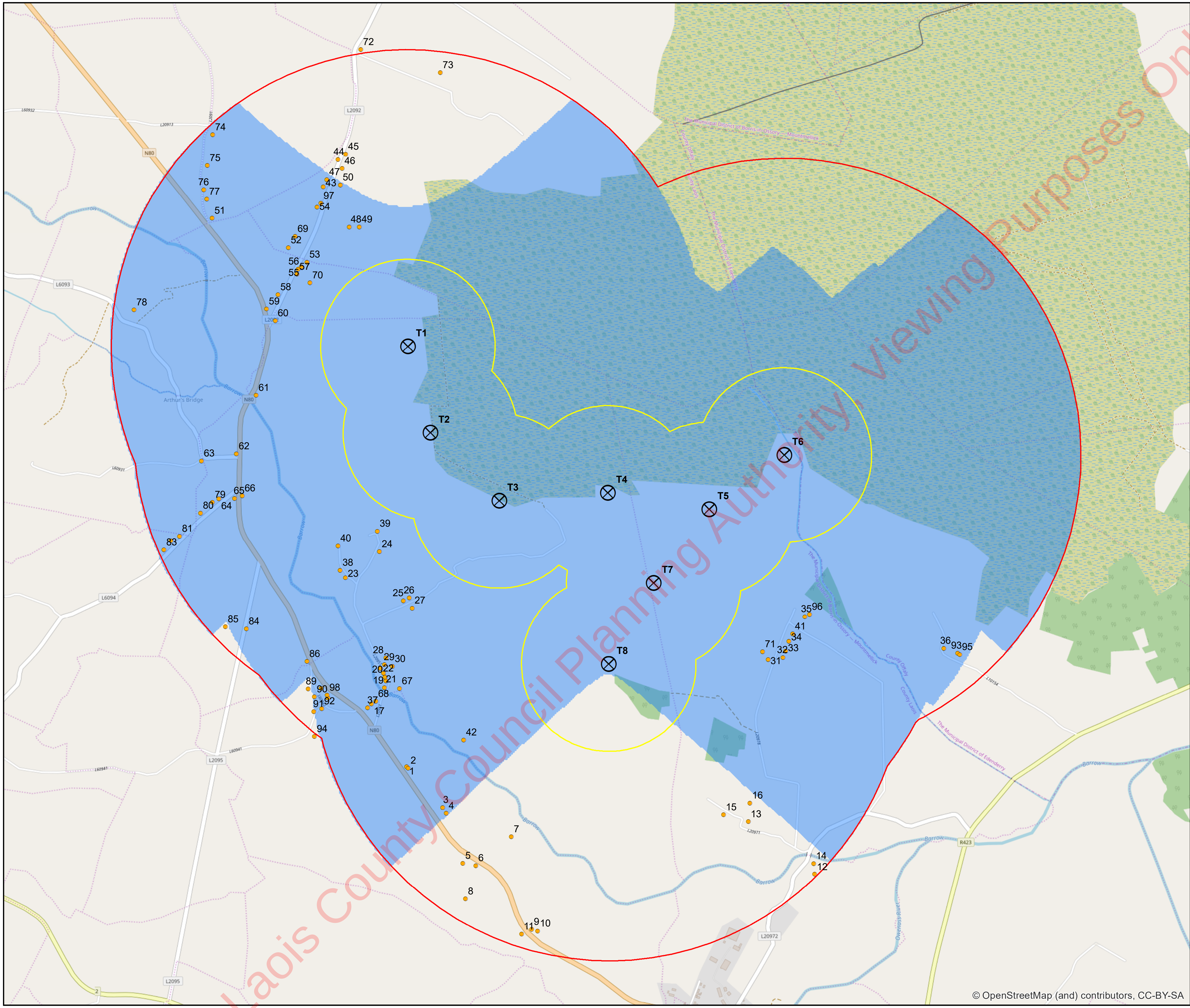
Where measurements of a building could not be taken from aerial imagery, such as in the case of a house with planning permission that has not yet been constructed, indicative measurements have been used based on the measurements of nearby receptors.

The shadow flicker model accounts for screening effects due to topography only, and does not consider buildings or vegetation, which may prevent line of sight between a receptor and the turbines.

7.3 Existing Environment

In total, 109 properties have been identified within 10 rotor diameters of the turbines, and of these 98 have been identified as either dwellings or commercial premises (or could not be ruled out as either) and are therefore considered potential shadow flicker receptors. There are no receptors within 500 m of the wind turbines.

The remaining 11 buildings have been classified as uninhabited, derelict or otherwise insensitive to shadow flicker; these have not been considered as part of the shadow flicker assessment.



Legend

- Proposed Wind Turbine
- 500m From Turbines
- Shadow Flicker Assessment Location
- 10 Rotor Diameter Study Area
- Maximum Extent of Shadow Coverage

REV.	DETAILS	DRAWN	CHK'D	APP'D	DATE
R1	SECOND ISSUE	MT	JS	JS	26/11/2019
R1	FIRST ISSUE	MT	JS	JS	25/09/2019

Project Dernacart Wind Farm

Client Fehily Timoney & Company

Title Shadow Flicker Study Area and Receptors

Figure No. 7.1

Scale 1:20,000 @A3

Doc. Ref. 13613-002

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7.4 Potential Impacts

The shadow flicker model calculates all possible instances of shadow flicker that may occur throughout the year, based on the sun's path across the sky relative to the turbine and receptor locations i.e. the total theoretical amount of shadow flicker that may be possible.

There is the potential for shadow flicker to occur at 78 of the 98 receptors considered within the overall study area (10 rotor diameters); at the remaining 20 receptors no shadow flicker effects are predicted.

A full listing of the predicted levels of shadow flicker by both receptor and turbine can be found in Appendix 7.1. The calculated area over which shadows from the turbines may be cast (resulting in the potential for shadow flicker to occur) is shown on Figure 7.1.

7.4.1 Annual Impacts

With due consideration of the annual average sunshine hours, the predicted likely levels of shadow flicker exceed the WEDG recommended 30 hours per year at 7 receptors within the 10 rotor diameter study area. At the remaining 71 receptors where shadow flicker may occur, annual shadow flicker is likely to be less than 30 hours per year.

Predicted likely levels of shadow flicker at the most affected receptor are approximately 39.9 hours per year; this is a conservative estimate and actual levels would likely be lower.

7.4.2 Daily Impacts

It is not appropriate to apply the annual average sunshine hours correction to the predicted daily totals as the data is based upon monthly averages, which cannot be applied to daily levels with sufficient accuracy. Furthermore, the infrequency of clear skies is more likely to reduce the overall number of instances of shadow flicker over the year, rather than reduce the length of each individual instance. As such, the assessment of daily impacts considers the maximum theoretical amount of shadow flicker only and is inherently conservative.

The predicted maximum theoretical hours per day of shadow flicker exceeds 30 minutes at 59 receptors within the overall study area. The maximum amount of shadow flicker per day predicted at any receptor is 1 hour 13.8 minutes (1.23 hours), however the average duration of shadow flicker effects at this receptor is likely to be lower, at 53.4 minutes (0.89 hours).

7.4.3 Potential Impact of Zero Shadow Flicker

It is possible to ensure the complete elimination of shadow flicker at all receptors within 10 rotor diameters by ensuring that the turbines do not operate during the times and conditions that shadow flicker may occur. This will result in energy yield losses, which can be estimated based on the total theoretical predictions of shadow flicker as well as considering the 'likely' levels, as shown in Table 7-2 below.

Table 7-2: Total % of Operational Hours where Shadow Flicker may occur

	Total Theoretical Predicted Levels (Assumes 100% Sunshine Hours)	'Likely' Predicted Levels (Assumes 26% Sunshine Hours)
Predicted Hours of Shadow Flicker Per Year	1825.3	474.6
% of Total Operational Hours Per Year	2.6%*	0.68%**

*Based on 1825.3 Total Predicted Hours divided by 70080 operational hours per year (8760 hours X 8 turbines)
** Based on 474.6 'Likely' Predicted Hours divided by 70080 operational hours per year (8760 hours X 8 turbines)

The assessment found that for shadow flicker levels to be reduced to zero at all sensitive receptors within the study area the turbines would need to be shut down for approximately 2.6% of the maximum potential operating time (assuming worst-case conditions). However, considering the 'likely' levels of shadow flicker this may be reduced to 0.68% of the maximum potential operating time. Given that the 'likely' levels are still a conservative estimate, the actual impact upon energy yield would be lower.

7.4.4 Potential Cumulative Impacts

The IWEA Guidelines recommend that all existing and/or permitted wind farm developments within 2 km of a proposed development should be considered in a cumulative shadow flicker assessment; however, there are no neighbouring wind farms within 2 km, therefore no cumulative shadow flicker effects are anticipated.

7.5 Mitigation Measures

Shadow flicker control modules, consisting of light sensors and specialised software, can be installed on the turbines to prevent operation during periods when shadow flicker may occur. The calculated shadow flicker periods can be input into the turbine control software and when the correct conditions are met i.e. the light intensity is sufficient and during a potential period of shadow flicker, individual turbines will cease operation until the conditions for shadow flicker are no longer present. This method of mitigation is typically used in the event of adverse shadow flicker effects occurring to prevent any further instances of shadow flicker at nearby receptors, rather than merely reduce shadow flicker to acceptable levels. For Dernacart Wind Farm, the applicant is committing to zero shadow flicker for all receptors within 1.7km (10 times the rotor diameter) of the turbines.

7.6 Residual Impacts

The results of the shadow flicker assessment predict that Dernacart Wind Farm has the potential to introduce shadow flicker at a number of buildings surrounding the site. The implementation of a scheme of mitigation to cease operation of the turbines during periods of potential shadow flicker will ensure that no shadow flicker effects are experienced within any sensitive building within 10 rotor diameters of a turbine.

7.7 References

1. Laois County Council. (2017). Laois County Development Plan 2017-2023, https://laois.ie/departments/planning/development-plans/draft-laois-county-development-plan-2017-2023/

2. Department of the Environment, Heritage and Local Government (DoEHLG). Wind Energy Development Guidlines (2006).

3. Irish Wind Energy Association. Best Practice Guidlines for the Irish Wind Energy Industry. (2012).

4. ReSoft Ltd. WindFarm Release 4.2.1.9. (1997-2014).