Pennant Walters Ltd

Mynydd Glyn Wind Farm

Draft Environmental Statement

Chapter 15 Shadow Flicker

This report was prepared by WSP Environment & Infrastructure Solutions UK Limited (formerly known as Wood Environment & Infrastructure Solutions UK Limited), company registration number 02190074, which is carrying out these services as a subcontractor and/or agent to Wood Group UK Limited

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15. Shadow Flicker

15.1 Introduction

15.1.1 This chapter presents the likely significant effects of the Proposed Development with respect to shadow flicker. It should be read in conjunction with the Project description provided in **Chapter 4: Description of the Proposed Development.**

15.1.2 This chapter describes:

- the legislation, policy and technical guidance that has informed the assessment (**Section 15.2**);
- consultation and engagement that has been undertaken and how comments from consultees relating to shadow flicker have been addressed (**Section 15.3**);
- the methods used for baseline data gathering (**Section 15.4**);
- overall baseline (**Section 15.5**);
- embedded measures relevant to shadow flicker (**Section 15.6**);
- the scope of the assessment for shadow flicker (**Section 15.7**);
- the methods used for the assessment (**Section 15.8**);
- the assessment of shadow flicker effects (**Section 15.8.2**);
- assessment of cumulative (inter-project) effects (**Section 15.10**); and
- a summary of the significance conclusions (**Section 15.11**).

Limitations and assumptions

15.1.3 The information provided in this Draft ES is preliminary, the final assessment of likely significant effects will be reported in the ES. The Draft ES has been produced to fulfil Pennant Walters's consultation duties and enable consultees to develop an informed view of the likely significant effects of the Project.

15.1.4 There are no limitations relating to shadow flicker that affect the robustness of the assessment of the potential likely significant effects of the Proposed Development.

15.1.5 The properties were not visited because a worst case scenario has been assessed. An estimate of the number, orientation and location of windows has been made, based on available information such as OS maps, aerial photographs and Google Streetview.

15.2 Relevant legislation, planning policy and technical guidance

15.2.1 This section identifies the legislation, planning policy and technical guidance that has informed the assessment of effects with respect to shadow flicker. Further information on policies relevant to the Proposed Development is provided in **Chapter 5: Legislation and policy overview**.

Planning policy

15.2.2 A summary of the relevant national and local planning policy is given in **Table 15.1**.

Table 15.1 Planning policy relevant to the Shadow Flicker assessment

Policy	Policy context
National planning policy	
National Policy Statement for Renewable Energy Infrastructure (EN3)[1]	National Policy Statement for Renewable Energy Infrastructure (EN3) includes a fuller description of the effect of shadow flicker and more detailed guidance. Paragraph 2.7.63 of EN3 describes shadow flicker as: "*...the effect caused when an operating turbine is located between the sun and a receptor, such as a dwelling or place of work.* *The effect occurs when the shadow of the rotating blades falls over the dwelling causing the light intensity within specific affected rooms of the occupied building to fluctuate."* Paragraph 2.7.64 sets out the factors affecting the potential significance of the effect and goes on to state that: "*Research and computer modelling on flicker effects has demonstrated that there is unlikely to be a significant impact at distances greater than ten rotor diameters from a turbine. Therefore, if the turbine has 90 m diameter blades, the potentially significant shadow flicker effect could be observed up to 900 m from a turbine."* With regard to the requirements of the developer's assessment, paragraph 2.7.66 states: "*Where wind turbines have been proposed within 10 rotor diameters of an existing occupied building, a shadow flicker assessment should be carried out by the applicant.* *The IPC should anticipate that the intensity of the shadow of the rotating blades from turbines at distances from such buildings of 10 rotor diameters and beyond is sufficiently diminished so as to have no significant impact on occupied buildings."* With regard to human health, paragraph 2.7.70 states that: *"The maximum frequency of the shadowing effect from commercial scale wind turbines is less than 1 hertz, which is well below the frequency known to affect sufferers of epilepsy (which is above 2.5 hertz). Therefore, shadow flicker frequencies are not in the region known to induce seizures in sufferers of epilepsy, and as such, where the frequency of potential flashes will not exceed 2.5 hertz..."*
Future Wales: The National Plan [2]	With respect to shadow flicker, this states: *"Policy 18 – Renewable and Low Carbon Energy Developments of National Significance* *… 7. there are no unacceptable adverse impacts by way of shadow flicker, noise, reflected light, air quality or electromagnetic disturbance;"*

[1] Department of Energy and Climate Change (2011). National Policy Statement for Renewable Energy Infrastructure (EN3). (online) Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/37048/1940-nps-renewable-energy-en3.pdf (Accessed September 2022).
[2] Welsh Government (2021). Future Wales: The National Plan 2040. (online) Available at: https://gov.wales/sites/default/files/publications/2021-02/future-wales-the-national-plan-2040.pdf (Accessed September 2022).

Policy	Policy context
Technical Advice Note (TAN) 8: Planning for Renewable Energy (2005) – Para 2.32 (revoked however used as a guide for this assessment)	*"Under particular circumstances the sun may pass behind the rotors of a wind turbine and cast a shadow over neighbouring properties. The shadow flicks on and off as the blades rotate. This can be disturbing for the affected residents or even have the potential of being a health problem for people who are photo-sensitive epileptics.* *The problem is only seasonal and lasts for a few hours per day but needs to be investigated where any potential exists. Developers should provide an analysis of the potential shadow flicker impacting upon nearby properties".*
Local planning policy	
Rhondda Cynon Taff County Borough Council Local Development Plan up to 2021 (Adopted November 2012)[3] **Policy AW 13 - Large Wind Farm Development**	With respect to shadow flicker, there is no content, however the LDP states: *"(The proposal) Is located a minimum of 500 metres away from the nearest residential property unless it can be demonstrated that locating turbines closer to residential properties will have no unacceptable impact on human health;"*

Technical guidance

15.2.3 A summary of the technical guidance for shadow flicker is given in **Table 15.2**.

Table 15.2 Technical guidance relevant to the Shadow Flicker assessment

Technical guidance document	Context
Best Practice Guidance to Planning Policy Statement 18 (PPS 18) Renewable Energy (Northern Ireland Department of the Environment, 2009)[4]	Whilst not strictly applicable in a Welsh context, the guidance in Northern Ireland provided in the draft Best Practice Guidance to Planning Policy Statement 18 (PPS 18) Renewable Energy (Northern Ireland Department of the Environment, 2009) is noteworthy. The draft guidance reaffirms the advice provided by DECC (2011) and the Welsh Government, but further recommends that *"shadow flicker at neighbouring offices and dwellings within 500m should not exceed 30 hours per year or 30 minutes per day."* The recommendation is based on a European Union sponsored study undertaken by Predac (2004), an organisation that promotes best practice in energy use and supply.
Department of Energy and Climate Change, Update of UK Shadow Flicker Evidence Base, 2011[1]	Provides evidence and guidance to support shadow flicker assessments.

[3] Rhondda Cynon Taff County Borough Council (2012). Local Development Plan up to 2021. (Online) Available at: Adopted LDP 2011 (rctcbc.gov.uk) (Accessed September 2022).
[4] Northern Ireland Department of the Environment (2009). Best Practice Guidance to Planning Policy Statement 18 'Renewable Energy'. (online) Available at: https://www.infrastructure-ni.gov.uk/sites/default/files/publications/infrastructure/Best%20Practice%20Guidance%20to%20PPS%2018%20-%20Renewable%20Energy_0.pdf (Accessed September 2022).

15.3 Consultation and engagement

Overview

15.3.1 The assessment has been informed by consultation responses and ongoing stakeholder engagement. An overview of the approach to consultation is provided in **Section 2.4** of **Chapter 2: Approach to Environmental Impact Assessment**.

Scoping Direction

15.3.2 A Scoping Direction was issued by the Planning and Environment Decisions Wales (PEDW, formerly Planning Inspectorate Wales), on behalf of the Welsh Ministers, on 01 December 2021. A summary of the relevant responses received in the Scoping Direction in relation to shadow flicker and confirmation of how these have been addressed within the assessment to date is presented in **Table 15.3**.

Table 15.3 Summary of EIA Scoping Direction responses for shadow flicker

Consultee	Consideration	How addressed in this ES
PEDW	PEDW notes that in "*The approach set out in the SR is considered appropriate. However, see section 6 of this Direction in relation to the application of ten rotor diameters as a cut off*." Section 6 States: *"PEDW notes that in 'Review of Light and Shadow Effects from Wind Turbines in Scotland' (L.U.C. for climateXchange, 2017) it was found that "there is a lack of evidence to support the use of ten rotor diameters as a cut off, and this is entirely down to is interpretation of the original reference to this distance."* *The ES should provide a clear rationale as to the methodology adopted, and why it is considered appropriate given the scale of turbines proposed and the requirement for more nuanced assessment suggested by the concerns raised in the above document."*	The methodology adopted for the Shadow Flicker assessment is recognised as industry best practice and discussed further in **Section 15.8**.

Technical engagement

15.3.3 This Shadow Flicker assessment is a desk based exercise and no technical consultation has been undertaken.

15.4 Data gathering methodology

Study area

15.4.1 The Shadow Flicker assessment comprises numerical modelling of the proposed turbines and receptors within the defined study area. It is noted that whilst there are a number of computer models available, the DECC study (2011)[5] confirms that there are limited differences between outputs of the various packages. For Shadow Flicker assessments, one of the industry standard software packages, ReSoft Wind Farm software (version 4.2.5.2) is used.

15.4.2 The calculations from this assessment process assume a worst-case scenario based on the sun shining during all daylight hours over the course of a year, no obscuring features (such as trees, hedges, other buildings) being present, the face of the rotor always being aligned towards the dwelling, and that the rotor is always turning (i.e. the wind is always blowing between 4m/s and 25m/s, and no account is taken of shut down periods for maintenance). This methodology yields a theoretical maximum indication of potential shadow flicker incidence, together with the times of day, and dates during the year when potential incidence may occur.

15.4.3 The software performs calculations to determine the position of the sun throughout the year, and thus during what times of day it will theoretically cast a shadow across the windows of nearby houses within 10 rotor diameters (plus 50m micrositing). Data input into the model where Shadow Flicker assessment is required is as follows:

- the locations of all properties within ten times the rotor diameter (including an allowance of 50m for micrositing) and 130 degrees either side of north of any turbine;
- the surrounding topography (Ordnance Survey Digital Terrain Model); and
- the locations and dimensions of the turbines.

Desk study

15.4.4 A summary of the organisations that have supplied data, together with the nature of that data is outlined in **Table 15.4**.

Table 15.4 Data sources used to inform the Shadow Flicker assessment

Organisation	Data source	Data provided
Ordinance Survey	Residential properties Location in relation to Proposed Development.	Ordnance Survey (OS) 1:25,000 Mapping
Ordinance Survey	OS Terrain 5[6]	Terrain data

[5] Department of Energy and Climate Change (2011). Update of UK Shadow Flicker Evidence Base. (online) Available at: http://www.decc.gov.uk/assets/decc/What%20we%20do/UK%20energy%20supply/Energy%20mix/Renewable%20energy/ORED/1416-update-uk-shadow-flicker-evidence-base.pdf (Accessed September 2022).

[6] Ordnance Survey (2022). *OS Terrain 50 (Free OS OpenData)*. (online) Available at: https://osdatahub.os.uk/downloads/open/Terrain50 (Accessed 14 January 2022).

Organisation	Data source	Data provided
Google	Google Earth Pro 7.3.4.8248[7]	Aerial imagery

15.5 Overall baseline

Current baseline

15.5.1 As outlined in **Section 15.2** and **15.4** it is considered that shadow flicker does not have a significant effect at properties located at a distance greater than ten rotor diameters from the wind turbines. The turbines under consideration for development at this Site have rotor diameters of up to 132m, meaning a study area of 1,320m. We have also allowed 50m for micrositing, giving a total study area of 1,370m.

15.5.2 Properties falling within this baseline will be assessed with regards to the potential to experience shadow flicker. The study area is shown in **Figure 15.1**. None of the properties considered currently experience shadow flicker from other wind farm developments.

Future baseline

15.5.3 On the basis of the information currently available, no changes to the baseline conditions are anticipated in the event that the Proposed Development does not proceed.

15.6 Embedded measures

15.6.1 There are no UK guidelines which quantify what exposure levels to shadow flicker would be acceptable. Therefore, where particular combinations of circumstances arise that have the potential for nuisance (particularly where rooms affected are in regular occupancy and the effect proves to be a frequent occurrence in reality), measures may be required to reduce the level of exposure to acceptable levels.

15.6.2 If shadow flicker effects occur in practice at a particular occupied building, it does not immediately follow that additional mitigation is required. Such effects would need to occur in a room that was occupied at the times of occurrence and for a duration that caused a nuisance. For example, if an effect was predicted to occur for a three-week period in the early hours of the morning in a room unlikely to be occupied at that time, with each occurrence lasting just a few minutes, then it is unlikely that mitigation measures would be needed.

15.6.3 However, until the turbine locations and technical parameters are precisely defined (following micrositing and turbine selection through competitive tender activities), and the wind turbines are operating, neither the requirement for, nor the exact details of mitigation can be finalised.

15.6.4 The Applicant is committed to installing a shadow flicker impact control module prior to operation to turbines which have the potential to cause shadow flicker on nearby properties. Therefore if, following a complaint and appropriate investigation, shadow flicker is confirmed to result in a loss of residential amenity at any location, the technical

[7] Google (2021). *Google Earth Pro, version 7.3.4.8248*. (online) Available at: https://www.google.com/earth/download/gep/agree.html?hl=en-GB (Accessed 13 January 2021).

mitigation measures built into these turbines would be activated. This covers all properties that could experience shadow flicker.

15.6.5 The shadow flicker control module consists of bespoke software, a clock, a timer, a switch, a wind direction sensor and a light sensor. The module can control a specific turbine (or turbines) which would be programmed to shut down on specific dates at specific times when the sun is bright enough, there is sufficient wind to rotate the blades and the wind direction is such that nuisance shadow flicker could occur. There is no specific UK guidance regarding what level of light is sufficient to cause a shadow flicker event. However, the actual light level that would trigger a turbine shut down can be manually configured onsite, following installation, to reflect local conditions.

15.6.6 A planning condition would provide for an appropriate form of mitigation to ensure that any complaints would be investigated within a reasonable timescale and that the rectification of any shadow flicker problem that is substantiated would be implemented promptly and effectively. As noted previously, the DECC guidance (2011) states that *"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".*

15.6.7 **Table 15.5** describes the environmental measures embedded within the Proposed Development and how these embedded measures will influence the Shadow Flicker assessment.

Table 15.5 Summary of the embedded environmental measures related to shadow flicker

Receptor	Potential changes and effects	Embedded measures and influence on assessment	Compliance mechanism
Residential and/or occupied buildings within the study area	Experiencing shadow flicker effects	Implementation of a shadow flicker control module will reduce effects to an acceptable level	DNS planning condition

15.7 Scope of the assessment

The Proposed Development

15.7.1 The approach to Shadow Flicker assessment as set out in **Section 15.4** was outlined in the Scoping Report. It was stated that following determination of the final turbine layout for the Proposed Development, an assessment would be carried out if potential shadow flicker receptors were identified.

15.7.2 No shadow flicker effects would arise from the proposed grid connection. This element of the Proposed Development is therefore not considered further in this chapter.

Spatial scope

15.7.3 The spatial scope of the assessment of shadow flicker covers the area of the Proposed Development contained within the Site red line boundary, together with the Zones of Influence (ZoIs) that have formed the basis of the study area described in **Section 15.4**.

Temporal scope

15.7.4 Shadow flicker is an operational effect of the wind farm and is not present during construction or decommissioning. Therefore, the temporal scope of the assessment of shadow flicker is consistent with the period over which the development would be carried out and therefore covers the operational period of the wind farm.

Potential receptors

15.7.5 The shadow flicker receptors that have been identified as being potentially subject to effects are summarised in **Table 15.6**.

Table 15.6 Shadow Flicker receptors subject to potential effects

Receptor	Reason for consideration
Residential receptors	Considered of high sensitivity with respect to shadow flicker

15.7.6 The residential receptors considered further in this assessment are detailed in **Table 15.7**.

Table 15.7 Potential residential receptors

Reference	Receptor Name	Easting	Northing
1	Rhiw-garn-fach Farm	302509	189598
2	Home Farm, east of Trebanog	302409	189511
3	Glyn, northeast of Tonyrefail	302391	188873
4	Lan, north of Castellau Uchaf	304017	187986
5	Cefn-coed Farm	304447	188618
6	Tyla-winder Farm	304702	188812
7	Brookland Bungalow, south of Trefahod	304198	190618
8	Henllys, Trebanog	302103	189730
9	Craig Crescent, Trebanog	301625	190472
10	Concorde Drive, Tonyrefail	302052	188644
11	Llys Tylcha Fawr, Tonyrefail	301199	188032
12	Plas-Rhiwinder, adjacent to Bryngwion House	302394	187950
13	Tre-boeth Farm	302543	188333
14	Mountain View, east of Ynys Crug Stud Farm	303075	187396
15	Rackett Cottages, west of Castallau Uchaf	303668	187558
16	Twin Pines, Maesycoed	306209	189402

Reference	Receptor Name	Easting	Northing
17	Rheolau Terrace, Trehafod	306367	190056
18	Glynfach, Porth	302958	190664
19	Kensington Drive, Porth	303400	190909
20	Gwaun Bedw, Cymmer	302346	190389
21	Langton Court Farm	304440	188953
22	Ty-draw Farm	305105	188699
23	Gelli-wion	305579	189006
24	Langton Court Farm Cottage	304428	188969

Likely significant effects

15.7.7 Shadow flicker is a potential operational effect of the Proposed Development (with no effects during construction or decommissioning).

Photo Sensitive Epilepsy

15.7.8 Research has been carried out to determine whether shadow flicker from wind turbines can cause seizures in photo-sensitive epilepsy sufferers[8]. Sufferers are usually sensitive to flickering light at frequencies from 3Hz–60Hz. For a typical 3-blade, 45m rotor diameter wind turbine the maximum rotational speed will be less than 20 revolutions per minute so the blade passing frequency is 60rpm, or 1Hz; this is well below the 3Hz–60Hz sensitivity range.

15.7.9 The proposed turbines will operate at varying speeds, up to 15 RPM. As the turbine rotors will have three blades, each blade will pass a particular point no more than 45 times a minute, which equates to a maximum frequency of 0.75 Hertz. This is much lower than the 3-60 Hertz frequency range generally thought to risk triggering photo-sensitive epilepsy. It is also noted in the DECC Report (2011)[5] that "*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*".

15.7.10 Therefore photo-sensitive epilepsy is not considered further in this assessment.

15.8 Assessment methodology

15.8.1 The generic project-wide approach to the assessment methodology is set out in **Chapter 2: Approach to Environmental Impact Assessment** and specifically in **Sections 2.5** to **2.8**. However, whilst this has informed the approach that has been used in this Shadow Flicker assessment, it is necessary to set out how this methodology has been applied, and adapted as appropriate, to address the specific needs of this Shadow Flicker assessment.

15.8.2 The assessment approach recommended within both national and local planning guidance – recognised as industry best practice - is for the assessment of shadow flicker

[8] Harding G, Harding P, and Wilkins A, (2008): Wind turbine, flicker, and photosensitive epilepsy: Characterizing the flashing that may precipitate seizures and optimizing guidelines to prevent them. (online) Available at: https://onlinelibrary.wiley.com/doi/10.1111/j.1528-1167.2008.01563.x (Accessed September 2022).

effects to be carried out at properties within 130 degrees either side of north and 10 rotor diameter distance from the nearest property. It is considered that this approach is appropriate and proportionate based on the national guidance defined significance thresholds as discussed in the next section, of greater than 30 minutes a day or greater than 30 hours per year at the affected receptors, fall well within the 10 rotor diameter distance. A study area of 1,370m from each turbine has therefore been adopted for the Shadow Flicker assessment in order to include land within 10 times the maximum rotor diameter (based on a 132m rotor diameter in line with the worst-case access study scenario) plus a 50m micro-siting allowance.

Significance evaluation methodology

15.8.3 The EIA Regulations require that a final judgement is made about whether or not each effect is likely to be significant. In this assessment, effects are considered to be significant or not significant according to the matrix in **Table 15.8.**

15.8.4 Whilst the time and duration of shadow flicker events can be predicted accurately, the level of the effect is difficult to quantify as this would depend on the location of windows within a property, the use of the rooms affected, the level of shading surrounding the property and how susceptible the receptor is to light flicker.

15.8.5 As confirmed by the DECC study (2011)[5], there is no standard UK or Welsh guidance relating to a limit for shadow flicker. The only guidance providing additional recommendations is the aforementioned Northern Irish PPS 18 (2009) guidance which recommends that for properties within 500m of the turbines, shadow flicker should not exceed 30 hours per year or 30 minutes per day.

15.8.6 For the purpose of this assessment, once the effect of theoretical shadow flicker has been modelled, the approach to establishing the magnitude of change is based on professional judgement.

15.8.7 Significance is typically defined as a function of the sensitivity of a receptor with the magnitude of change. In this case the sensitivity of the receptor (an occupied building) is considered to be high and as such significance will be defined largely as a function of the magnitude of change. A methodology for the establishment of the magnitude of change has therefore been derived based on professional experience and is presented in **Table 15.8.** This is based on the distance of the property from the turbine location along with the number of predicted hours of shadow flicker effect.

Table 15.8 Scoring Methodology for Magnitude of Change

Magnitude of Change	Distance from Turbine	And / Or	Predicted Shadow Flicker Effect Duration
High	<500m		>30 minutes a day or >30 hours per year.
Medium	500 – 700m		>30 minutes a day or >30 hours per year.
Low	700m – 1,550m		<30 minutes a day or <30 hours per year.
No Change	>1,550m		No shadow flicker effect predicted.

15.8.8 The EIA Regulations require that a final judgement is made about whether or not each effect is likely to be significant. In this assessment, effects are considered to be significant or not significant according to the matrix in **Table 15.9**. Effects are rated as being either major or moderate (significant) where the magnitude of change is high or medium, or minor or negligible (not significant) where magnitude of change is low, or no change.

Table 15.9 Matrix of EIA Significance

	Magnitude of change			
Sensitivity	**High**	**Medium**	**Low**	**No change**
High	Major (Significant)	Moderate (Significant)	Minor (Not Significant)	Negligible (Not significant)

Factors limiting the occurrence of shadow flicker

15.8.9 There are several additional factors that can influence the amount of shadow flicker actually experienced and these cannot be readily included in a computer-based assessment.

15.8.10 Climatic conditions dictate that the sun is not always shining. The closest Met Office location providing long term climate summaries is Tredegar, located some 13km from the Site.

15.8.11 Historic Met Office data (over the period 1991–2020) gives actual sunshine hours for the Tredegar Met Station to be 32% of total daylight hours[9]. Cloud cover during other times may obscure the sun and prevent shadow flicker occurrence. While some shadows may be cast under slightly overcast conditions, no shadow at all would be cast when heavy cloud cover prevails. During calm periods, or very high winds, the wind turbine blades would not rotate and shadow flicker would not occur. Turbines would also be periodically shut-down for maintenance or repair work.

15.8.12 Wind turbines automatically orientate themselves to face the prevailing wind direction. This means that the turbine rotors would not always face directly towards the occupied buildings. Under some wind conditions, the proposed turbines would face 'side-on' to properties, and in these conditions only a very small area of blade movement would be visible.

15.9 Preliminary assessment of shadow flicker effects

Baseline conditions

15.9.1 Baseline conditions are discussed in **Section 15.5**.

Predicted effects: operation

15.9.2 **Figure 15.2** shows a contour map representing the annual number of hours of potential shadow flicker effects on the occupied buildings included in the assessment.

[9] Met Office (2022). UK Climate Averages: Blaenau Gwent. (online) Available at: https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/gcjww0udy
Average sunshine hours of 1422 / Total number of daylight hours 4380 = 32% (Accessed 21 January 2022)

15.9.3 **Table 15.10** below shows the number of days per year that each occupied building could be affected by shadow flicker. It also shows the maximum number of hours per day, the mean number of hours per day and the total number of hours per year that shadow flicker could occur. The likely number of hours per year when shadow flicker could occur has been calculated using Met Office records of the number of annual sunshine hours per year at Tredegar. Individual results for each receptor are provided in **Appendix 15A.**

Table 15.10 Shadow Flicker Model Results

ID	Days / Year	Turbine(s) causing shadow flicker	Distance to nearest turbine (m)	Mean no. of minutes / day	Theoretical max hours / year	Likely hours / year[1]
1	204	1, 3, 6, 7	442	35.4	119.8	38.3
2	149	1, 3, 4, 6, 7	567	28.2	70.6	22.6
3	130	6, 7	688	36	77.8	24.9
4	0	-	1,104	0	0	0.0
5	90	7	805	30	44.7	14.3
6	33	7	768	21.6	11.8	3.8
7	36	2	1,013	25.2	15	4.8
8	155	1, 2, 3, 6	827	27.6	70.6	22.6
9	0	-	1,498	0	0	0.0
10	80	6	1,073	28.8	38.2	12.2
11	0	-	2,099	0	0	0.0
12	0	-	1,236	0	0	0.0
13	0	-	838	0	0	0.0
14	0	-	1,589	0	0	0.0
15	0	-	1,424	0	0	0.0
16	0	-	2,024	0	0	0.0
17	0	-	2,284	0	0	0.0
18	43	2	794	31.2	22.2	7.1
19	62	1, 2	909	37.8	38.9	12.4
20	76	1, 2, 3	876	26.4	33.1	10.6
21	48	7	497	27.6	22	7.0
22	0	-	1,144	0	0	0.0
23	0	-	1,443	0	0	0.0

ID	Days / Year	Turbine(s) causing shadow flicker	Distance to nearest turbine (m)	Mean no. of minutes / day	Theoretical max hours / year	Likely hours / year[1]
24	87	3, 7	477	24	35	11.2

[1] Based on average sunshine hours at the site, 32% of daylight hours.

15.9.4 The approach taken to the modelling assessment is theoretical and based on the worst-case scenario in that it assumes each property is occupied, that there are windows or doors facing the wind turbines, that there are no intervening obstructions, that the sun shines throughout daylight hours, that the wind blows constantly within the operating parameters of the wind turbines and that the rotor is always orientated towards the receptor.

15.9.5 The results show that all the turbines apart from T5 have the potential to cause shadow flicker effects.

15.9.6 Examination of the detailed results of the model found in **Appendix 15A** shows that receptors 4, 9, 11, 12, 13, 14, 15, 16, 17, 22, and 23 would not experience any shadow flicker as a result of the development. The remaining 13 receptors could experience between 11.8 and 119.8 hours of shadow flicker per year, based on the worst-case model.

15.9.7 If average annual sunshine hours are applied to the model, then all currently occupied buildings are likely to experience shadow flicker for no more than 38.3 hours per annum.

15.9.8 Due to the number of properties in the study area, a selection of properties has been chosen to illustrate the potential effects of shadow flicker. As many of the properties are grouped close together and experience similar levels of potential effect, a sample property has been chosen from each group. The representative property has the highest predicted levels of effect within the group. The groupings are shown below in **Table 15.11**.

Table 15.11 Shadow Flicker Model Results Groups

Grouping	Description of Group	Properties included (ID)	Representative property ID
1	Rhiw-garn-fach Farm	1	1
2	Home Farm, east of Trebanog	2	2
3	Glyn, northeast of Tonyrefail	3	3
4	Cefn-coed Farm	5	5
5	Tyla-winder Farm	6	6
6	Brookland Bungalow, south of Trefahod	7	7
7	Henllys, Trebanog	8	8
8	Concorde Drive, Tonyrefail	10	10
9	Glynfach, Porth	18	18
10	Kensington Drive, Porth	19	19

Grouping	Description of Group	Properties included (ID)	Representative property ID
11	Gwaun Bedw, Cymmer	20	20
12	Langton Court Farm	21 and 24	24

Receptor group 1

15.9.9 The model shows that receptor 1 could experience shadow flicker effects from turbine 1 for an average duration of 43 minutes from late May until late July between the hours of 05.39 and 06.39.

15.9.10 The model shows that receptor 1 could experience shadow flicker effects from turbine 3 for an average duration of 36 minutes from late March until mid April between the hours of 07.23 and 08.08 and from early September until late September between the hours of 07.13 and 07.58.

15.9.11 The model shows that receptor 1 could experience shadow flicker effects from turbine 6 for an average duration of 30 minutes from mid January until mid February between the hours of 09.09 and 09.48 and from mid October until late October between the hours of 08.39 and 09.18.

15.9.12 The model shows that receptor 1 could experience shadow flicker effects from turbine 7 for an average duration of 19 minutes from mid February until early March between the hours of 08.13 and 08.41 and from late October until late October between the hours of 07.44 and 08.12.

15.9.13 In total the property could experience up to 119.8 hours per year of potential shadow flicker. Based on the significance criteria presented in **Section 15.4**, the effect on this property would be High and therefore significant according to **Table 15.9**. However, as stated in **Section 15.6**, the developer is committed to installing a shadow flicker control module where required. This module can control a specific turbine (or turbines) which would be programmed to shut down on specific dates at specific times when the sun is bright enough, there is sufficient wind to rotate the blades and the wind direction is such that nuisance shadow flicker could occur. The effects are therefore concluded as not significant once this mitigation is taken into consideration.

Receptor group 2

15.9.14 The model shows that receptor 2 could experience shadow flicker effects from turbine 1 for an average duration of 16 minutes from early June until early July between the hours of 05.32 and 05.55.

15.9.15 The model shows that receptor 2 could experience shadow flicker effects from turbine 3 for an average duration of 31 minutes from late March until late April between the hours of 06.56 and 07.37 and from late August until mid September between the hours of 06.54 and 07.35.

15.9.16 The model shows that receptor 2 could experience shadow flicker effects from turbine 4 for an average duration of 8 minutes mid April between the hours of 06.34 and 06.49 and late August between the hours of 06.35 and 06.51.

15.9.17 The model shows that receptor 2 could experience shadow flicker effects from turbine 6 for an average duration of 29 minutes from early February until early March between the hours of 08.40 and 09.18 and from mid October until early November between the hours of 08.10 and 08.48.

15.9.18 The model shows that receptor 2 could experience shadow flicker effects from turbine 7 for an average duration of 20 minutes from late February until mid March between the hours of 07.54 and 08.20 and from early October until mid October between the hours of 07.28 and 07.55.

15.9.19 In total the property could experience up to 70.6 hours per year of potential shadow flicker. Based on the significance criteria presented in **Section 15.4**, the effect on this property would be Medium and therefore significant according to **Table 15.9**. However, as stated in **Section 15.6**, the developer is committed to installing a shadow flicker control module where required. This module can control a specific turbine (or turbines) which would be programmed to shut down on specific dates at specific times when the sun is bright enough, there is sufficient wind to rotate the blades and the wind direction is such that nuisance shadow flicker could occur. The effects are therefore concluded as not significant once this mitigation is taken into consideration.

Receptor group 3

15.9.20 The model shows that receptor 3 could experience shadow flicker effects from turbine 6 for an average duration of 38 minutes from early May until mid August between the hours of 06.00 and 06.56.

15.9.21 The model shows that receptor 3 could experience shadow flicker effects from turbine 7 for an average duration of 22 minutes from mid April until early May between the hours of 06.00 and 06.56 and from early August until late August between the hours of 06.14 and 06.43.

15.9.22 In total the property could experience up to 77.8 hours per year of potential shadow flicker. Based on the significance criteria presented in **Section 15.4**, the effect on this property would be Medium and therefore significant according to **Table 15.9**. However, as stated in **Section 15.6**, the developer is committed to installing a shadow flicker control module where required. This module can control a specific turbine (or turbines) which would be programmed to shut down on specific dates at specific times when the sun is bright enough, there is sufficient wind to rotate the blades and the wind direction is such that nuisance shadow flicker could occur. The effects are therefore concluded as not significant once this mitigation is taken into consideration.

Receptor group 4

15.9.23 The model shows that receptor 5 could experience shadow flicker effects from turbine 7 for an average duration of 29 minutes from early May until early August between the hours of 18.29 and 19.13.

15.9.24 In total the property could experience up to 44.7 hours per year of potential shadow flicker. Based on the significance criteria presented in **Section 15.4**, the effect on this property would be Medium and therefore significant according to **Table 15.9**. However, as stated in **Section 15.6**, the Applicant is committed to installing a shadow flicker control module where required. This module can control a specific turbine (or turbines) which would be programmed to shut down on specific dates at specific times when the sun is bright enough, there is sufficient wind to rotate the blades and the wind direction is such that nuisance shadow flicker could occur. The effects are therefore concluded as not significant once this mitigation is taken into consideration.

Receptor group 5

15.9.25 The model shows that receptor 6 could experience shadow flicker effects from turbine 7 for an average duration of 21 minutes from mid April until late April between the hours of

17.56 and 18.24 and from mid August until late August between the hours of 18.00 and 18.28.

15.9.26 In total the property could experience up to 11.8 hours per year of potential shadow flicker. Based on the significance criteria presented in **Section 15.4**, the effect on this property would be Low and therefore not significant according to **Table 15.9**.

Receptor group 6

15.9.27 The model shows that receptor 7 could experience shadow flicker effects from turbine 2 for an average duration of 25 minutes from mid February until early March between the hours of 15.29 and 16.01 and from mid October until late October between the hours of 15.01 and 15.33.

15.9.28 In total the property could experience up to 15 hours per year of potential shadow flicker. Based on the significance criteria presented in **Section 15.4**, the effect on this property would be Low and therefore not significant according to **Table 15.9**.

Receptor group 7

15.9.29 The model shows that receptor 8 could experience shadow flicker effects from turbine 1 for an average duration of 30 minutes from early April until late April between the hours of 06.16 and 06.56 and from mid August until mid September between the hours of 06.16 and 06.56.

15.9.30 The model shows that receptor 8 could experience shadow flicker effects from turbine 2 for an average duration of 19 minutes from mid April until early May between the hours of 05.36 and 06.02 and from early August until late August between the hours of 05.42 and 06.08.

15.9.31 The model shows that receptor 8 could experience shadow flicker effects from turbine 3 for an average duration of 22 minutes from early March until late March between the hours of 07.21 and 07.50 and from late September until early October between the hours of 07.02 and 07.31.

15.9.32 The model shows that receptor 8 could experience shadow flicker effects from turbine 6 for an average duration of 21 minutes from late January until mid February between the hours of 08.30 and 08.58 and from late October until mid November between the hours of 08.00 and 08.28.

15.9.33 In total the property could experience up to 70.6 hours per year of potential shadow flicker. Based on the significance criteria presented in **Section 15.4**, the effect on this property would be Medium and therefore significant according to **Table 15.9**. However, as stated in **Section 15.6**, the Applicant is committed to installing a shadow flicker control module where required. This module can control a specific turbine (or turbines) which would be programmed to shut down on specific dates at specific times when the sun is bright enough, there is sufficient wind to rotate the blades and the wind direction is such that nuisance shadow flicker could occur. The effects are therefore concluded as not significant once this mitigation is taken into consideration.

Receptor group 8

15.9.34 The model shows that receptor 10 could experience shadow flicker effects from turbine 6 for an average duration of 28 minutes from mid May until late July between the hours of 05.25 and 06.05.

15.9.35 In total the property could experience up to 38.2 hours per year of potential shadow flicker. Based on the significance criteria presented in **Section 15.4**, the effect on this property would be Medium and therefore significant according to **Table 15.9**. However, as stated in **Section 15.6**, the Applicant is committed to installing a shadow flicker control module where required. This module can control a specific turbine (or turbines) which would be programmed to shut down on specific dates at specific times when the sun is bright enough, there is sufficient wind to rotate the blades and the wind direction is such that nuisance shadow flicker could occur. The effects are therefore concluded as not significant once this mitigation is taken into consideration.

Receptor group 9

15.9.36 The model shows that receptor 18 could experience shadow flicker effects from turbine 2 for an average duration of 31 minutes from early February until late February between the hours of 09.56 and 10.35 and from mid October until early November between the hours of 09.26 and 10.05.

15.9.37 In total the property could experience up to 22.2 hours per year of potential shadow flicker. Based on the significance criteria presented in **Section 15.4**, the effect on this property would be Medium and therefore significant according to **Table 15.9**. However, as stated in **Section 15.6**, the Applicant is committed to installing a shadow flicker control module where required. This module can control a specific turbine (or turbines) which would be programmed to shut down on specific dates at specific times when the sun is bright enough, there is sufficient wind to rotate the blades and the wind direction is such that nuisance shadow flicker could occur. The effects are therefore concluded as not significant once this mitigation is taken into consideration.

Receptor group 10

15.9.38 The model shows that receptor 19 could experience shadow flicker effects from turbine 1 for an average duration of 17 minutes from mid January until late January between the hours of 13.34 and 14.03 and from mid November until late November between the hours of 13.14 and 13.40.

15.9.39 The model shows that receptor 19 could experience shadow flicker effects from turbine 2 for an average duration of 29 minutes from mid January until mid February between the hours of 12.05 and 12.41 and from late October until late November between the hours of 11.37 and 12.13.

15.9.40 In total the property could experience up to 38.9 hours per year of potential shadow flicker. Based on the significance criteria presented in **Section 15.4**, the effect on this property would be Medium and therefore significant according to **Table 15.9**. However, as stated in **Section 15.6**, the Applicant is committed to installing a shadow flicker control module where required. This module can control a specific turbine (or turbines) which would be programmed to shut down on specific dates at specific times when the sun is bright enough, there is sufficient wind to rotate the blades and the wind direction is such that nuisance shadow flicker could occur. The effects are therefore concluded as not significant once this mitigation is taken into consideration.

Receptor group 11

15.9.41 The model shows that receptor 20 could experience shadow flicker effects from turbine 1 for an average duration of 28 minutes from early February until early March between the hours of 09.23 and 09.59 and from mid October until early November between the hours of 08.53 and 09.30.

15.9.42 The model shows that receptor 20 could experience shadow flicker effects from turbine 2 for an average duration of 23 minutes from mid March until late March between the hours of 07.42 and 08.11 and from mid September until late September between the hours of 07.27 and 07.56.

15.9.43 The model shows that receptor 20 could experience shadow flicker effects from turbine 3 for an average duration of 16 minutes from early February until mid February between the hours of 09.27 and 09.52 and from late October until early November between the hours of 08.57 and 09.22.

15.9.44 In total the property could experience up to 33.1 hours per year of potential shadow flicker. Based on the significance criteria presented in **Section 15.4**, the effect on this property would be Medium and therefore significant according to **Table 15.9**. However, as stated in **Section 15.6**, the Applicant is committed to installing a shadow flicker control module where required. This module can control a specific turbine (or turbines) which would be programmed to shut down on specific dates at specific times when the sun is bright enough, there is sufficient wind to rotate the blades and the wind direction is such that nuisance shadow flicker could occur. The effects are therefore concluded as not significant once this mitigation is taken into consideration.

Receptor group 12

15.9.45 The model shows that receptor 24 could experience shadow flicker effects from turbine 3 for an average duration of 19 minutes from late April until mid August between the hours of 18.37 and 19.12.

15.9.46 The model shows that receptor 24 could experience shadow flicker effects from turbine 7 for an average duration of 27 minutes from late March until mid April between the hours of 17.32 and 18.08 and from late August until mid September between the hours of 17.29 and 18.05.

15.9.47 In total the property could experience up to 35 hours per year of potential shadow flicker. Based on the significance criteria presented in **Section 15.4**, the effect on this property would be Medium and therefore significant according to **Table 15.9**. However, as stated in **Section 15.6**, the Applicant is committed to installing a shadow flicker control module where required. This module can control a specific turbine (or turbines) which would be programmed to shut down on specific dates at specific times when the sun is bright enough, there is sufficient wind to rotate the blades and the wind direction is such that nuisance shadow flicker could occur. The effects are therefore concluded as not significant once this mitigation is taken into consideration.

Predicted effects and their significance

15.9.48 A summary of the results of the assessment of shadow flicker is provided in **Table 15.12.**

Table 15.12 Summary of significance of adverse effects

Receptor and summary of predicted effects	Sensitivity of receptor[1]	Magnitude of change[2]	Significance[3]	Summary rationale
Shadow flicker effects on residential property:	High	High	Major (Not significant following mitigation)	Although, according to **Table 15.9**, any shadow flicker effects would be investigated and fully mitigated through a shadow

Receptor and summary of predicted effects	Sensitivity of receptor[1]	Magnitude of change[2]	Significance[3]	Summary rationale
one occupied building				flicker control module in turbines. No significant effects would therefore arise.
Shadow flicker effects on residential property: nine occupied buildings	High	Medium	Moderate (Not significant following mitigation)	Although, according to **Table 15.9**, any shadow flicker effects would be investigated and fully mitigated through a shadow flicker control module in turbines. No significant effects would therefore arise.
Shadow flicker effects on residential property: three occupied buildings	High	Low	Minor (Not significant)	Modelling has shown that significant effects are considered unlikely. Any shadow flicker effects would be fully mitigated through a shadow flicker control module in turbines.
Shadow flicker effects on residential property: eleven occupied buildings	High	No change	Negligible (Not significant)	

1. The sensitivity of a receptor is defined using the criteria set out in **Section 15.4** above and is defined as high
2. The magnitude of change on a receptor resulting from activities relating to the development is defined using the criteria set out in **Section 15.4** above and is defined as no change, low, medium and high
3. The significance of the environmental effects is based on the combination of the sensitivity/importance/value of a receptor and the magnitude of change and is expressed as major (significant), moderate (significant) or minor/negligible (not significant), subject to the evaluation methodology outlined in **Section 15.4**.

15.10 Preliminary assessment of cumulative (inter-project) effects

15.10.1 Due to their location and distance from the Proposed Development, and as shadow flicker effects would be mitigated via control modules on turbines as appropriate, and no significant effects are concluded as a result of the Proposed Development, no cumulative effects are expected in combination with other wind farm developments.

15.11 Preliminary Significance conclusions

15.11.1 A summary of the results of the preliminary Shadow Flicker assessment is provided in **Table 15.10**.

15.11.2 The assessment has identified the potential for significant shadow flicker effects at ten occupied buildings, and non-significant effects at 14 occupied buildings. Mitigation has been identified in the form of a control system which automatically shuts down the wind

turbine causing the effect to restrict effects to less than 30 minutes per day and / or 30 hours per year at any property.

15.11.3 With this measure in place no significant effects from shadow flicker would arise as a result of the Proposed Development.

15.11.4 A programme of monitoring would ensure the effectiveness of the proposed mitigation and allow for it to be adapted, e.g. to cater for turbine micrositing issues.

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