10.0 SHADOW FLICKER

10.1 INTRODUCTION

This chapter assesses the potential for shadow flicker from the proposed project to impact on sensitive receptors in the surrounding area. The objectives of this chapter are to describe what shadow flicker is, describe assessment methodology and best practice guidance, describe the potential effects, mitigation measures, if required and any residual effects. This chapter deals only with the proposed turbines, as there is no potential for shadow flicker effects from any other elements of the proposed project, such as the proposed grid connection route (GCR), site roads, met mast, substation, and works associated with the proposed turbine delivery route (TDR).

10.1.1 Proposed Project

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 site are shown in Figure 10-1 and all coordinates referred to in this chapter are to Irish Transverse Mercator (ITM). This chapter comprehensively assesses all scenarios within the turbine dimension range which is described in Chapter 2 of this EIAR (Description of the Proposed Project).

As mentioned above, this chapter only addresses effects from the proposed turbines, as there are considered to be no potential shadow flicker effects from the other elements of the project, including the proposed GCR.

10.1.2 Statement of Authority

This assessment has been carried out by TOBIN Consulting Engineers. The shadow flicker modelling and assessment was carried out by Michael Nolan, Project Manager in TOBIN, and Oonagh Fleming, Graduate Environmental Scientist in TOBIN. Michael 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. Oonagh Fleming is a Graduate Environmental Scientist in TOBIN. Oonagh holds a B.A. (Hons) in Geography and Sociology from Trinity College Dublin. She has approximately two years of experience as an environmental consultant and has been involved in delivery of EIARs and other reports on a range of projects including SID wind farms.

This chapter has been reviewed by Dr John Staunton, Senior Project Manager and Environmental Scientist in TOBIN. John has more than fifteen years' postgraduate experience in both research and environmental consultancy. John holds a BSc and PhD in Environmental Science and has considerable experience in project managing wind energy developments and carrying out shadow flicker impact assessments.

10.2 METHODOLOGY

10.2.1 Background

Wind turbines can cast long shadows when the sun is low in the sky. 'Shadow flicker' is an effect that occurs when the rotating blades of a wind turbine cast a moving shadow over a building. The effect is experienced indoors where a moving shadow passes over a window in a nearby property and results in a rapid change or flicker in the incoming sunlight.

Rotating wind turbine blades can cause brightness levels to vary periodically at locations where they obstruct the sun's rays. This can result in a nuisance when the shadow is cast over the windows of a building, primarily concerned with residential properties. This intermittent shadow flicker can be a cause of annoyance at residences near wind turbines if it occurs for a significant period of time. 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. affecting the position of the sun). 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 would not occur at that property.
- **The orientation of the property**: The windows of the sensitive property 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 10.2.2).
- **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 property.
- **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.
- **The presence of people**: If the property is empty at the time of a shadow flicker event, then it would not cause a nuisance.

Given the above requirements for the presence of a shadow flicker effect, it is likely that for the vast majority of the time at any given property, the probability of shadow flicker occurring is low. Nevertheless, this chapter will assess the potential occurrences of shadow flicker on all potentially sensitive properties in proximity to the proposed wind farm site on the basis that the criteria in the above list are not applicable.

10.2.2 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 (2006):

The 2006 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. 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 (2019):

Draft WEDGs were published in December 2019 and are subject to a consultation process. It is noted that at the time of submission (December 2024) the Draft 2019 WEDGs have not yet been adopted and the 2006 Guidelines referred to above remain in place. Nonetheless, this EIAR is cognisant of the content and proposed measures set out in the Draft 2019 WEDGs. The Draft 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 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 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 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 current draft of the Guidelines 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 10.5.2 discusses the measures that could be taken to ameliorate potential shadow flicker effects.

<u>Parsons Brinckerhoff – Update of UK Shadow Flicker Evidence Base (2011)</u>

Parsons Brinckerhoff were 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."* It is noted that the WindPRO modelling software has been used in the assessment of shadow flicker for Scart Mountain 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."*

<u>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)</u>

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".*

<u>Irish Wind Energy Association (IWEA) – Best Practice Guidelines for the Irish Wind Energy Industry (2012)</u>

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.*

10.2.3 10x Rotor Diameter Assessment Zone

As per the guideline documents set out in Section 10.2.1 above, it is common 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 10.2.1 acknowledges that the latitude of the 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 500m.

Ireland's 2006 Wind Energy Development Guidelines 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 500m should not exceed 30 hours per year or 30 minutes per day".* It is noted that the Draft 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 site and the terrain around the development location.

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 Scart Mountain wind farm is between 149 – 163m, so on the basis of the largest 163m rotor diameter, all sensitive receptors within 1.63km 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 1.63km of a proposed turbine location.

For dwellings where shadow flicker is likely to exceed threshold limit values there are a range of measures that can be implemented to ameliorate shadow flicker effects such as the planting or screening vegetation or the turbine in question can be programmed to shut down during periods when shadow flicker is predicted to occur. This strategy has been successfully employed at other wind farms. Shadow flicker control modules (SFCM), which operate by standing the turbine down based on times of day and the relative angle of the sun and turbine, will be installed on the appropriate turbines which can be programmed to shut down turbines if shadow flicker is anticipated to exceed nuisance levels (these potential measures are discussed further in Section 10.5.2).

10.2.4 Shadow Flicker Modelling

The analysis has been undertaken using WindPRO: Shadow – Version 3.3.294 (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 development latitude; and
- Defined receptors.

The wind turbine dimensions inputted to the model are consistent with the maximum turbine-size envelope discussed in Section 2.5.2 of Chapter 2 (Description of the Proposed Project). The maximum turbine tip height used is 185m which represents the worst-case shadow flicker conditions as the height of the turbine would result in the longest potential shadow length.

In order to ensure the full extent of the moving shadow which would be created by the proposed turbine range is considered in the assessment, the following representative scenario was modelled:

- Hub height of 103.5m, tip height of 185m and rotor diameter of 163m (i.e. largest rotor diameter at the tallest tip height).

As seen in Drawing 11303-2017 of Appendix 1-1 the above scenario will include any and all variations of the proposed turbine range, therefore the proposed turbine range has been assessed in full (see below section 10.2.4 for further details).

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 site and specifically in relation to this shadow flicker assessment, within 1.63km of a proposed. A ground truthing exercise was carried out on this data in the area surrounding the proposed project to ensure accuracy of the identified sensitive receptors. This exercise is further detailed in Section 5.3.1 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 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 accordingly 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 suns 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[1] 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[2]. 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.

10.2.5 Assessment of the proposed turbine range

In respect of shadow flicker, any alternative configuration of tip height, hub height and rotor diameter (which is within the proposed range of dimensions) will result in a swept area contained within the maximum swept area presented and modelled (i.e. 185m tip height, 163m rotor diameter and 103.5m hub height). In this regard, the potential for shadow flicker to occur as a result of all configurations within the turbine range, will be less than that modelled. This is because the overall area of the shadow for all other scenarios is smaller and within the modelled shadow that has been assessed (see drawing 11303-2017 within Appendix 1-1 of this EIAR). As such, the potential shadow flicker effect from within these dimensional boundaries will be less than that presented above.

Following on from all the above, the full range of proposed turbine dimensions has been assessed in relation to shadow flicker.

[2] https://www.met.ie/climate-ireland/1981-2010/kilkenny.html (Accessed on 09th Sept. 2023)

10.2.6 Cumulative Assessment

The shadow flicker assessment considers the 15 no. proposed wind turbines and quantifies the potential shadow flicker effects that may arise from the turbines either on their own or in combination with each other. The guidance mentioned in Section 10.2.1 above was used for this assessment.

Other wind farms within 4km of the proposed wind farm site (i.e. to account for a receptor that might be within 10 rotor diameters of this proposed project and also another in the opposite direction, with a conservative additional buffer) have also been considered to assess any potential cumulative effects with regard to shadow flicker. A planning search was conducted using the Waterford City and County Council (WCCC) and Tipperary County Council websites, An Bord Pleanála website and EIA portal to identify any existing, consented or proposed wind farm sites in proximity to the proposed project. The proposed Dyrick Hill Wind Farm (ABP Ref. 317265), the site of which is located directly adjacent to the currently proposed project, was recently (October 2024) refused planning permission by An Bord Pleanála. As there is still a potential for judicial review at the time of writing this EIAR chapter (November 2024), it has been decided to include the proposed Dyrick Hill Wind Farm in the cumulative impact assessments. In the event that the refusal of the proposed Dyrick Hill Wind Farm application is confirmed prior to the determination of the current application, then any discussions around cumulative impacts for the proposed project in this EIAR can be removed from consideration by An Bord Pleanála. The proposed Dyrick Hill Wind Farm is for 12 wind turbines with a tip height of 185m, a rotor diameter of 162m and a hub height of 104m.

The potential cumulative effects have been modelled in the assessment below.

10.3 EXISTING ENVIRONMENT

10.3.1 Identification of Sensitive Receptors

The shadow flicker receptors identified for the purpose of this assessment are shown on Figure 10-1. The figure also displays the locations of the proposed turbines as well as the shadow flicker study area which extends to 1.63km 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 >800m (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[3], aerial imagery, street-level imagery and Geodirectory address data[4] . Following this, a thorough ground truthing survey was undertaken by the Project Team to verify the list of properties. In addition, a search of planning applications within 1.63km of the proposed turbine locations was carried out to identify proposed developments and consented, but as yet not built, developments (most recently carried out in Sept 2024). A total of 68 no. sensitive receptors were identified and are presented in Table 10-1. Each receptor identified has been assigned an ID number in the shadow flicker modelling software for reference.

During the verification process, any properties/buildings identified that would not be considered sensitive receptors (i.e. farm sheds, garages, etc.) were omitted. Only existing

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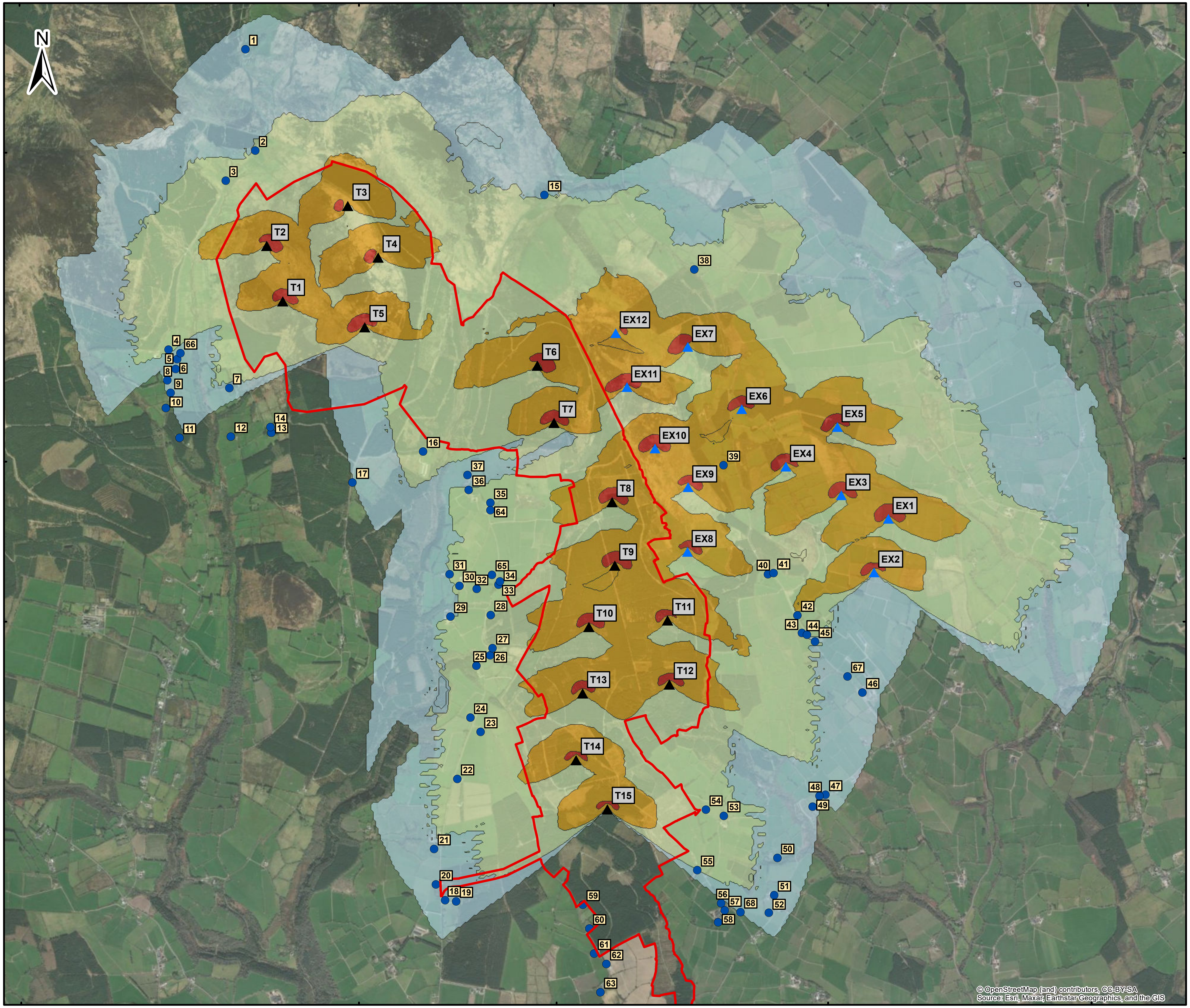
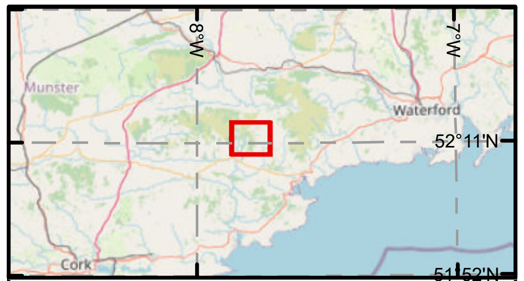
[3] https://www.myplan.ie/national-planning-application-map-viewer/ (Accessed Q3 2024)
[4] Geodirectory address data captured from https://mygeoaddress-online.ie/#/ in Q3 2024

dwellings and planning consented dwellings and offices were included as shadow flicker receptors. Planning consented dwellings and offices, which were not built, and where the expiry period for development had elapsed were excluded. There were no offices found in the study area. Derelict houses (i.e. considered as those which could not be re-occupied without planning permission due to poor condition) were included in the model for robustness, but due to their uninhabited nature they were not considered as sensitive.





Legend

- Proposed wind farm site
- Cumulative Turbine Locations
- Proposed Turbine Locations
- Sensitive Receptors within 10 Rotor Diameters

Shadow Mins. Per Day

- 0.1 - <10.0
- 10.0 - <30.0
- 30.0 - <60.0
- >60.0

0 0.5 1 1.5 2
Kilometers

NOTES

1. FIGURED DIMENSIONS ONLY TO BE TAKEN FROM THIS DRAWING
2. ALL DRAWINGS TO BE CHECKED BY THE CONTRACTOR ON SITE
3. ENGINEER TO BE INFORMED OF ANY DISCREPANCIES BEFORE ANY WORK COMMENCES
4. ALL LEVELS RELATE TO ORDNANCE SURVEY DATUM AT MALIN HEAD

Rev	Date	Description	By	Chkd.
A	17/12/2024	Final Issue	M.N.	J.S.

Client: FuturEnergy Ireland

Project: Scart Mountain Wind Farm

Title: Fig 10-1 Shadow Flicker Assessment
Cumulative Real Case Scenario

Scale @ A3: 1:30,000

Prepared by:	Checked by:	Date:
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Map Ref: 11303-023-S.F-S.BO-TOB-A

Draft: A

10.4 POTENTIAL EFFECTS

10.4.1 Do-Nothing Effect

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.

10.4.2 Construction Phase

There are no potential 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 2.7.1 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 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 potential effect from shadow flicker in the worst-case scenario at the defined shadow 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 10.5 will be applied.

10.4.3 Operational Phase

The shadow flicker model provides a detailed report and illustration of the potential shadow effects on the identified potential receptors. The full report is provided in Appendix 10-1.

Hours per day

Table 10-1 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 53 no. receptors of the 68 no. included in the modelling assessment (i.e. within 10 rotor diameters) will experience some level of daily shadow flicker, with 30 no. of these in excess of the 2006 WEDGs threshold of 30 minutes per day. This includes derelict properties. There were no office properties identified in the area. A total of 15 no. sensitive receptors will not experience any shadow flicker.

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 10-1.

Hours per year

Table 10-1 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 10-1 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 10.2.3, 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[5] 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 10-1.

The technical assessment shows that the guideline threshold limit of 30 hrs per year is predicted to be exceeded at 31 receptors in the worst-case scenario and is expected to be exceeded at 4 receptors when the statistical sunshine probability is taken into account. Therefore, the realistic 'Expected Values' for shadow flicker at the identified receptors are significantly reduced from the worst-case scenario.

For the operational phase of the proposed wind farm site, the potential 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 10-1 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).

Table 10-1: Predicted Daily and Annual Shadow Flicker Effects

[5] WindPRO V3.3.294 – EMD International - https://www.emd-international.com/windpro/

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)
1	Sensitive Receptor (Dwelling)	00:26	0	20:55	03:52
2	Derelict	00:41	73	74:49	16:10
3	Derelict	01:06	149	128:35	29:14
4	Sensitive Receptor (Dwelling)	00:37	47	42:46	12:57
5	Sensitive Receptor (Dwelling)	00:24	0	10:39	03:23
6	Sensitive Receptor (Dwelling)	00:23	0	11:11	03:33
7	Sensitive Receptor (Dwelling)	00:32	29	26:30	07:53
8	Sensitive Receptor (Dwelling)	00:22	0	10:48	03:25
9	Sensitive Receptor (Dwelling)	00:22	0	12:43	04:00
10	Sensitive Receptor (Dwelling)	00:00	0	0:00	0:00
11	Sensitive Receptor (Dwelling)	00:00	0	0:00	0:00
12	Derelict	00:00	0	0:00	0:00
13	Sensitive Receptor (Dwelling)	00:00	0	0:00	0:00
14	Sensitive Receptor (Dwelling)	00:00	0	0:00	0:00
15	Derelict	00:25	0	18:39	5:05
16	Sensitive Receptor (Dwelling)	00:34	29	36:12	10:58
17	Derelict	00:00	0	0:00	0:00
18	Sensitive Receptor (Dwelling)	00:23	0	14:13	4:21
19	Sensitive Receptor (Dwelling)	00:25	0	21:12	6:20
20	Sensitive Receptor (Dwelling)	00:22	0	8:49	2:46
21	Sensitive Receptor (Dwelling)	00:29	0	31:31	9:32

22	Sensitive Receptor (Dwelling)	00:38	22	45:53	13:50
23	Sensitive Receptor (Dwelling)	00:44	91	94:07	27:00
24	Sensitive Receptor (Dwelling)	00:40	66	68:52	19:10
25	Sensitive Receptor (Dwelling)	00:55	138	126:48	33:33
26	Sensitive Receptor (Dwelling)	00:48	165	134:41	35:31
27	Sensitive Receptor (Dwelling)	00:46	143	131:10	34:46
28	Sensitive Receptor (Dwelling)	01:00	118	112:44	31:02
29	Sensitive Receptor (Dwelling)	00:32	18	69:49	17:36
30	Sensitive Receptor (Dwelling)	00:33	17	77:56	21:24
31	Sensitive Receptor (Dwelling)	00:30	1	65:13	17:53
32	Sensitive Receptor (Dwelling)	00:47	74	92:25	23:54
33	Sensitive Receptor (Dwelling)	00:47	118	99:21	24:56
34	Sensitive Receptor (Dwelling)	00:45	107	93:15	23:32
35	Sensitive Receptor (Dwelling)	00:36	37	47:36	12:14
36	Sensitive Receptor (Dwelling)	00:31	10	40:41	9:31
37	Sensitive Receptor (Dwelling)	00:30	7	25:20	6:25
38	Derelict	00:00	0	0:00	0:00
39	Sensitive Receptor (Dwelling)	00:37	34	59:52	15:22
40	Sensitive Receptor (Dwelling)	00:45	32	84:47	21:51
41	Sensitive Receptor (Dwelling)	00:41	27	71:39	18:27

42	Sensitive Receptor (Dwelling)	00:34	20	41:50	11:51
43	Sensitive Receptor (Dwelling)	00:33	23	42:10	12:28
44	Sensitive Receptor (Dwelling)	00:32	14	38:54	11:33
45	Sensitive Receptor (Dwelling)	00:30	4	25:58	7:35
46	Sensitive Receptor (Dwelling)	00:23	0	17:14	5:25
47	Sensitive Receptor (Dwelling)	00:16	0	6:57	2:02
48	Sensitive Receptor (Dwelling)	00:07	0	1:53	0:33
49	Sensitive Receptor (Dwelling)	00:22	0	7:13	2:07
50	Sensitive Receptor (Dwelling)	00:26	0	12:39	4:01
51	Sensitive Receptor (Dwelling)	00:25	0	20:26	6:15
52	Sensitive Receptor (Dwelling)	00:25	0	17:56	5:19
53	Sensitive Receptor (Dwelling)	00:38	28	43:32	13:43
54	Sensitive Receptor (Dwelling)	00:45	69	60:34	18:52
55	Derelict	00:34	23	21:25	6:20
56	Sensitive Receptor (Dwelling)	00:00	0	0:00	0:00
57	Sensitive Receptor (Dwelling)	00:00	0	0:00	0:00
58	Sensitive Receptor (Dwelling)	00:00	0	0:00	0:00
59	Sensitive Receptor (Dwelling)	00:00	0	0:00	0:00
60	Sensitive Receptor (Dwelling)	00:00	0	0:00	0:00
61	Sensitive Receptor (Dwelling)	00:00	0	0:00	0:00

62	Sensitive Receptor (Dwelling)	00:00	0	0:00	0:00
63	Sensitive Receptor (Dwelling)	00:00	0	0:00	0:00
64	Sensitive Receptor (Dwelling)	00:36	46	62:25	15:36
65	Sensitive Receptor (Dwelling)	0:41	0	102:06	26:28
66	Sensitive Receptor (Dwelling)	0:24	0	10:57	3:29
67	Sensitive Receptor (Dwelling)	0:25	0	19:16	5:50
68	Sensitive Receptor (Dwelling)	0:01	0	0:07	0:02

* This property/receptor listing includes all properties which are located within 1.63km (ten rotor diameters) of the proposed turbine locations. A comprehensive list of all properties/receptors identified during the preparation of this EIAR (which includes all the properties above) is provided in Table 5-3 of Chapter 5 (Population and Human Health).

Note: Exceedances highlighted in blue on above table.

The commissioning phase of the proposed project is anticipated to have a two-month duration (see Appendix 2-8 CEMP for further details). During commissioning, the 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 potential effect from shadow flicker in the worst-case scenario at the defined shadow 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.

10.4.4 Decommissioning Phase

There are no potential 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.

10.5 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 almost exclusively occurs in the operational phase of a wind farm, however while 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.

10.5.1 Turbine Shutdown

It is noted that regardless of the wind energy guidelines which are in place, 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 and 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.

A Turbine Shutdown Scheme will be the primary mitigation measure for shadow flicker effect and will be implemented for the proposed project based on the predicted shadow flicker at each shadow flicker receptor. The Turbine Shutdown Scheme will be employed to ensure that shadow flicker does not occur at the affected property(s). 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. 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 shut down times for any given turbine.

During the commissioning phase, there is potential for some shadow flicker to be experienced as the shadow flicker management software is 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.

10.5.2 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 screening 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 10.5.1 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 to the satisfaction of the property owner/occupant, they will be included in the Turbine Shutdown Scheme as set out in Section 10.5.1.

10.6 RESIDUAL EFFECTS

The Applicant is committed to minimising any adverse 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 between 1 and 2 minutes at most. This would have an imperceptible long-term effect.

Based on the cumulative assessment above there is only one proposed wind farm (Dyrick Hill) which has the potential for cumulative effects, which is currently not yet permitted. Should that proposed wind farm get planning approval and be constructed then there is a potential for cumulative shadow flicker effects. However, as the currently proposed project has committed to effectively eliminating shadow flicker effects through the above prescribed mitigation, there is therefore no potential for cumulative effects from it in the operational phase. During commissioning, the cumulative shadow flicker effect on the identified receptors 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.

10.6.1 Cumulative Effect

The shadow flicker model described above includes the predicted shadow flicker effect from the proposed project only. The proposed Dyrick Hill Wind Farm (ABP Ref. 317265), the site of which is located directly adjacent to the currently proposed wind farm site, was recently (October 2024) refused planning permission by An Bord Pleanála. As there is still a potential for judicial review at the time of writing this EIAR chapter (November 2024), it has been decided to include the project in the cumulative impact assessments. In the event that the refusal of the Dyrick Hill Wind Farm application is confirmed prior to the determination of the current application, then any discussions around cumulative impacts for the proposed project in this EIAR can be removed from consideration by An Bord Pleanála. Dyrick Hill Wind Farm consists of 12 turbines which have a tip height of 185m, a rotor diameter of 162m and hub height of 104m.The details of these turbines were added to the modelling software, and the combined results are provided in Table 10-2. There are no other wind farms within 5km of the proposed project.

The technical cumulative assessment shows that the guideline threshold limits of 30 hrs per year and 30 minutes per day are predicted to be exceeded at 2 additional receptors (i.e. 31 total) in the theoretical worst-case scenario compared with the above assessment of the proposed wind farm alone. The annual threshold will be exceeded at 5 additional receptors (i.e. 9 total) when the statistical sunshine probability is taken into account. As with the assessment of the proposed project on its own in Section 10.4.2 above, the realistic 'Expected Values' for shadow flicker at the identified receptors are significantly reduced from the worst-case scenario.

For the operational phase of the proposed project, the potential cumulative effect from shadow flicker in the worst-case scenario at a defined number of receptors as set out in Table 10-2 will be likely, 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).

Table 10-2: Predicted Daily and Annual Cumulative Shadow Flicker Effects

Property / Receptor ID	Description			Worst Case Scenario		Expected (Realistic)	
		Maximum Daily Shadow Flicker (hrs:mins/day)	No. of Days exceeding 30 mins/day Threshold	Difference in No. Days exceeding 30 mins/day	Annual Shadow Flicker (hrs:mins/ year)	Annual Shadow Flicker (hrs:mins/ year)	Difference in Annual Shadow Flicker (hrs:mins/ year) – (i.e. cumulative vs non-cumulative)
1	Sensitive Receptor (Dwelling)	00:26	0	0	20:55	03:52	00:00
2	Derelict	00:41	73	0	74:49:00	16:10	00:00
3	Derelict	01:06	149	0	128:35:00	29:14:00	00:00
A4	Sensitive Receptor (Dwelling)	00:37	47	0	42:46:00	12:57	00:00
5	Sensitive Receptor (Dwelling)	00:24	0	0	10:39	03:23	00:00
6	Sensitive Receptor (Dwelling)	00:23	0	0	11:11	03:33	00:00
7	Sensitive Receptor (Dwelling)	00:32	29	0	26:30	07:53	00:00
8	Sensitive Receptor (Dwelling)	00:22	0	0	10:48	03:25	00:00
9	Sensitive Receptor (Dwelling)	00:22	0	0	12:43	04:00	00:00
10	Sensitive Receptor (Dwelling)	00:00	0	0	0:00	00:00	00:00
11	Sensitive Receptor (Dwelling)	00:00	0	0	0:00	00:00	00:00
12	Derelict	00:00	0	0	0:00	00:00	00:00
13	Sensitive Receptor (Dwelling)	00:00	0	0	0:00	00:00	00:00

14	Sensitive Receptor (Dwelling)	00:00	0	0	0:00	00:00	00:00
15	Derelict	00:50	49	49	61:04	13:01	07:56
16	Sensitive Receptor (Dwelling)	00:52	41	12	47:36	14:34	03:36
17	Derelict	00:00	0	0	0:00	00:00	00:00
18	Sensitive Receptor (Dwelling)	00:23	0	0	14:13	04:21	00:00
19	Sensitive Receptor (Dwelling)	00:25	0	0	21:12	06:20	00:00
20	Sensitive Receptor (Dwelling)	00:22	0	0	8:49	02:46	00:00
21	Sensitive Receptor (Dwelling)	00:29	0	0	31:31	09:32	00:00
22	Sensitive Receptor (Dwelling)	00:38	22	0	45:53	13:50	00:00
23	Sensitive Receptor (Dwelling)	00:44	91	0	94:07	27:00:00	00:00
24	Sensitive Receptor (Dwelling)	00:40	66	0	68:52	19:10	00:00
25	Sensitive Receptor (Dwelling)	00:55	138	0	126:48	33:33:00	00:00
26	Sensitive Receptor (Dwelling)	00:55	165	0	145:28	38:53:00	03:22
27	Sensitive Receptor (Dwelling)	00:49	147	4	141:22	37:58:00	03:12
28	Sensitive Receptor (Dwelling)	01:00	118	0	132:46	37:05:00	06:03
29	Sensitive Receptor (Dwelling)	00:32	18	0	69:49	17:36	00:00
30	Sensitive Receptor (Dwelling)	00:33	17	0	79:12	21:48	00:24
31	Sensitive Receptor (Dwelling)	00:36	13	12	67:08	18:30	00:37
32	Sensitive Receptor (Dwelling)	00:47	74	0	104:07	27:35:00	03:41
33	Sensitive Receptor (Dwelling)	00:47	118	0	115:36	29:58:00	05:02

34	Sensitive Receptor (Dwelling)	00:45	107	0	108:48	28:24:00	04:52
35	Sensitive Receptor (Dwelling)	00:49	37	0	68:45	18:45	06:31
36	Sensitive Receptor (Dwelling)	00:45	21	11	63:11	16:17	06:46
37	Sensitive Receptor (Dwelling)	00:30	7	0	25:20	06:25	00:00
38	Derelict	00:57	136	136	115:53	25:06:00	01:06
39	Sensitive Receptor (Dwelling)	02:39	280	246	414:23	116:13:00	04:51
40	Sensitive Receptor (Dwelling)	01:13	129	97	163:24	46:29:00	00:38
41	Sensitive Receptor (Dwelling)	01:05	119	92	135:48	38:32:00	20:05
42	Sensitive Receptor (Dwelling)	01:31	89	69	139:55	41:23:00	05:32
43	Sensitive Receptor (Dwelling)	00:33	23	0	53:45	15:53	03:25
44	Sensitive Receptor (Dwelling)	00:32	14	0	51:17	15:12	03:39
45	Sensitive Receptor (Dwelling)	00:30	4	0	35:12	10:18	02:43
46	Sensitive Receptor (Dwelling)	00:23	0	0	17:14	05:25	00:00
47	Sensitive Receptor (Dwelling)	00:16	0	0	6:57	02:02	00:00
48	Sensitive Receptor (Dwelling)	00:07	0	0	1:53	00:33	00:00
49	Sensitive Receptor (Dwelling)	00:22	0	0	7:13	02:07	00:00
50	Sensitive Receptor (Dwelling)	00:26	0	0	12:39	04:01	00:00
51	Sensitive Receptor (Dwelling)	00:25	0	0	20:26	06:15	00:00
52	Sensitive Receptor (Dwelling)	00:25	0	0	17:56	05:19	00:00
53	Sensitive Receptor (Dwelling)	00:38	28	0	43:32	13:43	00:00

54	Sensitive Receptor (Dwelling)	00:45	69	0	60:34	18:52	00:00
55	Derelict	00:34	23	0	21:25	06:20	00:00
56	Sensitive Receptor (Dwelling)	00:00	0	0	0:00	00:00	00:00
57	Sensitive Receptor (Dwelling)	00:00	0	0	0:00	00:00	00:00
58	Sensitive Receptor (Dwelling)	00:00	0	0	0:00	00:00	00:00
59	Sensitive Receptor (Dwelling)	00:00	0	0	0:00	00:00	00:00
60	Sensitive Receptor (Dwelling)	00:00	0	0	0:00	00:00	00:00
61	Sensitive Receptor (Dwelling)	00:00	0	0	0:00	00:00	00:00
62	Sensitive Receptor (Dwelling)	00:00	0	0	0:00	00:00	00:00
63	Sensitive Receptor (Dwelling)	00:00	0	0	0:00	0:00	00:00
64	Sensitive Receptor (Dwelling)	00:46	46	0	83:48:00	22:10	06:34
65	Sensitive Receptor (Dwelling)	00:24	0	0	115:34	30:43	04:15
66	Sensitive Receptor (Dwelling)	00:25	0	0	10:57	3:29	00:00
67	Sensitive Receptor (Dwelling)	00:24	0	0	19:16	5:50	00:00
68	Sensitive Receptor (Dwelling)	00:01	0	0	0:07	0:02	00:00

Note: Exceedances highlighted in blue in above table.

There are no other existing, permitted or planned wind turbine developments within 4km (i.e. comfortably over 20 times rotor diameter - see Section 10.2.5) of the proposed turbine locations which could contribute to shadow flicker effects[6].

Given that the Applicant has committed to near zero shadow flicker for this project (see Section 10.5), there is will therefore be no potential for noticeable cumulative shadow flicker from the proposed project.

The location of any offsite replanting (alternative afforestation) associated with the project will have no cumulative effects as there is no shadow flicker associated with afforestation.

[6] No wind energy developments submitted for planning or approved based on search of planning records conducted in September 2022.

10.7 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 800m of a proposed turbine location. 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 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 10.5, will ensure that there are no significant post-mitigation effects of shadow flicker on the local community irrespective of which turbine is selected within the turbine range.

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