

## 16. SHADOW FLICKER

### 16.1 INTRODUCTION

This chapter assesses the potential for shadow flicker from the operation of the proposed turbines, as part of the proposed project, to impact on sensitive receptors in the surrounding area to the proposed wind farm site. The Applicant is committed to minimising the potential for shadow flicker to occur at any dwelling within the study area and the shadow flicker assessment described herein will be used to inform the Shadow Flicker Control Measures that will be designed for each turbine. This chapter presents the results and findings of the assessment of the potential for shadow flicker effects at sensitive receptors within the study area and quantifies the theoretical maximum number of hours per annum where shadow flicker might occur at a property. The objectives of this chapter are to describe what shadow flicker is, describe assessment methodology and best practice guidance, describe the likely effects, mitigation measures if required, and any residual effects.

#### 16.1.1 Proposed Wind Farm

The proposed project is described in Chapter 2 of this EIAR (Description of the Proposed Project). For the purpose of this assessment, the proposed wind turbines are the only infrastructure that have the potential to cause shadow flicker, so other elements of the proposed project are not considered. The locations of these turbines at the proposed wind farm site are shown in Figure 16-1 (see below) and all coordinates referred to in this chapter are to Irish Transverse Mercator (ITM). The shadow flicker assessment undertaken for the proposed project comprehensively assesses all scenarios within the turbine dimension range which is described in Chapter 2 of this EIAR (Description of the Proposed Project).

#### 16.1.2 Statement of Authority

Michael Nolan, CAD Manager in TOBIN, undertook the modelling as part of this assessment. He has over 20 years' of professional experience in building and environmental consulting including the preparation of shadow flicker impact assessments. Michael has worked on a number of wind farms with various roles (which included carrying out shadow flicker modelling and providing content for reports). Michael completed training with EMD International, a global consultancy providing software for wind energy projects including WindPRO, which has been used to model the shadow effects at this wind farm.

The contents of this chapter have been written by Oonagh Fleming who is an Environmental Scientist in TOBIN. Oonagh holds a B.A. (Hons) in Geography and Sociology from Trinity College Dublin. She has two years of experience as an environmental consultant and has been involved in the delivery of shadow flicker assessments as part of wind farm EIARs.

This chapter has been reviewed by Orla Fitzpatrick, Technical Director in TOBIN. Orla has over 20 years' experience working in the delivery of EIA projects in environmental consultancy. She holds a BSc in Geophysics and MSc in Environmental Consultancy and is a Chartered Environmentalist. She has considerable experience as technical approver of environmental deliverables for major infrastructure projects.



## 16.2 METHODOLOGY

### 16.2.1 Conditions Required for Shadow Flicker

Under certain combinations of geographical position, wind direction, weather conditions, 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 industry standard best practice approach is to use a distance of ten rotor diameters as a maximum limit within which significant shadow flicker effects can occur (see section 16.2.2).

Rotating wind turbine blades can cause brightness levels to vary periodically at locations where they obstruct the sun’s rays. This effect can occur when the shadow is cast over the windows of a building. Shadow flicker is largely dictated by the relative position of the turbine(s) and the window, in combination with weather conditions (i.e. presence of direct sunlight, wind speed and wind direction) and the time of day and year (i.e. the position of the sun in the sky). Shadow flicker will only occur if the turbine rotors are located between an observer within a dwelling and the sun. The frequency of the flicker effect is related to the frequency of the rotating turbine blades. It can also be dependent on the number of individual turbine rotors that are casting shadows on a window.

The occurrence of shadow flicker effects are determined by a number of criteria as follows:

- **The presence of screening:** Screening can occur from a variety of sources including vegetation, terrain, and buildings. If screening is present between the property and the wind turbine/sun, then shadow flicker may not occur at that property or would be reduced.
- **The orientation of the property:** The windows of the sensitive property (see Chapter 5, Section 5.3.1.3) must be facing the proposed turbines in order to be able to receive shadow flicker.
- **The distance of the property from turbines:** The potential effect of shadow flicker diminishes as distance from the turbine increases. An industry standard best practice approach is to use a distance of ten rotor diameters as a maximum limit within which significant shadow flicker effects can occur (see section 16.2.2).
- **The presence of direct sunlight:** Cloud cover can remove the presence of direct sunlight so that it is diffused and does not cast a shadow. If direct sunlight is present, the turbine blades must be located in the direct path between the sun and the affected window (or building façade).
- **The time of year and day:** The path of the sun varies over the seasons resulting in a changing potential for a shadow to be cast throughout the year. Similarly, the sun’s



position in the sky over the course of a day is changing such that the shadow cast by a turbine is constantly changing.

- **Wind speed:** In order for shadow flicker to occur, the turbine must be rotating. This requires a wind speed high enough to cause the turbine to turn on.
- **Direction of Wind:** The width of a shadow at any given property is dependent on the direction of the wind. This will be different on any given day at every property. The worst-case shadow occurs when the turbine faces directly towards or away from a property, while minimum flicker occurs when it faces perpendicular to the property.

## 16.2.2 Guidance

There are various sources of guidance with regard to the assessment and management of shadow flicker effects caused by wind turbines. Irish guidance relevant to the proposed project is summarised below. Additional guidance from the UK is also presented to provide technical context.

### **Department of Environment, Heritage & Local Government – Wind Energy Development Guidelines (WEDG) (2006):**

The 2006 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”.*

The Guidelines also state 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 shadow flicker modelling approach in this assessment is consistent with this recommendation.

### **Draft Revised Wind Energy Development Guidelines (WEDG) (2019):**

Draft Revised WEDGs were published in December 2019. It is noted that at the time of submission the Draft Revised 2019 WEDGs have not yet been adopted and the 2006 WEDG referred to above remain in place. Nonetheless, this EIAR is cognisant of the content and proposed measures set out in the Draft Revised 2019 WEDGs. The Draft Revised 2019 WEDGs note that:

*“Generally only properties within 130 degrees either side of north, relative to the turbines, can be affected at these latitudes in the UK and Ireland – turbines do not cast long shadows on their southern side.”*



The Draft Revised 2019 WEDGs also outline that the time period in which a neighbouring property may be affected by shadow flicker is completely predictable from the relative locations of the wind turbine(s) and the property. To support this, *“A Shadow Flicker Study detailing the outcome of computational modelling for the potential for shadow flicker from the development should accompany all planning applications for wind energy development.”*

The Draft Revised 2019 WEDGs advise that if shadow flicker prediction modelling indicates that there is potential for shadow flicker to occur at any particular dwelling or other potentially affected property, that a design review should be carried out to consider if one or more of the turbines can be relocated to eliminate the occurrence of shadow flicker. If this cannot be accommodated, then measures which provide for automated turbine shutdown to eliminate shadow flicker would be required.

The Draft Revised 2019 WEDGs also state that:

*“The planning authority or An Bord Pleanála should impose condition(s) 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”.*

This approach in the Draft Revised 2019 WEDGs provides for the prevention of shadow flicker by automatic shutdown of the turbines. This means that turbines will need to be programmed to shut down when shadow flicker effects occur, i.e. no amount of shadow flicker per day or per year would be acceptable. The nature of the automatic shutdown process in modern turbine technology requires a very short period of shadow flicker to occur as the blades are moved into the idle position and the blade movement comes to a halt.

Section 16.5 discusses the measures that could be taken to ameliorate likely shadow flicker effects.

#### **Offaly County Development Plan 2021 - 2027**

The Offaly CDP 2021 – 2027 states that it will have regard to the Wind Energy Development Guidelines for Planning Authorities, DoEHLG, (2006) and any amendments to the Guidelines which may be made and will consider the impact on human health in relation to noise disturbance, shadow flicker and air quality.

#### **Tipperary County Development Plan 2022 - 2028**

The Tipperary CDP 2022 - 2028 sets out that wind energy developments must comply with the Department of the Environment’s Wind Energy Development Guidelines (2006), as well as any updated national guidance. When assessing planning applications, the Council considers likely effects on residential amenity, including shadow flicker. Developers are required to demonstrate that proposed turbines are designed and located so that nearby dwellings will be largely unaffected by shadow flicker.

#### **Parsons Brinckerhoff – Update of UK Shadow Flicker Evidence Base (2011)**

Parsons Brinckerhoff was commissioned by the Department of Energy and Climate Change in the UK to carry out a study to advance the understanding of the shadow flicker effect. The report *“presents an update of the evidence base which has been produced by carrying out a thorough review of international guidance on shadow flicker, an academic literature review and by investigating current assessment methodologies employed by developers and case study evidence”.*



The report sets out that *“Consultation (by means of a questionnaire) was carried out with stakeholders in the UK onshore wind farm industry including developers, consultants and Local Planning Authorities (LPAs). This exercise was used to gauge their opinion and operational experience with shadow flicker, current guidance and the mitigation strategies that can and have been implemented.”*

The report summarised that *“The current recommendation in Companion Guide to PPS22 (Planning Policy Statement 22) (2004) to assess shadow flicker impacts within 130 degrees either side of north is considered acceptable, as is the 10 rotor diameter distance from the nearest property”*, though it is mentioned that this approach may not be suitable at all latitudes.

The Companion Guide to PPS22 was a planning policy statement produced by the UK Government in 2004 and, in addition to the above, states that *“Shadow flicker only occurs inside buildings where the flicker appears through a narrow window opening”*.

In terms of shadow flicker modelling, the report states that *“The three key computer models used by the industry[at that time] are WindPro, WindFarm and Windfarmer. It has been shown that the outputs of these packages do not have significant differences between them. All computer model assessment methods use a “worst case scenario” approach and don’t consider “realistic” factors such as wind speed and cloud cover which can reduce the duration of the shadow flicker impact.”*The WindPRO modelling software has been used in the assessment of shadow flicker for Ballincor Wind Farm.

The report goes on to say, *“On health effects and nuisance of the shadow flicker effect, it is considered that the frequency of the flickering caused by the wind turbine rotation is such that it should not cause a significant risk to health”*. Further discussion on shadow flicker and human health risks is contained in Chapter 5 (Population and Human Health) of this EIAR.

In summarising measures to minimise shadow flicker effects, *“Mitigation measures which have been employed to operational wind farms such as turbine shut down strategies, have proved very successful, to the extent that shadow flicker cannot be considered to be a major issue in the UK.”*

#### **UK Department for Business Enterprise and Regulatory Reform – Onshore Wind Energy Planning Conditions Guidance Note – A Report for the Renewables Advisory Board and BERR (2007)**

This guidance note was prepared in the UK for the Renewables Advisory Board and Department for Business, Enterprise and Regulatory Reform (BERR) in 2007 and states that shadow flicker *“occurs only within buildings where the shadow appears through a narrow window opening”* and that *“Only dwellings within 130 degrees either side of north relative to a turbine can be affected and the shadow can be experienced only within 10 rotor diameters of the wind farm”*.

The guidance note advises in terms of planning control that *“a local planning authority may consider it appropriate to impose a planning condition to provide that wind turbines should operate in accordance with a shadow flicker mitigation scheme..... Unless a survey carried out on behalf of the developer in accordance with a methodology approved in advance by the local planning authority confirms that shadow flicker effects would not be experienced within habitable rooms within any dwelling”*.



### Irish Wind Energy Association (IWEA) – Best Practice Guidelines for the Irish Wind Energy Industry (2012)

The IWEA Best Practice Guidelines note that, *“At certain times of the year, the moving shadows of the turbine blades could periodically reduce light to a room causing the light to appear to flicker. This would not generally have any effect on health or safety but could on limited occasions present a brief nuisance effect for some neighbours.”*

The Guidelines identify that modifications to predicted worst-case shadow flicker effects to account for sunshine probability and wind direction are reasonable and refers to mitigation measures such as wind turbine operation controls and screening where shadow flicker is anticipated to lead to potential problems.

This document also includes guidance on cumulative shadow flicker assessments, stating:

*It is important to determine if there are other existing and/or permitted but not constructed wind farms in the vicinity of the proposed development which could contribute towards a cumulative shadow flicker impact on any receptors. Any such wind farm developments within 2 km of the proposed development should be considered in a separate cumulative shadow flicker assessment.*

### 16.2.3 Assessment Study Area

As per the guideline documents set out in Section 16.2.2 above, it is best practice to use a distance of ten rotor diameters as a maximum limit within which significant shadow flicker effects can occur. The validity of this limit is discussed at length within the relevant literature, and guidance varies in different documents and countries, with some stating that effects can only occur within this distance and others stating that the risk beyond this distance is low. The Parsons Brinckerhoff Report referenced in Section 16.2.2 acknowledges that the latitude of a site will determine the distance from a wind turbine where shadow flicker can occur.

The Onshore Wind Energy Planning Conditions Guidance Note (2007) stated that *“shadow flicker has been proven to occur only within ten rotor diameters of a turbine position”*. The Scottish Government *Onshore Wind Turbines: Planning Advice* (2014) states that *“where separation is provided between wind turbines and nearby dwellings (as a general rule 10 rotor diameters), “shadow flicker” should not be a problem”*. The Northern Ireland (NI) Department of the Environment *Best Practice Guidance to Planning Policy Statement 18 ‘Renewable Energy’* (2009) states that *“At distances greater than 10 rotor diameters from a turbine, the potential for shadow flicker is very low”*.

The IWEA Guidelines referred to above state that *“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”* and refers to the 2006 WEDGs recommended threshold limits of 30 hours per year or 30 minutes per day for receptors within 500 m.

Ireland’s 2006 WEDG use the exact same wording as the NI Guidance above and, in addition, 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”*. It is noted that the Draft Revised 2019 WEDGs do not specify a maximum distance for assessing shadow flicker. There is no fixed cut off distance at which effects can occur, as this is sensitive to many parameters including the exact latitude of the proposed wind farm site and the terrain surrounding it.



Given the recommendations in the above guidance documents, it is considered that an assessment of potential shadow flicker at properties within ten rotor diameters of the turbine locations is appropriate to provide a robust assessment of shadow flicker from the proposed project.

The proposed rotor diameter for the proposed project is between 149 – 163 m, so on the basis of the largest 163 m rotor diameter, all sensitive receptors within 1.63 km of the proposed turbine locations have been included in the shadow flicker assessment. For the purpose of this assessment, the 2006 WEDGs recommended maximum thresholds of 30 hours per year or 30 minutes per day have been applied to all sensitive receptor locations within 1.63 km of a proposed turbine location (10x rotor diameter).

### 16.2.4 Shadow Flicker Modelling

The analysis has been undertaken using WindPRO: Shadow – Version 3.6.361 (by EMD International) which is one of the leading industry software packages for carrying out a shadow flicker simulation. It is a specialist modelling software package that incorporates:

- Wind turbine configuration;
- Terrain mapping;
- Sun path throughout the year at the proposed wind farm site latitude; and
- Defined receptors.

Three scenarios have been modelled to consider the extent of the proposed range of turbine dimensions (see Chapter 2):

Scenario 1: N163 (98.5m hub height, 180m tip height, 163m rotor diameter)

Scenario 2: N149 (105m hub height, 179.5m tip height, 149m rotor diameter)

Scenario 3: V150 (105m hub height, 180m tip height, 150m rotor diameter)

This chapter will discuss Scenario 1 in detail and present the results of Scenarios 2 and 3 for comparison.

Scenario 1 represents the maximum extent of the moving shadow (as is illustrated in Drawing 11333-2032 of Appendix 1-1). It encompasses all variations within the proposed turbine range, ensuring that the full range has been assessed as it results in a swept area that is equal to or greater than any other configuration modelled (i.e. 180 m tip height, 163 m rotor diameter, and 98.5 m hub height).

As such, any alternative configuration within the proposed range will result in a swept area that is smaller than or equal to that modelled in Scenario 1. Therefore, the potential for shadow flicker from all other configurations will be less than that assessed in Scenario 1.

The full range of proposed turbine dimensions has been comprehensively assessed in relation to shadow flicker.

The ground level on which the wind turbines and surrounding properties are situated has been incorporated into the model using Digital Terrain Modelling. This terrain mapping ensures that the realistic elevation variations between the turbines and properties is accounted for. This



includes a Zone of Visual Influence (ZVI) calculation that checks whether the terrain provides screening for a given property from each turbine and from the sun.

The model allows for user defined receptor locations (i.e. size, position, and orientation of windows at a receptor/property location). The location of properties in the model has been defined using address data from the Geodirectory database which is used to populate Eircodes. As discussed in Chapter 5 (Population and Human Health), this data has been used to define the sensitive receptor properties in the vicinity of the proposed wind farm site and specifically in relation to this shadow flicker assessment, within 1.63 km from the proposed turbines. A ground truthing exercise was carried out on this data in the area surrounding the proposed wind farm site to ensure accuracy of the identified sensitive receptors. This exercise is further detailed in Section 5.3.1.3 of Chapter 5 (Population and Human Health).

The model can be set up to incorporate windows within a property (typically with a size of 1m x 1m and an elevation of 1m above ground level) directed towards the centre of the wind farm. This feature can be used to provide specific detailed analysis on the locations of windows and allow for modelling multiple windows on properties facing different groups of turbines. However, to ensure consideration of a worst-case scenario, these features are over-ridden in the model by the 'greenhouse mode' which assumes that shadows can be seen from 360 degrees at a property/receptor as opposed to only through windows facing the wind turbines.

The model default also assumes that the turbine rotor is turning at all times. However, in practice, calm conditions, low wind speeds and maintenance shutdown will reduce the duration of operation of the turbines throughout the year and therefore the potential flicker effect. The model default also assumes that the wind direction is such that the turbine rotor is always perpendicular to the direction to the property so that it casts the maximum shadow possible for each wind turbine. Again, in practice, the wind direction will change periodically over the course of the year and the wind turbines are programmed to rotate around, or 'yaw', in order to face the wind direction.

The modelling software has built-in long-term solar statistics that accurately replicate the sun's path throughout the year at the development latitude. The model considers a minimum sun elevation of 3 degrees over the horizon which is a typical value at this latitude to accommodate terrain obstruction at the horizon for low solar elevation angles.

There are several features of the software that can produce highly conservative or 'worst-case' results in terms of modelling the potential shadow flicker effect. For example, there are a range of factors that could diminish shadow flicker effects namely cloud cover, varying wind direction and low wind speed. In relation to cloud cover, the default annual shadow flicker calculated by the model for each property assumes 100% sunshine during daytime hours. However, Met Éireann data for this region shows that the sun shines on average for 30% of the daylight hours per year<sup>1</sup> thus, the total hours per year of shadow flicker is likely to be significantly less than the theoretical worst-case durations produced by the model. The modelled results, therefore, overestimate the likely effects based on sunshine probability.



Similarly, the worst-case model inputs assume that the wind direction is such that all turbines are orientated to cast the maximum shadow over the identified receptors. However, Met Éireann meteorological data indicates that the prevailing wind direction across the country is between south and west<sup>2</sup>. Onsite wind measurement has confirmed this to be the case locally. Therefore, the direction that the blades of the turbine face (the turbine blades automatically orientate to face into the wind) will vary and, as such, will not always be perpendicular to the position of the receptors. The modelled results, therefore, overestimate the likely effects based on wind direction.

The worst-case modelled shadow flicker outputs assume unobstructed (from vegetation or other obstacles) visibility between a receptor and the turbine rotors, bright weather conditions and rotor alignment with maximum potential to cast a shadow. These are worst-case conditions used to predict the maximum possible shadow flicker effect. In practice, over the course of any year, the actual weather conditions and any screening will reduce the worst-case modelled effects.

### 16.2.5 Cumulative Assessment

The shadow flicker assessment considers the 11 no. proposed wind turbines and quantifies the likely shadow flicker effects that may arise from the turbines either on their own or in combination with each other. There is no potential for overlap of the same receptor with any other proposed or operational wind farm developments. The guidance mentioned in Section 16.2 above was used for this assessment.

## 16.3 EXISTING ENVIRONMENT

### 16.3.1 Identification of Sensitive Receptors

The shadow flicker receptors identified for the purpose of this assessment are shown on the figures below. The figures also display the locations of the proposed turbines as well as the shadow flicker study area which extends to 1.63 km from the proposed turbine locations (i.e. allowing for 10 x rotor diameters of the full range being considered). The proposed layout has achieved a high level of separation between dwellings and turbines by providing a minimum separation distance of 720 m (with the exception of involved landowner) (i.e. allowing for greater than 4 times tip height of the full proposed range of tip heights).

The shadow flicker receptors have been identified from a combination of publicly available mapping<sup>3</sup>, aerial imagery, street-level imagery and Geodirectory address data<sup>4</sup>. Following this, a thorough ground truthing survey was undertaken to verify the list of properties. In addition, a search of planning applications within 1.63 km of the proposed turbine locations was carried out to identify proposed projects and consented, but as yet not built, developments (most recently carried out in September 2025). A total of 126 no. sensitive receptors were identified and are presented in Table 16-1. Each receptor identified has been assigned an ID number in the shadow flicker modelling software for reference.

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<sup>2</sup> <https://www.met.ie/climate-ireland/1981-2010/birr.html> (Accessed on March 2025)

<sup>3</sup> <https://www.myplan.ie/national-planning-application-map-viewer/> (Accessed March 2025)

<sup>4</sup> Geodirectory address data captured from <https://mygeoaddress-online.ie/#/> in Q2 2025



During the verification process, any properties/buildings identified that would not be considered sensitive receptors (i.e. farm sheds, garages, derelict buildings etc.) were omitted. Derelict houses that could be reoccupied without planning permission were included in the model for robustness. Derelict houses that could not be reoccupied without planning permission were excluded from the model.



## 16.4 ASSESSMENT OF EFFECTS

### 16.4.1 Do-Nothing Effect / Future Baseline Scenario

The shadow flicker effects examined in this chapter are entirely dependent on the installation and operation of proposed turbines at the proposed wind farm site. In the event that the proposed project does not proceed, there will be no shadow flicker effects.

### 16.4.2 Construction Phase

There are no likely effects relating to shadow flicker during the vast majority of the construction phase of the proposed project as shadow flicker can only occur when the proposed turbine blades are installed and rotating.

At the very end of the construction phase there may be a short time where there is a potential for shadow flicker to occur. This would be in the stage of testing and commissioning of the proposed turbines. As set out in Section 2.8 in Chapter 2 (Description of the Proposed Project), the commissioning phase of the proposed project is anticipated to have a two-month duration. During this stage there would be a potential for a slight momentary effect on any receptor. During commissioning, the proposed turbine blades and shadow flicker management software will be installed and tested. Some shadow flicker may be experienced while the software is being refined but there will be no exceedance of the maximum daily limit of 30 minutes per day during this period. The likely effect from shadow flicker in the worst-case scenario at the defined receptors during commissioning will be slight over a temporary period and will have a momentary to brief effect with respect to the duration of the effect on a daily basis. The shadow flicker mitigation strategies described in Section 16.5 will be applied.

### 16.4.3 Operational Phase

The shadow flicker model provides a detailed report and illustration of the likely shadow effects on the identified potential receptors. The full report for all three modelled scenarios is provided in Appendix 16-1. Scenario 1 is discussed in detail below and the key results from Scenario 2 and 3 are highlighted.

#### Hours per day (Scenario 1)

Table 16-1 details the predicted maximum daily shadow flicker representing the maximum number of hours in any one day when shadow flicker may be experienced by a potential receptor in the worst-case conditions. The number of days where the predicted daily shadow flicker exceeds the 30 minutes per day threshold is also detailed. Based on the worst-case conditions (and without any mitigation), it is predicted that 81 no. receptors of the 129 no. included in the modelling assessment (i.e. within 1.63 km, 10 rotor diameters) would experience some level of daily shadow flicker, with 46 no. of these in excess of the 2006 WEDG threshold of 30 minutes per day.

The model inputs used to predict the daily shadow flicker levels have assumed worst-case conditions, including direct sunshine for the full duration of daylight hours throughout the year, that the proposed turbine blades are always turning, that the proposed turbine blades are always facing the receptors, the property has windows facing the turbines, the property is



always occupied and that there is no screening (vegetation or other obstacles). In reality, the actual occurrence and incidence of shadow flicker over the course of a day is likely to be significantly less than that the maximum predicted in Table 16-1.

### Hours per year (Scenario 1)

Table 16-1 also details the total shadow flicker hours per year for comparison against the 2006 WEDG threshold of 30 hours per year. The *'Worst Case Annual Shadow Flicker'* column in Table 16-1 represents the worst-case scenario which assumes 100% sunshine on every day during daylight hours as well as worst-case wind conditions resulting in maximum shadow cast in the direction of a receptor for the entire year.

As noted in Section 16.2, the Met Éireann data for this region shows that the sun shines on average for only 30% of the daylight hours per year. Accordingly, a sunshine reduction factor can be applied to account for the more realistic sunshine probability at the site. Additionally, as it is not possible for all turbines to face directly towards sensitive receptors at all times and wind direction is subject to change, a wind direction reduction factor can also be applied to the worst-case annual shadow flicker results. The *WindPRO* modelling software<sup>5</sup> has built-in options to specify statistical weather data to produce more realistic (referred to as 'Expected' in the modelling software) predictions of annual shadow flicker effects. These predicted results are presented in the column titled *'Expected (Realistic)'* in Table 16-1.

The technical assessment shows that the guideline threshold limit of 30 hrs per year is predicted to be exceeded at 41 receptors in the worst-case scenario and is expected to be exceeded at 0 receptors when the statistical sunshine probability<sup>6</sup> is taken into account. Therefore, the realistic 'Expected Values' for shadow flicker at the identified receptors are reduced from the worst-case scenario.

For the operational phase of the proposed wind farm site, the likely effect from shadow flicker in the worst-case scenario and before mitigation measures are applied, at a defined number of receptors as set out in Table 16-1 is likely to be significant and periodic over the long-term and will have a momentary to brief effect with respect to the duration of the effect on a daily basis at any receptor that does receive shadow flicker (with no effect at receptors that do not receive it).

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<sup>5</sup> WindPRO: Shadow – Version 3.6.361 (by EMD International)

<sup>6</sup> <https://www.met.ie/cms/assets/uploads/2024/07/Mullingar-1979%E2%80%932008-averages.html> (Accessed March 2025)



Table 16-1 Predicted Daily and Annual Shadow Flicker Effects (Scenario 1)

Property / Receptor ID for Shadow Flicker model	Description	Worst Case Scenario			Expected (Realistic)
		Maximum Daily Shadow Flicker (hrs:mins/day)	No. of Days exceeding 30 mins/day Threshold	Annual Shadow Flicker (hrs:mins/year)	Annual Shadow Flicker (hrs:mins/year)
05	Sensitive receptor	0:33	13	40:04	6:26
08	Sensitive receptor	0:34	13	25:39	4:29
10	Sensitive receptor	1:06	139	139:53	18:02
14	Sensitive receptor	0:00	0	0:00	0:00
17	Sensitive receptor	0:46	85	83:56	13:18
24	Sensitive receptor	0:43	44	33:26	3:42
26	Sensitive receptor	0:00	0	0:00	0:00
29	Sensitive receptor	0:00	0	0:00	0:00
31	Sensitive receptor	0:29	0	14:56	2:25
34	Sensitive receptor	0:27	0	27:38	4:24
37	Sensitive receptor	0:31	5	39:59	6:19
38	Sensitive receptor	0:00	0	0:00	0:00
39	Sensitive receptor	0:25	0	21:25	3:27
41	Sensitive receptor	0:00	0	0:00	0:00
42	Sensitive receptor	0:27	0	23:06	3:07
43	Sensitive receptor	0:41	68	71:04	8:57
46	Sensitive receptor	0:00	0	0:00	0:00
47	Sensitive receptor	0:46	63	51:15	9:03
53	Sensitive receptor	0:47	86	73:33	13:11
54	Sensitive receptor	0:00	0	0:00	0:00
57	Sensitive receptor	0:46	46	42:23	5:10



Property / Receptor ID for Shadow Flicker model	Description	Worst Case Scenario			Expected (Realistic)
		Maximum Daily Shadow Flicker (hrs:mins/day)	No. of Days exceeding 30 mins/day Threshold	Annual Shadow Flicker (hrs:mins/year)	Annual Shadow Flicker (hrs:mins/year)
58	Sensitive receptor	0:00	0	0:00	0:00
61	Sensitive receptor	0:00	0	0:00	0:00
63	Sensitive receptor	0:00	0	0:00	0:00
66	Sensitive receptor	0:00	0	0:00	0:00
67	Sensitive receptor	0:27	0	13:33	2:08
68	Sensitive receptor	0:34	18	26:07	4:34
73	Sensitive receptor	0:36	29	50:24	6:51
75	Sensitive receptor	0:00	0	0:00	0:00
77	Sensitive receptor	0:22	0	6:50	1:14
80	Sensitive receptor	0:37	26	30:09	5:17
83	Sensitive receptor	0:50	132	98:57	13:43
84	Sensitive receptor	0:00	0	0:00	0:00
87	Sensitive receptor	0:30	1	33:41	5:33
89	Sensitive receptor	0:24	0	29:14	4:49
90	Sensitive receptor	0:26	0	9:06	1:16
91	Sensitive receptor	0:33	11	24:37	3:26
93	Sensitive receptor	0:18	0	5:19	0:56
95	Sensitive receptor	0:43	29	32:29	4:18
98	Sensitive receptor	0:00	0	0:00	0:00
101	Sensitive receptor	0:27	0	26:48	4:16
104	Sensitive receptor	0:00	0	0:00	0:00
105	Sensitive receptor	0:20	0	8:29	1:23



Property / Receptor ID for Shadow Flicker model	Description	Worst Case Scenario			Expected (Realistic)
		Maximum Daily Shadow Flicker (hrs:mins/day)	No. of Days exceeding 30 mins/day Threshold	Annual Shadow Flicker (hrs:mins/year)	Annual Shadow Flicker (hrs:mins/year)
109	Sensitive receptor	0:41	31	39:52	7:02
110	Sensitive receptor	0:00	0	0:00	0:00
111	Sensitive receptor	0:00	0	0:00	0:00
116	Sensitive receptor	0:24	0	35:46	5:55
117	Sensitive receptor	0:00	0	0:00	0:00
119	Sensitive receptor	0:00	0	0:00	0:00
120	Sensitive receptor	0:00	0	0:00	0:00
123	Sensitive receptor	0:00	0	0:00	0:00
132	Sensitive receptor	0:00	0	0:00	0:00
133	Sensitive receptor	0:00	0	0:00	0:00
135	Sensitive receptor	0:19	0	12:30	2:13
136	Sensitive receptor	0:38	33	40:39	6:29
137	Sensitive receptor	0:00	0	0:00	0:00
138	Sensitive receptor	0:08	0	2:53	0:29
139	Sensitive receptor	0:34	37	41:18	7:10
140	Sensitive receptor	0:44	38	56:25	9:41
141	Sensitive receptor	0:40	61	65:49	8:23
143	Sensitive receptor	0:21	0	7:43	1:02
144	Sensitive receptor	0:00	0	0:00	0:00
146	Sensitive receptor	0:41	78	73:42	9:15
149	Sensitive receptor	0:00	0	0:00	0:00
150	Sensitive receptor	0:22	0	6:22	0:52



Property / Receptor ID for Shadow Flicker model	Description	Worst Case Scenario			Expected (Realistic)
		Maximum Daily Shadow Flicker (hrs:mins/day)	No. of Days exceeding 30 mins/day Threshold	Annual Shadow Flicker (hrs:mins/year)	Annual Shadow Flicker (hrs:mins/year)
151	Sensitive receptor	0:00	0	0:00	0:00
153	Sensitive receptor	0:00	0	0:00	0:00
156	Sensitive receptor	0:40	26	29:14	5:10
157	Sensitive receptor	0:00	0	0:00	0:00
160	Sensitive receptor	1:00	86	99:59	15:50
162	Sensitive receptor	0:21	0	9:20	1:24
164	Sensitive receptor	0:00	0	0:00	0:00
166	Sensitive receptor	0:00	0	0:00	0:00
170	Sensitive receptor	0:22	0	6:03	0:50
173	Sensitive receptor	0:21	0	7:30	1:00
178	Sensitive receptor	0:32	8	43:47	6:57
180	Sensitive receptor	0:46	64	59:31	10:30
183	Sensitive receptor	0:00	0	0:00	0:00
185	Sensitive receptor	0:00	0	0:00	0:00
186	Sensitive receptor	0:34	29	42:43	7:24
188	Sensitive receptor	0:43	66	66:14	11:20
192	Sensitive receptor	0:35	33	41:20	5:34
194	Sensitive receptor	0:00	0	0:00	0:00
200	Sensitive receptor	0:00	0	0:00	0:00
202	Sensitive receptor	0:44	51	52:48	9:17
203	Sensitive receptor	0:00	0	0:00	0:00
204	Sensitive receptor	0:00	0	0:00	0:00



Property / Receptor ID for Shadow Flicker model	Description	Worst Case Scenario			Expected (Realistic)
		Maximum Daily Shadow Flicker (hrs:mins/day)	No. of Days exceeding 30 mins/day Threshold	Annual Shadow Flicker (hrs:mins/year)	Annual Shadow Flicker (hrs:mins/year)
205	Sensitive receptor	0:20	0	5:13	0:49
210	Sensitive receptor	0:20	0	5:11	0:42
216	Sensitive receptor	0:40	52	60:18	9:27
218	Sensitive receptor	0:21	0	25:57	4:26
219	Sensitive receptor	0:00	0	0:00	0:00
221	Sensitive receptor	0:30	2	36:06	5:59
225	Sensitive receptor	0:00	0	0:00	0:00
236	Sensitive receptor	0:20	0	11:02	1:30
238	Sensitive receptor	0:00	0	0:00	0:00
239	Sensitive receptor	0:00	0	0:00	0:00
243	Sensitive receptor	0:00	0	0:00	0:00
244	Sensitive receptor	0:29	0	26:25	4:35
246	Sensitive receptor	0:45	63	58:31	9:22
248	Sensitive receptor	0:00	0	0:00	0:00
249	Sensitive receptor	0:19	0	9:16	1:01
250	Sensitive receptor	0:48	78	72:51	12:59
253	Sensitive receptor	0:44	31	27:52	3:49
254	Sensitive receptor	0:31	6	44:36	7:15
260	Sensitive receptor	0:00	0	0:00	0:00
261	Sensitive receptor	0:42	65	75:40	12:07
267	Sensitive receptor	0:21	0	5:41	0:46
269	Sensitive receptor	0:30	1	15:24	2:22



Property / Receptor ID for Shadow Flicker model	Description	Worst Case Scenario			Expected (Realistic)
		Maximum Daily Shadow Flicker (hrs:mins/day)	No. of Days exceeding 30 mins/day Threshold	Annual Shadow Flicker (hrs:mins/year)	Annual Shadow Flicker (hrs:mins/year)
270	Sensitive receptor	0:27	0	34:01	5:51
271	Sensitive receptor	0:26	0	24:38	3:58
272	Sensitive receptor	0:27	0	28:43	4:34
274	Sensitive receptor	0:31	4	16:57	2:30
275	Sensitive receptor	0:24	0	7:18	1:00
279	Sensitive receptor	0:00	0	0:00	0:00
280	Sensitive receptor	0:28	0	33:15	5:36
282	Sensitive receptor	0:00	0	0:00	0:00
284	Sensitive receptor	0:39	32	24:53	2:42
285	Sensitive receptor	0:49	94	80:45	14:26
289	Sensitive receptor	0:51	79	79:25	12:26
292	Sensitive receptor	0:00	0	0:00	0:00
294	Sensitive receptor	0:48	53	53:26	9:20
295	Sensitive receptor	0:39	50	59:55	9:25
296	Sensitive receptor	0:55	90	77:21	13:49
297	Sensitive receptor	0:27	0	23:57	4:13
302	Sensitive receptor	0:21	0	5:55	0:56
306	Sensitive receptor	0:00	0	0:00	0:00
312	Sensitive receptor	0:24	0	35:55	5:56
314	Sensitive receptor	0:00	0	0:00	0:00

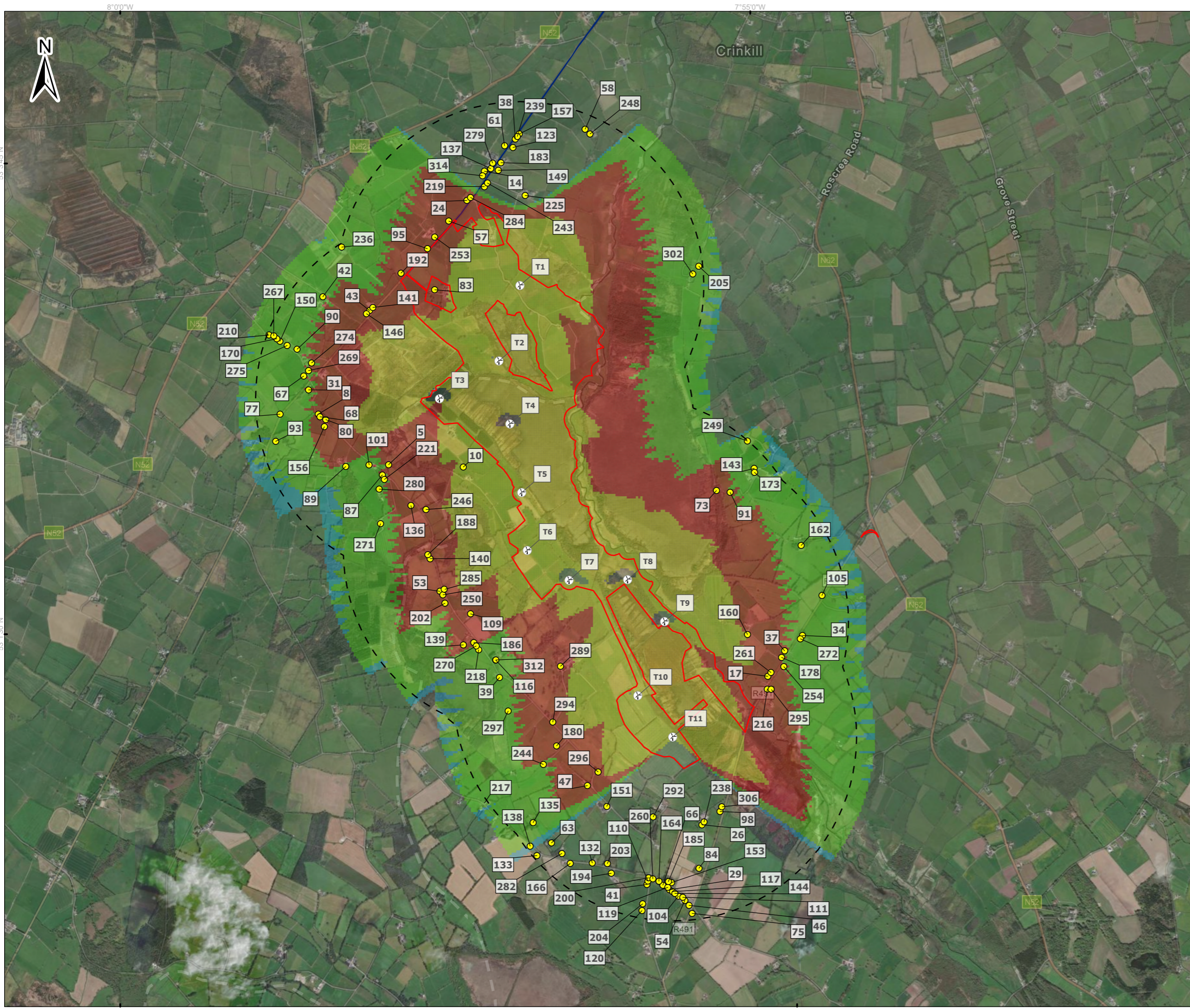
**Note:**



1. The receptor dataset presented in Table 16-1 is based on the ground-truthing exercise described in Chapter 5. For the purposes of this assessment, the dataset has been refined to focus on receptors located within the defined study area. Receptors identified as not sensitive to shadow flicker, following the ground-truthing process, have been excluded. As a result, the receptor identifiers used in this chapter correspond to those in the original dataset and may appear non-sequential.
2. Exceedances highlighted in red on above table.

As can be seen in the figures below there is a negligible difference between each modelled scenarios.



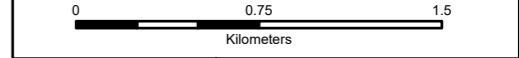


**Legend**

- Wind Farm Site Boundary
- Proposed Turbine locations
- 10 rotor diameters study area (1.63km)
- Proposed Grid Connection Route
- Sensitive Receptors

**Shadow Flicker (Minutes per Day)**

- 0.1 -< 10.0
- 10.0 -< 30.0
- 30.0 -< 60.0
- 60.0 <= 1,440.0



<b>Spatial Reference</b>		<b>Copyrights:</b>	
Datum: IRENET95		Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community,	
EPSG: 2157			

Rev	Date	Description	By	Chkd.
A	08/04/2026	First issue	S.P	J.D

Client:

Project: **Ballincor Wind Farm**

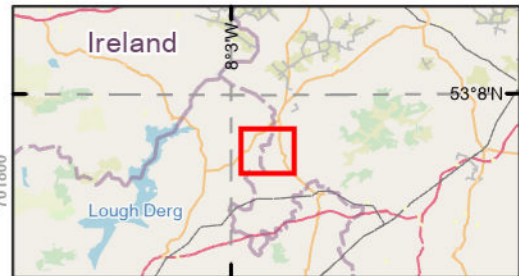
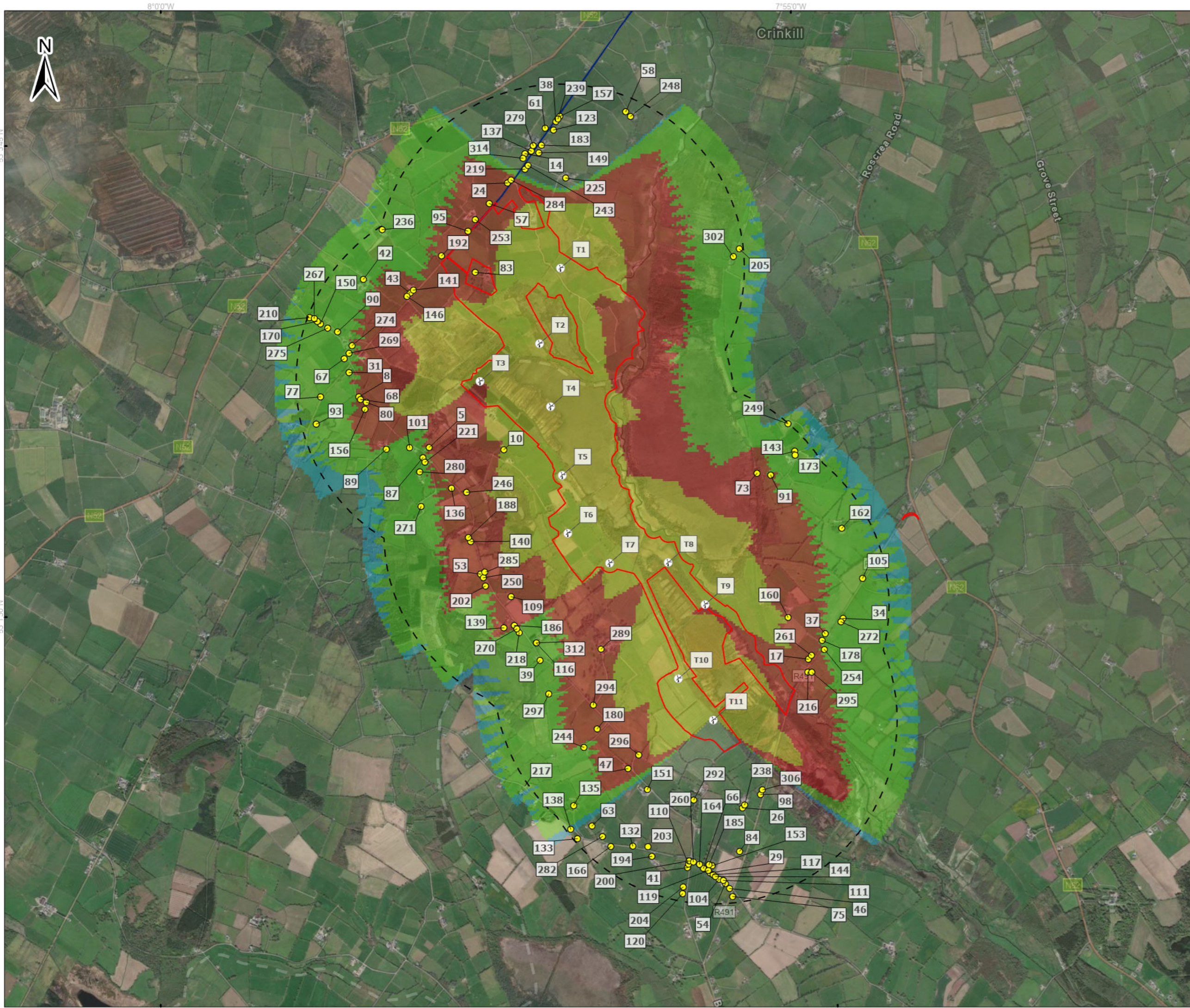
Title: **Figure 16-1  
Shadow Flicker  
Minutes per Day  
WTGs N163**

Scale @ A3:	1:31,000
Prepared by:	Checked by:
S.Pezzetta	J.Dillon
	April 2026

**TOBIN**

Tel: +353-(0)1-8030406  
Email: info@tobin.ie  
www.tobin.ie

Map Ref:	Draft:
11333-019-SHADW.FLCKR-SENS.R-TOB-A	<b>A</b>

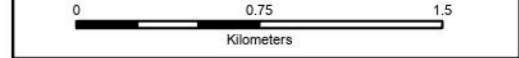


**Legend**

- Wind Farm Site Boundary
- Proposed Turbine locations
- 10 rotor diameters study area (1.63km)
- Proposed Grid Connection Route
- Sensitive Receptors

**Shadow Flicker (Minutes per Day)**

- 0.1 -< 10.0
- 10.0 -< 30.0
- 30.0 -< 60.0
- 60.0 <= 1,440.0



**Spatial Reference**  
 Datum: IRENET95  
 EPSG: 2157

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 Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

Rev	Date	Description	By	Chkd.
A	18/03/2026	First issue	S.P	J.D

Client:

Project: **Ballincor Wind Farm**

Title: **Figure 16-2  
 Shadow Flicker  
 Minutes per Day  
 WTGs N149**

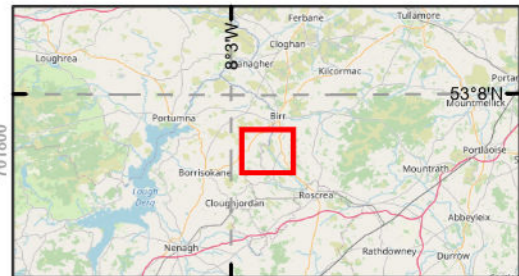
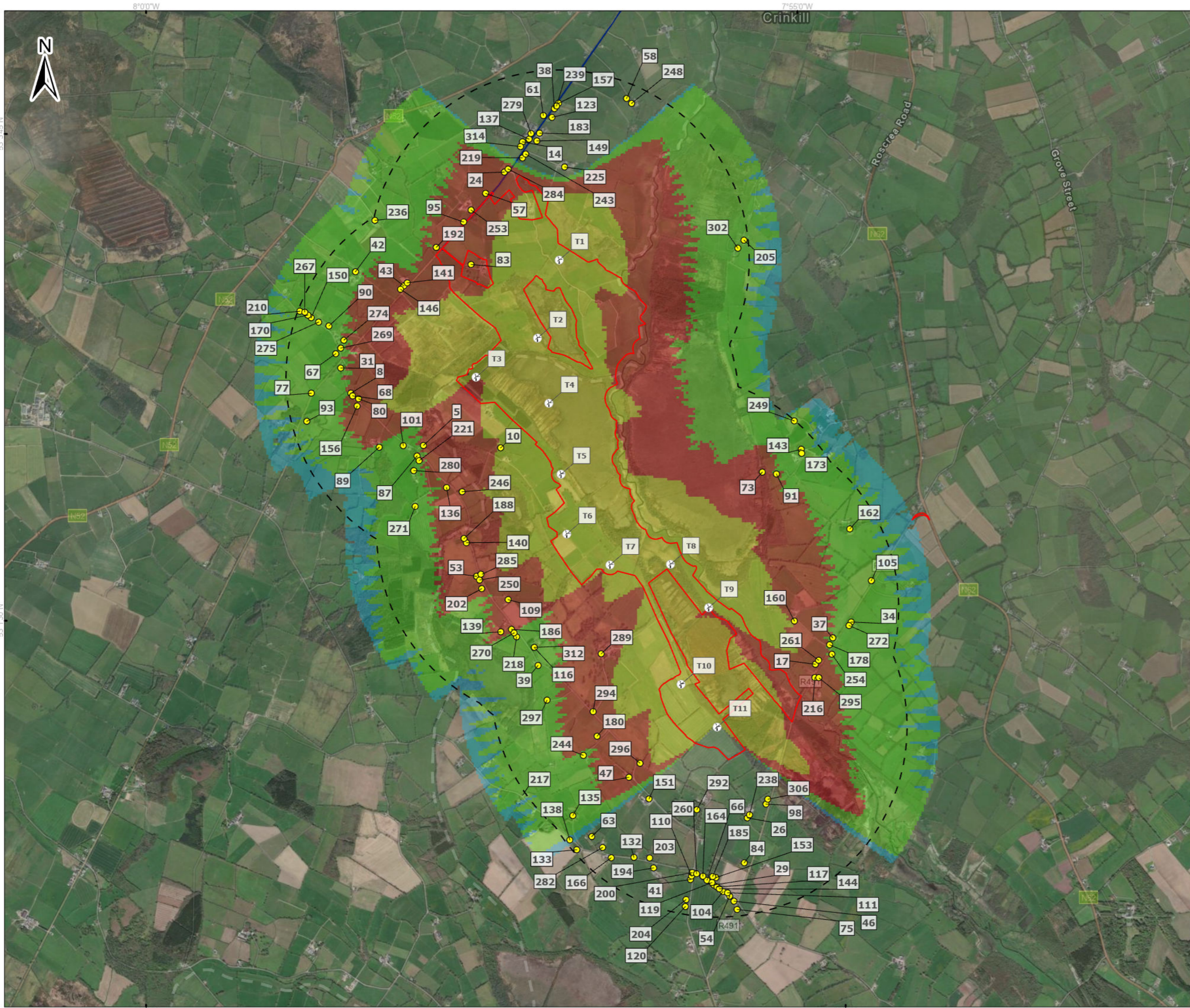
Scale @ A3: 1:31,000

Prepared by: S.Pezzetta      Checked by: J.Dillon      Date: March 2026

**TOBIN**

Tel: +353-(0)1-8030406  
 Email: info@tobin.ie  
 www.tobin.ie

Map Ref: 11333-041-SHADW.FLCKR.N149-SENS.R-TOB-A      Draft: **A**



**Legend**

- Wind Farm Site Boundary
- Proposed Turbine locations
- 10 rotor diameters study area (1.63km)
- Proposed Grid Connection Route
- Sensitive Receptors

**Shadow Flicker (Minutes per Day)**

- 0.1 -< 10.0
- 10.0 -< 30.0
- 30.0 -< 60.0
- 60.0 <= 1,440.0

<p><b>Spatial Reference</b> Datum: IRENET95 EPSG: 2157</p>	<p><b>Copyrights:</b> Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.</p>										
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%;">A</th> <th style="width: 20%;">18/03/2026</th> <th style="width: 40%;">First issue</th> <th style="width: 10%;">S.P</th> <th style="width: 10%;">J.D</th> </tr> </thead> <tbody> <tr> <td>Rev</td> <td>Date</td> <td>Description</td> <td>By</td> <td>Chkd.</td> </tr> </tbody> </table>	A	18/03/2026	First issue	S.P	J.D	Rev	Date	Description	By	Chkd.	
A	18/03/2026	First issue	S.P	J.D							
Rev	Date	Description	By	Chkd.							

Client:

Project: **Ballincor Wind Farm**

Title: **Figure 16-3  
Shadow Flicker  
Minutes per Day  
WTGs V150**

Scale @ A3: 1:30,000

Prepared by: S.Pezzetta      Checked by: J.Dillon      Date: March 2026

TOBIN

Tel: +353-(0)1-8030406  
Email: info@tobin.ie  
www.tobin.ie

Map Ref: 11333-042-SHADW.FLCKR.V150-SENS.R-TOB-A      Draft: **A**

## 16.4.4 Decommissioning Phase

There are no likely effects relating to shadow flicker during the decommissioning phase of the proposed project as shadow flicker can only occur when the turbine blades are installed and rotating. Turbines would not be rotating during this phase.

## 16.5 MITIGATION MEASURES

The shadow flicker modelling predicts worst-case 'bare earth' conditions without vegetation (including forestry), buildings or other obstacles. In reality, existing screening in the form of buildings, vegetation and local topographic variations will have a significant effect on the level of shadow flicker that will actually be experienced by the identified shadow flicker receptors. When these additional screening features are taken into account, the actual effect in terms of incidence and duration may be significantly reduced or even eliminated.

Shadow flicker is something that only occurs in the operational phase of a wind farm, but there is a potential for slight momentary effects to occur during turbine commissioning at the end of the construction phase while the mitigation strategy is being refined, this would be anticipated to be very limited due to the short timeframe that this takes (approximately 2 months) and the fact that turbines are often left stationary (i.e. not rotating) during this stage unless it is required for them to be rotating. All of the mitigation described below would apply during this final stage of the construction phase also.

### 16.5.1 Turbine Shutdown

It is noted as might be required by potential adoption of the 2019 draft wind energy guidelines, shadow flicker control modules can be used to ensure that a near zero level of shadow flicker is achieved, allowing for the reaction time of the shadow flicker control modules and also allowing for a short period of time for the turbine blades to slow down to a stop. As such the Applicant has committed to having near zero shadow flicker at any occupied dwelling house within 1.63km (> ten rotor diameters) of the proposed turbine locations. There may be a very brief time where a shadow moves over a property in the time it takes for the proposed turbine rotor to come to a safe stop, between 1-2 minutes. This will depend on the reaction time of the shadow flicker control modules and the particular proposed turbine type, however this is considered a negligible effect as it would likely take at most 1-2 minutes to stop. In the interest of transparency, it has been called "near zero shadow flicker" in this EIAR to account for this fact that it will never be possible to entirely eliminate it. Due to the potential for shadow flicker to affect receptors within the shadow flicker study area, it is proposed that a shadow control system will be installed on each of the wind turbines that have the potential to cause shadow flicker for sensitive receptors. The control system will detect and 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 outlined in this assessment;
- Wind speed (can effect how fast the proposed turbine will turn and how quickly the flicker will occur);
- Wind direction;
- The intensity of the sunlight.



When the sunlight is strong enough to cast a shadow, and the shadow falls on a property or properties, then the proposed turbine will automatically shut down; and will restart when the potential for shadow flicker ceases at the affected properties.

The Developer will install a shadow flicker impact control system at turbines which have the potential to cause shadow flicker on nearby properties. This system will be installed prior to operation of turbines.

This shadow flicker control system, consisting of light sensors and specialised software, will be installed on the turbines to ensure that mitigation is implemented if shadow flicker exceeds the thresholds as set out in the assessment criteria. 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) during a potential period of shadow flicker, individual turbines will cease operation as required until the conditions for shadow flicker are no longer present. This method of mitigation will be used to ensure that mitigation will be implemented for all instances where shadow flicker effects might occur at a residential dwelling within 10 rotor diameters of the turbines.

A process will be established by the proposed wind farm operator whereby local residents can highlight any concerns or complaints about the operation of the scheme. Any complaints relating to shadow flicker will be fully investigated by the Developer and the shadow flicker control system updated accordingly if required.

All concerns raised will be investigated by the proposed wind farm operator and the turbine shutdown software adjusted accordingly, to ensure that the turbines shut down at the appropriate time. After adjustments are made to the software, the flicker occurrence will be monitored where the residents still report flicker occurrence. This will determine any further adjustments that might be required to the shutdown times for any given turbine.

An updated model will be run at the pre-construction phase once the detailed specifications of the chosen turbine model are confirmed, on account that design flexibility has been sought for the proposed Ballincor Wind Farm and to ensure all receptors are up to date. That will be used for the basis of the turbine control programme used should the wind farm become operational.

During the commissioning phase, there is potential for some shadow flicker to be experienced as the shadow flicker management software is being installed and refined. However, the commissioning team will ensure that the maximum daily limit of 30 minutes per day is not exceeded during this temporary commissioning period, which will last approximately 2 months.

### 16.5.2 Screening Measures

If there is sufficient existing screening at a shadow flicker receptor, the Turbine Shutdown Scheme may not be necessary for that receptor. The Applicant will engage with any affected residents to investigate options for new or additional measures (such as planting vegetation to act as a screen or installation of suitable window blinds in the affected rooms of the residence) where appropriate and agreeable to the affected residents. If screening is not acceptable and/or will not be effective, the Turbine Shutdown Scheme as set out in Section 16.5.1 will be implemented to ensure 'near zero shadow flicker'.

Where agreed screening measures are implemented, the effectiveness of the measures will be monitored and if the measures are not functioning properly to the satisfaction of the property



owner/occupant, they will be included in the Turbine Shutdown Scheme as set out in Section 16.5.1.

## 16.6 RESIDUAL EFFECTS

The Applicant is committed to minimising any negative effects from the proposed project on the local community. The implementation of mitigation measures to screen shadow flicker effects from sensitive receptors and/or implement wind turbine control measures in accordance with a defined Turbine Shutdown Scheme will ensure that any residual shadow flicker effects from the proposed project will be almost entirely eliminated at any shadow flicker receptors. This will be the case irrespective of which turbine dimensions are selected within the turbine range. As noted previously, the immediate shutdown of a turbine(s) is subject to the technical capabilities of turbine technology where a controlled and safe slow-down of blade rotation is required, lasting 2 minutes at most. This would have an imperceptible long-term effect. During commissioning, the shadow flicker effect on the identified receptors will be slight over a temporary period and will have a brief, insignificant, effect with respect to the duration of the impact on a daily basis.

## 16.7 CUMULATIVE EFFECT

As discussed above, the Applicant has committed to near-zero shadow flicker for the proposed wind farm (see Section 16.5). Cumulative effects have been considered in relation to the developments listed in Chapter 4. As the shadow flicker control measures will ensure near-zero shadow flicker, the contribution from the proposed project is considered negligible and would not result in any perceptible cumulative impact. Any temporary turbine shutdowns required to achieve this outcome are subject to the technical capabilities of modern turbine control systems, which typically involve a controlled and safe slowdown of blade rotation lasting between one and two minutes. This operational measure would have an insignificant, imperceptible long-term effect.

## 16.8 CONCLUSION

The incorporation of set-back distances from the proposed turbines to buildings, which have been considered and implemented in the design of the proposed wind farm site layout, means that there are no sensitive receptors located within 720 m of a proposed turbine location, with the exception of involved landowner (see Chapter 5). The assessment above has considered the full range of proposed turbine dimensions. The potential for shadow flicker to occur is entirely predictable and the modelling software used in this assessment and installed in the proposed wind turbines can accurately predict when shadow flicker has the potential to occur at specific properties. This design measure, along with the implementation of screening and turbine shutdown mitigation measures as set out in Section 16.5, will ensure that there are no significant post-mitigation effects of shadow flicker on any residence in the area irrespective of the size of any turbine permitted or built.

In conclusion, due to the design of the project, the use of appropriate software to predict and assess effects of shadow flicker, it is not likely that there will be any significant effect from shadow flicker on the environment or on any residence from this project alone or in combination with any other projects.



## 16.9 REFERENCES

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