Parc Ynni Calon y Gwynt

ENVIRONMENTAL STATEMENT

Chapter 13 Shadow Flicker

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13 SHADOW FLICKER

13.1 INTRODUCTION

13.1.1. This chapter presents the assessment of the likely significant effects of the Proposed Development with respect to Shadow Flicker. The assessment is based on information obtained to date. This chapter should be read in conjunction with the development description provided in **Chapter 4: Description of the Proposed Development**.

13.1.2. This chapter describes:

- The legislation, policy and technical guidance that has informed the assessment **(Section 13.2**);
- Consultation and engagement that has been undertaken and how comments from consultees relating to shadow flicker have been addressed (**Section 13.3**);
- The methods used for baseline data gathering (**Section 13.4**);
- Overall baseline (**Section 13.5**);
- Embedded measures relevant to shadow flicker (**Section 13.6**);
- The scope of the assessment for shadow flicker (**Section 13.7**);
- The methods used for the assessment (**Section 13.8**);
- The assessment of shadow flicker effects (**Section 13.9**);
- The assessment of cumulative (inter-project) effects (**Section 13.10**); and
- A summary of the significance conclusions (**Section 13.11**);

LIMITATIONS AND ASSUMPTIONS

13.1.3. 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.

13.1.4. The properties considered in the Shadow Flicker assessment were not visited because a realistic worst-case scenario has been assessed. The realistic worse worst-case scenario assumes that for all properties, one window at ground level is always perpendicular to the wind turbines e.g. facing the wind turbines. The model and results therefore assume that at least 1 window in each property will always be oriented in a direction that allows shadow flicker effects to occur. In reality, some properties may not have windows oriented in a direction that allows shadow flicker effects to occur. In addition, the worst-case results are based on a ‘bare earth’ digital terrain model (DTM) that does not account for screening from vegetation or other obstacles, which may prevent or limit views of the turbines further reducing the potential for shadow flicker in reality.

13.2 RELEVANT LEGISLATION, PLANNING POLICY AND TECHNICAL GUIDANCE

13.2.1. This section identifies the legislation, planning policy and technical guidance that has informed the assessment of effects with respect to shadow flicker.

PLANNING POLICY

13.2.2. A summary of the relevant national and local planning policy is provided in **Table 13-1** below.

Table 13-1 - Planning Policy Relevant to the Shadow Flicker Assessment

Policy	Policy Context
National Planning Policy	
Future Wales: The National Plan 2040[1]	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;"*
Local Planning Policy	
Powys County Council: The Replacement Local Development Plan (2022-2037)	This document is set to supersede the adopted Local Development Plan (2011-2026) but at the time of writing, is not yet available.
Powys County Council: Local Development Plan (2011-2026)[2]	Paragraph 4.10.13 pertains to shadow flicker and states: *All renewable energy proposals and associated infrastructure, such as power lines or battery storage facilities, must respect the existence and amenities of neighbouring residential and sensitive properties including approved development. This is particularly the case when it comes to 'shadow flicker', reflected light or noise from wind turbines, 'glint and glare' from solar developments, and odour associated with anaerobic digestion.*

[1] 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 April 2026).

[2] Powys County Council (2018). Local Development Plan 2011-2026 (Adopted April 2018) (online). Available at: https://en.powys.gov.uk/article/4898/Adopted-LDP-2011---2026 (Accessed April 2026).

TECHNICAL GUIDANCE

13.2.3. A summary of the technical guidance for shadow flicker is provided in **Table 13-2** below.

Table 13-2 - 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)[3]	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[4]	Provides an evidence base supporting the commonly adopted quantitative thresholds and confirms that predicted shadow flicker effects are generally manageable through appropriate siting, assessment and mitigation. The technical conclusions are considered transferable and consistent with good practice. The report states that…. *"the 10 rotor diameter rule has been widely accepted across different European countries, and is deemed to be an appropriate assessment area, although there is potentially a need to differentiate between appropriate assessment areas at different latitudes. This is an area where the scientific evidence base could be readdressed."* *"Across Europe and further afield, different countries have varying guidance on shadow flicker assessment. In all countries investigated where shadow flicker is a perceived issue, it falls under the remit of "best practice" guidelines rather than regulatory policy. Some countries have adopted quantitative guidance, with limits on the flicker that can result from a development."* *"Mitigation measures adopted by developers have been successful. Careful site design to eliminate shadow impacts is important, with mitigation measures such as turbine shut down systems being used regularly. These systems are acceptable for all parties, and by virtue of their success, the issue of shadow flicker appears to be minor. Mitigation measures are often put into planning conditions."*

[3] 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 May 2026).

[4] Department of Energy and Climate Change (2010). Update of UK Shadow Flicker evidence base (online). Available at: https://assets.publishing.service.gov.uk/media/5a79770bed915d0422068aa3/1416-update-uk-shadow-flicker-evidence-base.pdf (Accessed May 2026).

13.2.4. It should be noted that the 10-rotor diameter study and quantitative thresholds of 30 minutes per day or 30 hours per year (worst-case and referenced above) are frequently used as part of industry good practise methodologies in the UK and internationally (see Section 13.4 for further information)

13.3 CONSULTATION AND ENGAGEMENT

OVERVIEW

13.3.1. The assessment has been informed by consultation response and ongoing stakeholder engagement. An overview of the approach to consultation is provided in **Section 2.4** of **Chapter 2: Approach to EIA**.

SCOPING DIRECTION

13.3.2. A Scoping Direction (**Appendix 1B**) was issued by PEDW on behalf of the Welsh Ministers, on 14 May 2025. 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 13-3.**

Table 13-3 - Summary of EIA Scoping Direction Responses for Shadow Flicker

Consultee	Consideration	How Addressed in this Draft ES
PEDW	*Shadow Flicker: PEDW notes that in 'Review of Light and Shadow Effects from Wind Turbines in Scotland' (https://www.climatexchange.org.uk/projects/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 misinterpretation of the original reference to this distance."*	The study area is considered further in **Section 13.4.**
PEDW	*PEDW concur with shadow flicker being scoped in to the ES. The SR does not specify whether the shadow flicker assessment would include a cumulative assessment. PEDW direct that the ES must include a cumulative assessment for shadow flicker. If no cumulative impacts are anticipated, evidence should be provided in the ES to support this statement.*	A cumulative assessment is provided in **Section 13.10.**

13.4 DATA GATHERING METHODOLOGY

STUDY AREA

13.4.1. 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 several 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, WindPro Version 4.2 has been used.

13.4.2. 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, one window is always facing the wind turbine(s), and that the rotor is always turning (i.e., the wind is always blowing between 4 m/s and 25 m/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. The model factors in topography and landform 'blocking' of shadow flicker, assessing visibility from the receptor to the wind turbine and any intervening landform between the sun and turbine at each time interval.

13.4.3. 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. The shadow flicker model inputs are as follows:

- the locations of all residential properties as identified by OS Address Base within ten times the rotor diameter (including an allowance of 50m for micrositing);
- the surrounding topography (Ordnance Survey Digital Terrain Model); and
- the locations and dimensions of the turbines.

Spatial Extent

13.4.4. The comments received from PEDW in the scoping direction relating to assessment distance of shadow flicker effects have been noted, as well as reference to the research paper [6].

13.4.5. It is considered that it is appropriate and proportionate to assess shadow flicker effects within 10 rotor diameters of the proposed turbines, consistent with the established UK evidence base and commonly applied assessment practice. The DECC evidence base concluded that assessment within 10 rotor diameters is an acceptable approach and further stated that the 10 rotor diameter rule is deemed to be an appropriate assessment area, whilst acknowledging that latitude may be a factor warranting future scientific review. The 10 rotor diameter approach is an established feature of

[5] Department of Energy and Climate Change, (2011). Update of UK Shadow Flicker Evidence Base (online). Available at: Update of UK Shadow Flicker Evidence Base (Accessed May 2026)

[6] LUC (2017). Review of Light and Shadow Effects from Wind Turbines in Scotland. Available at: https://www.climatexchange.org.uk/wp-content/uploads/2023/09/light_and_shadow_effects_from_wind_turbines_in_scotland_stages_1_and_2.pdf (accessed May 2026)

UK best practice and is reflected in Irish guidance[7]; elsewhere in Europe, shadow flicker control is commonly addressed through alternative fixed-distance or exposure-based criteria[8].

13.4.6. There is also a clear physical basis for retaining 10 rotor diameters as a proportionate Study Area. The DECC evidence base explains that the effect becomes less pronounced with increasing distance because there are fewer occasions when the sun is low enough to cast a long shadow, low sun is more likely to be obscured by cloud or intervening features, and the rotor shadow passes more quickly over the land. It further states that, at distance, turbine blades increasingly only partly mask the sun, thereby substantially weakening the shadow, such that only a very weak effect is observed at greater separation distances. In this context, a blanket requirement to extend the Study Area beyond 10 rotor diameters would risk placing undue weight on highly conservative theoretical effects that are materially weaker and less likely to give rise to significant effects in EIA terms.

13.4.7. The report prepared for ClimateXChange by LUC and Pager Power is acknowledged; however, that document is best understood as a research review intended to inform possible future Scottish guidance, rather than adopted planning policy in Wales. Whilst it questions the robustness of relying on 10 rotor diameters as a universal distance rule, it does not establish a policy requirement for all developments to extend assessment beyond 10 rotor diameters; rather, it recommends that any future refinement should focus on exposure thresholds, receptor sensitivity, and improved modelling, supported by further research. Read in that context, the current evidence does not support a blanket departure from the accepted industry standard 10 rotor diameter approach, particularly where there is limited evidence of widespread operational problems and where identified issues have generally been capable of effective mitigation through established measures such as turbine shut-down protocols.

13.4.8. Taking the above into account, including the site latitude, WSP has defined the spatial scope to be 10 rotor diameters (RD) from any proposed wind turbine generator (WTG) in line with industry good practice.

[7] Department of Housing, Local Government and Heritage (2006). Wind Energy Development Guidelines (online). https://www.gov.ie/en/department-of-housing-local-government-and-heritage/publications/wind-energy-development-guidelines-2006/ (Accessed May 2026)

[8] Bund/Länder-Arbeitsgemeinschaft für Immissionsschutz (LAI) (2020) Hinweise zur Ermittlung und Beurteilung der optischen Immissionen von Windkraftanlagen (WKA-Schattenwurfhinweise), Aktualisierung 2019, Stand 23.01.2020. Available at: https://www.lai-immissionsschutz.de/documents/wka_schattenwurfhinweise_stand_23_1588595757.01.pdf (Accessed: May 2026).

DESK STUDY

13.4.9. A summary of the organisations that have supplied data, together with the nature of that data is outlined in **Table 13-4.**

Table 13-4 - Data Sources used to Inform the Shadow Flicker Assessment

Organisation	Data Source	Data Provided
Ordnance Survey	Ordnance Survey AddressBase Plus	Residential properties location in relation to Proposed Development.
Ordnance Survey	OS Terrain 5	Terrain data
Ordnance Survey	OS 1:25:000 Colour Raster	Background mapping

SURVEY WORK

13.4.10. No survey work was undertaken for this shadow flicker assessment.

13.5 OVERALL BASELINE

13.5.1. This section summarises the baseline shadow flicker conditions determined through the course of desk-based investigations. This section identifies and evaluates those shadow flicker features/receptors that lie within the relevant Study Area(s), and which are pertinent in the context of the Proposed Development.

CURRENT BASELINE

13.5.2. As outlined in **Section 13.2** and **Section 13.4**, 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 163m, meaning a study area of 1,630m. We have also allowed 50m for micrositing, giving a total Study Area of 1,680m.

13.5.3. Properties falling within this Study Area will be assessed with regards to the potential to experience shadow flicker. The Study Area is shown in **Figure 13.1**. None of the properties considered in this assessment currently experience shadow flicker from other wind farm developments (see **Section 13.10** for more detail on other wind farms and cumulative effects).

FUTURE BASELINE

13.5.4. 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.

13.6 EMBEDDED MEASURES

13.6.1. 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.

13.6.2. 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.

13.6.3. 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.

13.6.4. The Applicant is committed to installing a shadow flicker impact control module prior to operation of 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 mitigation measures built into these turbines would be activated. This covers all properties that could experience shadow flicker.

13.6.5. 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.

13.6.6. 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)[6] 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”.

13.6.7. Environmental measures have been embedded into the Proposed Development as outlined in **Section 4.7**. **Table 13-5** outlines how these embedded measures influence the shadow flicker assessment.

Table 13-5 - Summary of the Embedded Environmental Measures

Receptor	Potential Changes and Effects	Embedded Measures	Compliance Mechanism
Operation Phase			
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	Planning condition to ensure compliance with acceptable levels and investigation into reported shadow flicker effects.

13.7 SCOPE OF THE ASSESSMENT

OVERVIEW

13.7.1. The approach to the shadow flicker assessment as set out in **Section 13.8** was outlined in the Scoping Report (**Appendix 1A**). 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.

SPATIAL SCOPE

13.7.2. The assessment approach recommended within established technical guidance, recognised as industry good practice, is for the assessment of shadow flicker effects to be carried out at properties within 10 rotor diameter distance from the wind turbine. The spatial scope of the assessment therefore extends to 10RD from any WTG + a 50m micrositing buffer.

TEMPORAL SCOPE

13.7.3. 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 covers the operational period of the wind farm only.

POTENTIAL RECEPTORS

13.7.4. The shadow flicker receptors that have been identified as being potentially subject to effects are summarised in **Table 13-6**. Receptor sensitivity is provided in **Table 13-7.**

Table 13-6 - Shadow Flicker Receptors

Receptor ID	Receptor Name and Address	Easting	Northing
A	PANTY GESAIL, CAERSWS, SY17 5NW	298891	297185
B	PARC Y RHIW, CAERSWS, SY17 5NW	299253	296763
C	CWM YR ANNEL, CARNO, CAERSWS, SY17 5JY	297694	299044
D	PEN Y BANC, CARNO, CAERSWS, SY17 5JY	297958	298376

Receptor ID	Receptor Name and Address	Easting	Northing
E	AEL Y BRYN, CARNO, CAERSWS, SY17 5JR	298425	296924
F	TY GWYN, CARNO, CAERSWS, SY17 5JR	298303	296963
G	GROFFTYDD, CARNO, CAERSWS, SY17 5JR	298296	296531
H	GROFFTYDD COTTAGE, CARNO, CAERSWS, SY17 5JR	298529	296443
I	PEN Y BRYN, CARNO, CAERSWS, SY17 5JR	298063	297064
J	CWM GERWYN, CARNO, CAERSWS, SY17 5JR	298608	297167
K	DOL Y LLIN, CARNO, CAERSWS, SY17 5NW	298696	296399
L	YR HEN STABAL, CARNO, CAERSWS, SY17 5JR	298277	296534
M	THE ANNEXE, PARC Y RHIW, CAERSWS, SY17 5NW	299253	296763
N	TY UCHAF, CEFN COCH, WELSHPOOL, SY21 0AJ	301691	299516
O	CWMCLYS, CLATTER, CAERSWS, SY17 5NW	300026	296470
P	GILFACH-HIR, CLATTER, CAERSWS, SY17 5NW	300271	296306
Q	BRONFFYNON, CLATTER, CAERSWS, SY17 5NE	301495	296406
R	GELLI, CLATTER, CAERSWS, SY17 5NE	302202	296469
S	WYDDOL, PONTDOLGOCH, CAERSWS, SY17 5NE	301536	296163
T	TANY Y BWLCH, LLANWNOG, CAERSWS, SY17 5NE	301464	296100
U	LLUAST, PONTDOLGOCH, CAERSWS, SY17 5NE	301062	296588
V	LLYN MAWR, CLATTER, CAERSWS, SY17 5NE	301062	297330
W	NEW HOUSE, PONTDOLGOCH, CAERSWS, SY17 5NE	301299	296683
X	SLATE HOUSE, PONTDOLGOCH, CAERSWS, SY17 5NE	301168	296150
Y	CLOGAU, CLATTER, CAERSWS, SY17 5NE	301641	296760
Z	LAKESIDE VIEW, PONTDOLGOCH, CAERSWS, SY17 5NE	301135	297065
AA	CARREG ATEB, PONTDOLGOCH, CAERSWS, SY17 5NE	301146	296314
AB	LLUEST UCHAF, CLATTER, CAERSWS, SY17 5NE	300430	298022
AC	PANT Y GWALIA, PONTDOLGOCH, CAERSWS, SY17 5NE	301169	296172
AD	BLAEN Y CWM, CARNO, CAERSWS, SY17 5JR	298449	298598

13.7.5. Note that receptor AB, LLUEST UCHAF, has been purchased by the Applicant and will not be occupied during the Proposed Developments operational phase, therefore this receptor has been excluded from further assessment.

Table 13-7 - Shadow Flicker Receptors Subject to Potential Effects

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

LIKELY SIGNIFICANT EFFECTS

13.7.6. The effects on shadow flicker receptors which have the potential to be significant and have been taken forward for detailed assessment are summarised in **Table 13-6** and shown in **Figure 13.2.**

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

Photo Sensitive Epilepsy

13.7.8. Research has been carried out to determine whether shadow flicker from wind turbines can cause seizures in photo-sensitive epilepsy sufferers[9]**.** Sufferers are usually sensitive to flickering light at frequencies from 3Hz–30Hz. 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–30Hz sensitivity range.

13.7.9. 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 3-30 Hertz frequency range generally thought to risk triggering photo-sensitive epilepsy. It is also noted in the DECC Report (2011) 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".*

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

13.8 ASSESSMENT METHODOLOGY

OVERVIEW

13.8.1. The generic project-wide approach to the assessment methodology is set out in **Chapter 2: Approach to EIA.** However, whilst this has informed the approach that has 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.

[9] 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 2025).

13.8.2. The assessment approach recommended within planning guidance and recognised as industry good practice, is for the assessment of shadow flicker effects to be carried out at properties within 10 rotor diameter distance from the nearest turbine. 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 (worst case) at the affected receptors, that fall within the 10-rotor diameter distance. A Study Area of 1,680m 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 163m rotor diameter in line with the worst-case access study scenario) plus a 50m micro siting allowance.

SIGNIFICANCE EVALUATION METHODOLOGY

13.8.3. 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 and orientation of windows within a property, the use of the rooms affected, the level of shading and screening in the surrounding area, and how susceptible the receptor is to light flicker.

13.8.4. As confirmed by the DECC study (2011)[6], there is no standard UK or Welsh guidance relating to a limit for shadow flicker. The DECC study also reviewed international legislation relating to the assessment of shadow flicker and concluded that the area within 130 degrees either side of north from the turbine, and out to 10 rotor diameters, is considered acceptable for shadow flicker assessment. The only guidance providing additional recommendations is the 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.

13.8.5. 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.

13.8.6. 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 13-8.** 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 13-8 - Scoring Methodology for Magnitude of Change

Magnitude of Change	Distance from Turbine	And / Or	Predicted Shadow Flicker Duration
High	<500m	And	Shadow flicker predicted and ≥ 30 min/day or ≥ 30 hours/year
Medium	<500m	And	Shadow flicker predicted and < 30 min/day and <30 hours/year
Medium	500m-700m	And	Shadow flicker predicted and ≥ 30 min/day or ≥ 30 hours/year
Medium	700-1680m	And	Shadow flicker predicted and ≥ 30 min/day or ≥ 30 hours/year
Low	500m-700m	And	Shadow flicker predicted and < 30 min/day and <30 hours/year
Low	700-1680m	And	Shadow flicker predicted and < 30 min/day and <30 hours/year
No Change	>1680m	And	Any duration
No Change	<1680m	And	No shadow flicker predicted

13.8.7. 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 13-9**. Effects are rated as being either major or moderate (significant).

Table 13-9 - Summary of Significance of Effects

	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

13.8.8. There are several additional factors that can influence the amount of shadow flicker actually experienced.

13.8.9. Climatic conditions dictate that the sun is not always shining. Met Office regional data for Wales provides long term climate summaries.

13.8.10. Historic Met Office data (over the period 1991–2020) gives average sunshine hours for Wales to be 31% of total daylight hours, with averages lows in mid-winter being approximately 17%-18% and peak highs in May of 39%[10],[11]. 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.

13.8.11. 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.

13.9 ASSESSMENT OF SHADOW FLICKER EFFECTS

13.9.1. **Figure 13.2** shows a contour map representing the annual number of hours of potential shadow flicker effects on the occupied buildings included in the assessment.

13.9.2. **Table 13-10** 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 in Wales. Individual results for each receptor are provided in **Appendix 13A**. Note the significance of effects is based on the worst-case results, likely hours per year based on actual sunshine hours is provided for information only.

[10] Sun earth tools (2026). Sunrise Sunset Calendar. Available at https://www.sunearthtools.com/solar/sunrise-sunset-calendar.php#top (Accessed May 2026).

[11] Met Office (2026). UK Climate Averages. (online) Available at: https://www.metoffice.gov.uk/research/climate/maps-and-data/location-specific-long-term-averages/gcms1hjef. Average sunshine hours of 1407 / Total number of daylight hours 4484 = 31% (Accessed May 2026)

Table 13-10 - Shadow Flicker Model Results.

ID	Days / Year	Turbine Causing Shadow Flicker	Distance to Nearest Turbine (m)	Max no. of Minutes / Day	Mean no. of Minutes / Day	Maximum Hours / Year	Likely Hours / Year[12]	Magnitude of Change	Significance
A	0		768	0	0	0.00	0.00	No Change	Negligible (Not Significant)
B	0		948	0	0	0.00	0.00	No Change	Negligible (Not Significant)
C	0		1642	0	0	0.00	0.00	No Change	Negligible (Not Significant)
D	0		1309	0	0	0.00	0.00	No Change	Negligible (Not Significant)
E	0		1296	0	0	0.00	0.00	No Change	Negligible (Not Significant)
F	0		1375	0	0	0.00	0.00	No Change	Negligible (Not Significant)
G	0		1649	0	0	0.00	0.00	No Change	Negligible (Not Significant)
H	0		1560	0	0	0.00	0.00	No Change	Negligible (Not Significant)
I	60	5	1541	27	23	22.85	8.13	Low	Minor (Not Significant)

[12] Based on average sunshine hours for Wales as a percentage of daylight hours.

ID	Days / Year	Turbine Causing Shadow Flicker	Distance to Nearest Turbine (m)	Max no. of Minutes / Day	Mean no. of Minutes / Day	Maximum Hours / Year	Likely Hours / Year[12]	Magnitude of Change	Significance
J	0		1008	0	0	0.00	0.00	No Change	Negligible (Not Significant)
K	0		1504	0	0	0.00	0.00	No Change	Negligible (Not Significant)
L	0		1660	0	0	0.00	0.00	No Change	Negligible (Not Significant)
M	0		948	0	0	0.00	0.00	No Change	Negligible (Not Significant)
N	154	9, 10, 11	1012	40	23	59.60	13.23	Medium	Moderate (Significant)
O	0		1321	0	0	0.00	0.00	No Change	Negligible (Not Significant)
P	0		1453	0	0	0.00	0.00	No Change	Negligible (Not Significant)
Q	0		1367	0	0	0.00	0.00	No Change	Negligible (Not Significant)
R	0		1533	0	0	0.00	0.00	No Change	Negligible (Not Significant)
S	0		1613	0	0	0.00	0.00	No Change	Negligible (Not Significant)
T	0		1671	0	0	0.00	0.00	No Change	Negligible (Not Significant)

ID	Days / Year	Turbine Causing Shadow Flicker	Distance to Nearest Turbine (m)	Max no. of Minutes / Day	Mean no. of Minutes / Day	Maximum Hours / Year	Likely Hours / Year[12]	Magnitude of Change	Significance
U	0		1226	0	0	0.00	0.00	No Change	Negligible (Not Significant)
V	110	3, 5	546	47	33	61.32	22.10	Medium	Moderate (Significant)
W	0		1090	0	0	0.00	0.00	No Change	Negligible (Not Significant)
X	0		1634	0	0	0.00	0.00	No Change	Negligible (Not Significant)
Y	0		1040	0	0	0.00	0.00	No Change	Negligible (Not Significant)
Z	0		749	0	0	0.00	0.00	No Change	Negligible (Not Significant)
AA	0		1475	0	0	0.00	0.00	No Change	Negligible (Not Significant)
AB	Note that receptor AB was excluded from the assessment as it represents a property that is not occupied and will not be occupied for the duration of the project.								
AC	0		1613	0	0	0.00	0.00	No Change	Negligible (Not Significant)
AD	165	5, 6, 7, 8	810	52	32	87.23	26.72	Medium	**Moderate (Significant)**

13.9.3. 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.

13.9.4. The results show that 8 of 11 proposed turbines have the potential to cause shadow flicker effects.

13.9.5. Examination of the detailed results of the model found in **Appendix 13A** shows that receptors A-H, J-M, O-U, W-AA and AC would not experience any shadow flicker as a result of the Proposed Development, due to either topographic screening and/or being located where shadow flicker cannot geometrically occur. Receptor AB will not be occupied for the Proposed Developments operational life. The remaining four receptors (I, N, V, AD) could experience between 23 and 87 hours of shadow flicker per year, based on the worst-case model. Receptors N, V and AD could experience a maximum of between 40 and 52 minutes of shadow flicker on the worst-case day. Receptor I could experience a maximum of 27 minutes per day on the worst-case day.

13.9.6. If average sunshine hours are applied to the model, then all currently occupied buildings are likely to experience shadow flicker for no more than 27 hours per annum.

13.9.7. Receptors assessed as having potentially moderate to major significance impacts from shadow flicker could require mitigation measures to be applied. As stated in **Section 13.5**, 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

Table 13-11 - Summary of Significance of Effects

Receptor and Summary of Predicted Effects	Sensitivity of Receptor[13]	Magnitude of Change[14]	Significance[15]	Summary Rationale
Shadow flicker effects on residential property: Receptor N, V and AD. (3 occupied residential receptors)	High	Medium	Moderate (significant, and following mitigation not significant)	Although according to **Table 13-11**, shadow flicker effects are predicted; any shadow flicker effects during operation 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: Receptor I (1 occupied residential receptor)	High	Low	Minor (not significant)	Modelling has shown that significant effects are considered unlikely (**Table 13-11**). Any shadow flicker effects during operation 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: Receptors A-H, J-M, O-U, W-AA and AC (25 occupied residential receptors)	High	No Change	Negligible (not significant)	N/A

[13] The sensitivity of a receptor is defined using the criteria set out in **Section 13.8** and is defined as high.
[14] The magnitude of change on a receptor resulting from activities relating to the development is defined using the criteria set out in **Section 13.8** and is defined as no change, low, medium and high.
[15] 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 13.8**

13.10 ASSESSMENT OF CUMULATIVE (INTER-PROJECT) EFFECTS

13.10.1. A cumulative effects assessment (CEA) has been undertaken for the Proposed Development which considers the combined impacts with other developments on the same single receptor or resource (inter-project effects). The detailed method followed in identifying and assessing potential cumulative effects is set out in **Section 2.8** of **Chapter 2: Approach to EIA**.

13.10.2. In line with the shadow flicker methodology outlined in **Section 13.8**, shadow flicker has been assessed to a distance of 10 Rotor Diameters (RD) of any WTG + 50m for micro siting, comprising the shadow flicker study area. Applying this methodology in a cumulative context, an assessment may be required for any receptors that fall within 10 rotor diameters of both the Proposed Development and a cumulative site. The CEA has considered other operational wind farms in the vicinity of the Study Area and identified Tirgwynt Wind Farm and Mynydd Clogau Wind Farm. **Figure 13.3** shows the Proposed Development and cumulative sites with 10 rotor diameter distance buffers, based on the expected technical specifications of the 3rd party turbines.

13.10.3. No receptors fall within both 10 rotor diameters of both the Proposed Development and the identified cumulative wind farms; therefore, no cumulative effects are expected in combination with other operational wind farm developments.

13.10.4. A review of other cumulative projects within the planning process was undertaken, which identified both Esgair Cwmowen and Llyn Lort. However, no cumulative receptors were identified within 10 RDs of the proposed projects and the Proposed Development.

13.11 SIGNIFICANCE CONCLUSIONS

13.11.1. A summary of the results of the Shadow Flicker assessment is provided in **Table 13-11.**

13.11.2. The assessment has identified the potential for significant shadow flicker effects at three occupied buildings, and non-significant effects at 26 occupied buildings. Mitigation has been identified in the form of a control system which automatically shuts down the wind turbine, restricting effects to less than 30 minutes per day and / or 30 hours per year at every property.

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

13.11.4. Potential cumulative effects with other operational wind farms were assessed in **Section 13.10**; no cumulative effects are expected.

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

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