19 SHADOW FLICKER

19.1 Introduction

19.1.1 This chapter has been prepared by Wardell Armstrong LLP, who has extensive experience in providing advice on the predicted effects of wind farm-induced shadow flicker.

19.1.2 This chapter of the EIA Report identifies and assesses the potential effects that the Convatec Green Manufacturing Hub (the Proposed Development) will have on human receptors with regard to shadow flicker.

19.1.3 The assessment is based on the description of the development presented in Chapter 5: Project Description. The shadow flicker assessment will discuss the effects of the three wind turbines that are part of the Proposed Development. The size of the turbines will be taken into account in assessing shadow flicker effects.

19.1.4 The candidate turbine that is considered for the application is Enercon E138. The specifications of this turbine, three of which would be installed onsite, are as follows:

- Maximum blade tip height of 150 metres
- Hub height of 81 meters
- Rotor diameter of 138 meters

19.1.5 Other proposed infrastructure alongside the turbines includes an electrical substation and control building, access tracks, underground cables to link the turbines and solar array to the substation, Convatec's manufacturing facility, steel tower anemometer mast for monitoring wind speeds and turbine performance, and temporary construction and storage compounds. The associated infrastructure will not contribute to shadow flicker effects.

19.1.6 This chapter is structured as follows:

- Legislation, policy, and guidance;
- Assessment methodology and significance criteria;
- Baseline conditions;
- Assessment of potential effects;
- Mitigation; and
- Summary.

19.1.7 Additionally, Appendix 19.1 shows the graphical outputs of the shadow flicker modelling for all receptors within 11 rotor Diameters (RD).

19.2 Legislation, policy, and guidance

19.2.1 Chapter 3 of the EIA Reports sets out the policy framework that is relevant to the Environmental Impact Assessment. The following section highlights and summarises policies directly related to the shadow flicker.

- Future Wales: The National Plan 2040
- Planning Implications of Renewable and Low Carbon Energy, Planning Division – Welsh Assembly Government (2010)
- Planning for Renewable Energy – A Companion Guide to PPS22 (2004) (now superseded but still relevant)
- Update of the UK Shadow Flicker Evidence Based (2011);
- Wind Farm Impacts Study (2015); and,
- Review of Light and Shadow Effects from Wind Turbines in Scotland (2017)

Future Wales: The National Plan 2040[1]

19.2.2 Future Wales: The National Plan 2040, published by the Welsh Government in February 2021, contains information relevant to the assessment of shadow flicker. In particular, Policy 18 (7) Renewable and Low Carbon Energy Developments of National Significance from Future Wales: The National Plan 2040, requires "*proposals for renewable and low carbon energy projects (including repowering) qualifying as Developments of National Significance"* to demonstrate that *"there are no unacceptable adverse impacts by way of shadow flicker, noise, reflected light, air quality or electromagnetic disturbance*".

Planning Implications of Renewable and Low Carbon Energy, Planning Division – Welsh Assembly Government (2010)[2]

19.2.3 This guidance supports Local Planning Authority (LPA) decision-makers in relation to planning applications for renewable and low-carbon energy development by providing an evidence base of impacts and benefits of different energy developments. This

[1] Future Wales: The National Plan 2040, https://www.gov.wales/sites/default/files/publications/2021-02/future-wales-the-national-plan-2040.pdf [accessed 06/02/2024]

[2] Welsh Assembly Government, '*Practice Guidance: Planning Implications of Renewable and Low Carbon Energy*', February 2011, https://www.gov.wales/sites/default/files/publications/2018-09/planning-implications-renewable-low-carbon-energy-development.pdf [accessed 06/02/2024]

guidance helps to identify planning implications of renewable and low-carbon energy developments, providing developers and proposers with opportunities to solve the implications.

19.2.4 According to the guidance, "s*hadow flicker can cause a disturbance for affected residents of nearby properties and can have potentially harmful impacts on sufferers of photo-sensitive epilepsy. These potential impacts can be mitigated by micrositing turbines as far as practically possible from residential properties and through the use of technological fixes such as the shutting down of turbines during periods of predicted shadow flicker. The use of blinds at residential properties or tree/shrub planting to screen shadow flicker can also help minimise potential impact."*

Planning for Renewable Energy – A companion guide to PPS22 (2004) – now superseded but still relevant)[3]

19.2.5 Although superseded, this guidance is intended to assist planners, regional and local decision-makers, and other stakeholders in understanding complex issues associated with various technologies and their significance, as well as potential solutions.

19.2.6 In terms of the shadow flicker effect, the guidance states that *"although problems caused by shadow flicker are rare, for sites where existing development may be subject to this problem, applicants for planning permission for wind turbine installations should provide an analysis to quantify the effect."*

19.2.7 The companion guide goes on to provide advice on how, why and where shadow flicker develops and what sort of effects need to be considered.

Update of the UK Shadow Flicker Evidence Base (2011)[4]

19.2.8 The Update of the UK Shadow Flicker Evidence Base (2011) reviews international guidance on shadow flicker assessment and current methodologies used to assess the significance of shadow flicker effects. The report states that, *"planning guidance in the UK requires developers to investigate the impact of shadow flicker but does not specify methodologies."*

[3] Office of the Deputy Prime Minister, '*Planning for Renewable Energy - A Companion Guide to PPS22*', 2004, https://cumbria.gov.uk/elibrary/Content/Internet/538/755/1929/17716/17720/17723/42130145839.PDF [accessed 06/02/2024]

[4] Parsons Brinckerhoff, '*Update of UK Shadow Flicker evidence base*', March 2011, An update of the UK Shadow Flicker Evidence Base as reported for DECC by Parsons Brinckerhoff, https://www.gov.uk/government/publications/update-of-uk-shadow-flicker-evidence-base [accessed: 06/02/2024]

Wind Farm Impacts Study (2015)[5]

19.2.9 This report looks at a number of case study windfarms to identify how guidelines were followed during implementation and whether there were any unexpected effects recorded once the schemes became operational.

19.2.10 A Residents' Survey recorded that some people experienced shadow flicker beyond the distance at which most assessments predict it to occur (generally 10 times the rotor diameter).

19.2.11 The study concludes that there are no standard significance criteria used to assess shadow flicker impacts and no statutory limit or guidance to stipulate acceptable levels of shadow flicker. There also appears to be a range of lighting effects impacting people living close to wind farms, none of which were found to be clearly defined. It posits that a clearer definition of all shadow and light effects with reference to parameters such as the distances, directions, light and weather conditions in which they can occur would help both assessments and public understanding of this particular impact.

Review of Light and Shadow Effects from Wind Turbines in Scotland (2017)[6]

19.2.12 LUC, in association with Pager Power was commissioned by ClimateXChange to undertake a review of how light and shadow effects from wind farms were considered in the development planning process in Scotland. ClimateXChange published the report Wind Farm Impacts Study in July 2015, which made a number of recommendations for better guidance on predicting and mitigating the impacts of light and shadow flicker effects from wind turbines.

19.3 Assessment Methodology and Significance Criteria

Scope of the assessment

19.3.1 The assessment involves assessing the risk of shadow flicker from the Proposed Development to human receptors.

[5] SLR and Hoare Lea, on behalf of ClimateXchange, 'Wind Farm Impacts Study - Review of the visual, shadow flicker and noise impacts of onshore wind farms', July 2015, https://www.climatexchange.org.uk/media/1426/final_report_wind_farm_impacts_study_july_2015_issue.pdf [accessed 06/02/2024]

[6] Land Use Consultants in association with Pager Power, on behalf of ClimateXchange, '*Review of Light and Shadow Effects from Wind Turbines in Scotland*', March 2017, https://www.climatexchange.org.uk/media/2075/light_and_shadow_effects_from_wind_turbines_in_scotland_stages_1_and_2.pdf [accessed 06/02/2024]

19.3.2 Under certain daylight conditions, the relative position of the Sun can cause shadows to be cast from a wind turbine. These shadows move as the turbine blades rotate, and the sun appears to track across the sky. At certain times of the day and of the year, this shadow movement may be cast across nearby dwellings. When observed from inside the building and viewed through a narrow aperture such as a window, the effect created may appear as flickering of light and shadow. This phenomenon is known as shadow flicker. The potential significance of the effect of shadow flicker is dependent on a number of factors:

- The location of the relevant building relative to the position of the sun and the turbine;
- The distance from the turbine(s) from such buildings, the size of the window apertures, and their location in the building relative to the turbine;
- The turbine hub height and rotor diameter;
- The presence of intervening topography, buildings, or vegetation;
- The time of year;
- The proportion of daylight hours in which turbines operate;
- The frequency of bright sunshine and cloudless skies (particularly at low elevations above the horizon); and
- The prevailing wind direction.

19.3.3 Wind turbine objectors elsewhere have expressed concerns that shadow flicker from wind turbines may result in stroboscopic effects[7] that could induce epilepsy or similar symptoms. Around 0.5 % of the population is epileptic, and of these, around 5 % are photosensitive. Of photo-sensitive epileptics, less than 5 % are sensitive to the lowest frequencies of 2.5-3 Hz. The remainder are sensitive only to higher frequencies. The flicker caused by wind turbines is equal to the blade passing frequency. A fast-moving three-bladed machine will give rise to the highest levels of flicker frequency. These levels are well below 2 Hz. The new generation of wind turbines is known to operate at levels below 1 Hz.

[7] Stroboscopic effect is an optical phenomenon that causes moving objects to appear stationary when viewed in discrete series of short or instantaneous samples as distinct from a continuous view.

19.3.4 The effects of light flicker on humans in relation to shadow flicker from wind turbines have been reviewed by Verkuijlen and Westra[8] and again by Clarke[9]. Both references conclude that the frequencies capable of triggering epilepsy and general disturbance lie between 2.5Hz and 3Hz.

19.3.5 Wind turbines of the type proposed for installation operate at rotational speeds of up to about 22 revolutions per minute (rpm). Given that the turbines will have three blades, the frequency at which a blade will pass a particular point will be up to about 66 times a minute, which equates to 1.1 flashes per second (Hertz). This is significantly less than the 2.5 to 3 Hz frequency range generally thought to induce photosensitive epilepsy. As a result, the issue of photosensitive epilepsy is not considered further in this assessment as there are no predicted adverse health effects.

Study area

19.3.6 For the purpose of this assessment, and in line with the 'onshore wind turbines: planning advice', a study area of at least 10 rotor diameters (RD) is considered.

19.3.7 It is noted that the 2017 ClimateXChange report, *'Review of Light and Shadow Effects from Wind Turbines in Scotland*' identified that shadow flicker effects could potentially be observed beyond 10 rotor diameters (RD) from the turbines.

19.3.8 Beyond 10RD, shadow flicker effects will be weaker and shorter in overall duration and will continue to diminish with distance from the turbines. However, there is still some potential for effects to be observed.

Approach

19.3.9 The final choice of turbine will be determined through a competitive tendering process but in all cases the turbine will not exceed a tip height of 150m. For the purposes of the EIA, the proposed turbine candidate is the Enercon 138, with an 81m hub, 150m height tip, and 138m rotor diameter.

19.3.10 Within this assessment, shadow flicker effects will be considered for specific dwellings out to the distance of at least 11RD. 11RD equates to 1.518km so effects will be considered for dwellings within this distance of each of the three turbines.

19.3.11 Shadow flicker effects will be modelled within propriety wind farm analysis software as described in paragraph 19.3.26. Within this model, every building has been defined

[8] Verkuijlen, E. and Westra, C.A 'Shadow Hindrance by Wind Turbines', European Wind Energy Conference, 22-26 October 1984, Hamburg
[9] Clarke, A. D. 'A Case of Shadow Flicker/Flashing: Assessment and Solution', British Wind Energy Association Annual Conference, 1981

as having a window facing directly towards each turbine within 11RD to assume a worst-case scenario for shadow flicker potential. In the absence of detailed specifications for all the windows on all the properties, this assumes a worst-case scenario to ensure that all potential shadow flicker effects are included.

19.3.12 The shadow flicker contour map produced by the software shows effects within 11RD of the turbines. Although some effects may potentially be visible out to greater distances, effects will be very weak and may not even be discernible.

19.3.13 Figure 19.1 shows the study area (11RD), along with three turbines: 150m rotor diameter. It also shows all of the dwellings mentioned in Table 19.1.

19.3.14 The Proposed Site is located next to Rhymney town, with individual properties to the north and northwest of the Site. It is not reasonable to assess every house individually in Rhymney town. Therefore, for areas with clustered houses, a representative dwelling was chosen. Table 19.1 below shows representative dwellings located within the 11RD study area. As there are three turbines within the site boundary, some of the residential properties will be outside of the 11RD from turbines one and two. Those receptors are highlighted in grey colour.

19.3.15 Only properties within 130° on either side of the north are going to be assessed, as the turbines do not cast long shadows in the southern quadrant.

19.3.16 At a distance, the blades do not cover the sun but only partly mask it, substantially weakening the shadow. This effect occurs first with the shadow from the blade tip, the tips being thinner in section than the rest of the blade. The shadows from the tips extend the furthest, and so only a very weak effect is observed at a distance from the turbines.

Table 19.1: Residential Properties in the vicinity of the Proposed Wind Farm

House ID	Easting	Northing	Distance to Turbine 1 (m)	Distance to Turbine 2 (m)	Distance to Turbine 3 (m)
1	310771	207666	1257	953	637
2	310744	208563	1164	785	685
3	310876	208518	1278	893	754
4	310880	208411	1261	872	698
5	310954	208434	1337	949	774

6	310976	208252	1341	954	727
7	311000	208068	1371	995	726
8	311099	208183	1463	1080	834
9	311107	208317	1475	1087	870
10	311238	208061	< 11 RD	1232	964
11	311238	207740	< 11 RD	1321	1017
12	311569	207483	< 11 RD	< 11 RD	1419
13	311306	207589	< 11 RD	1446	1136
14	311182	208441	< 11 RD	1175	983
15	311357	208460	< 11 RD	1351	1153
16	311286	208557	< 11 RD	1299	1125
17	311232	208641	< 11 RD	1270	1118
18	311155	208789	< 11 RD	1253	1141
19	311437	207385	< 11 RD	< 11 RD	1347
20	311077	208641	1505	1123	988
21	311048	208872	< 11 RD	1197	1118
22	311093	208901	< 11 RD	1251	1171
23	311151	208928	< 11 RD	1314	1231
24	311220	208911	< 11 RD	1366	1270
25	311353	207750	< 11 RD	1424	1124
26	308946	208468	738	1097	1388
27	309022	208493	678	1028	1324
28	309368	208904	747	922	1236
29	310408	209178	1241	1001	1122
30	310257	209294	1252	1065	1230
31	310309	209258	1248	1044	1195
32	310286	209309	1280	1087	1245

33	310295	209354	1323	1132	1290
34	310035	209238	1106	984	1198
35	310518	209229	1350	1093	1190
36	310261	208787	853	583	723
37	310283	208762	853	570	698
38	309379	208352	295	650	940
39	309016	208711	799	1105	1415
40	311202	208756	< 11 RD	1282	1157
41	311234	208232	< 11 RD	1212	974
42	310752	209419	< 11 RD	1374	1437
43	310448	209496	< 11 RD	1312	1443

	Shaded cells represent dwellings more than 11RD from the turbines.

Survey methodology

19.3.17 No specific site survey has been carried out as part of the shadow flicker assessment. Instead, details of the relevant properties to include within the assessment have been acquired from the visual inspection of aerial photography and mapping and discussion with the design team.

19.3.18 As mentioned above, in the absence of a site survey to determine whether dwellings have windows facing towards the turbines, an assumption has been made that every house has a window facing directly towards each turbine within 11RD. This presents a worst-case scenario for modelling purposes.

Assessment Methodology

19.3.19 The seasonal duration of shadow flicker can be calculated from the geometry of the turbine and the latitude and topography of the Site.

19.3.20 The modelled shadow flicker is often an overstatement compared with actual shadow flicker occurrences once a wind farm is built. This is because modelling does not take into account a number of variables and site-specific factors which may serve to reduce the level of shadow flicker which occurs in practice:

- The proportion of daylight hours in which the turbines operate (wind turbines do not operate all the time, they do not rotate in calm and very low wind speeds, and they are switched off during maintenance periods);
- The frequency of bright sunshine and cloudless skies (particularly at low elevations above the horizon);
- The prevailing wind direction, and
- There is potential for screening from other buildings, walls, and vegetation.

19.3.21 The model may also overstate the impact of shadow flicker as it assumes that each of the receptors (typically a residential property) has a window directly facing each of the wind turbines, which is rarely the case. The model also assumes the wind turbines are turned such that the swept area of the rotor occupies a plane perpendicular to the line of sight from the sun through the rotor and to the receptor. Essentially, the software assumes that the turbine always aligns itself to face the sun and follow its trajectory rather than following the wind’s direction. This maximises the areas shadowed by the rotors during flicker events and presents a worst-case scenario.

19.3.22 The candidate wind turbine selected for the shadow flicker modelling has hub heights of 81m with rotor diameters of 150m, respectively. The rotor diameters of the turbines that are being considered for the Proposed Development are used within the model to represent the highest possible levels of shadow flicker exposure.

19.3.23 Shadow strength decreases with distance from the source. It is generally accepted that shadow flicker is not an issue at a distance greater than 10 times the turbine rotor diameter (RD). However, as discussed above, due to some effects still being noticeable beyond 10RD, this assessment considers effects on individual receptors out to 11RD, equating to 1.5 km for the 150 m to tip turbine, respectively.

19.3.24 The further the observer is from the turbine, the less pronounced the effect will be. There are several reasons for this:

- There are fewer times when the sun is low enough to cast a long shadow;
- when the sun is low, it is more likely to be obscured by either clouds on the horizon or intervening buildings and vegetation;

- the centre of the rotor's shadow passes more quickly over the land, reducing the duration of the effect, and
- at a distance, the blades do not cover the sun but only partly mask it, substantially weakening the shadow. This effect occurs first with the shadow from the blade tip, the tips being thinner in section than the rest of the blade. The shadows from the tips extend the furthest, so only a very weak effect is observed at a distance from the turbines.

19.3.25 The results presented below are based on the terrain of the surrounding area and do not take into account trees or buildings that will act as a barrier, which will overstate the potential effects. There is vegetation around Rhymney, but due to the much-elevated position of the Proposed Site, the turbines will overlook the existing vegetation.

Shadow flicker Modelling

19.3.26 The assessment of potential shadow flicker from the turbines has been undertaken using RESOFT Windfarm, version 4.2.5.1, an industry-standard software package widely used for the design and assessment of wind farms.

19.3.27 The software does not take into account prevailing whether conditions. It therefore presents a worst-case scenario for the reasons outlined in paragraph 19.3.21, which are unlikely to be replicated in reality. In Britain, average daily sunshine hours range from between one and two hours in midwinter to between five and seven hours in midsummer. Winter sunshine is reduced due to low cloud cover, fog, and mist. This is a consequence of winds from the Atlantic and seas surrounding Britain, which bring high humidity.

19.3.28 Figure 19.1 illustrates the variation in sunrise and sunset time over the course of the year. The figure illustrates that a shadow flicker event is more likely in the summer months, with these months (May, June, and July) having the highest number of daylight hours (Figure 19.2) as the sun rises earlier and sets later. There is potential for shadow flicker to occur at 05:00 GMT in June when the sun first rises, while it is not possible to obtain such an effect at 07:00 GMT in January because it will still be dark.

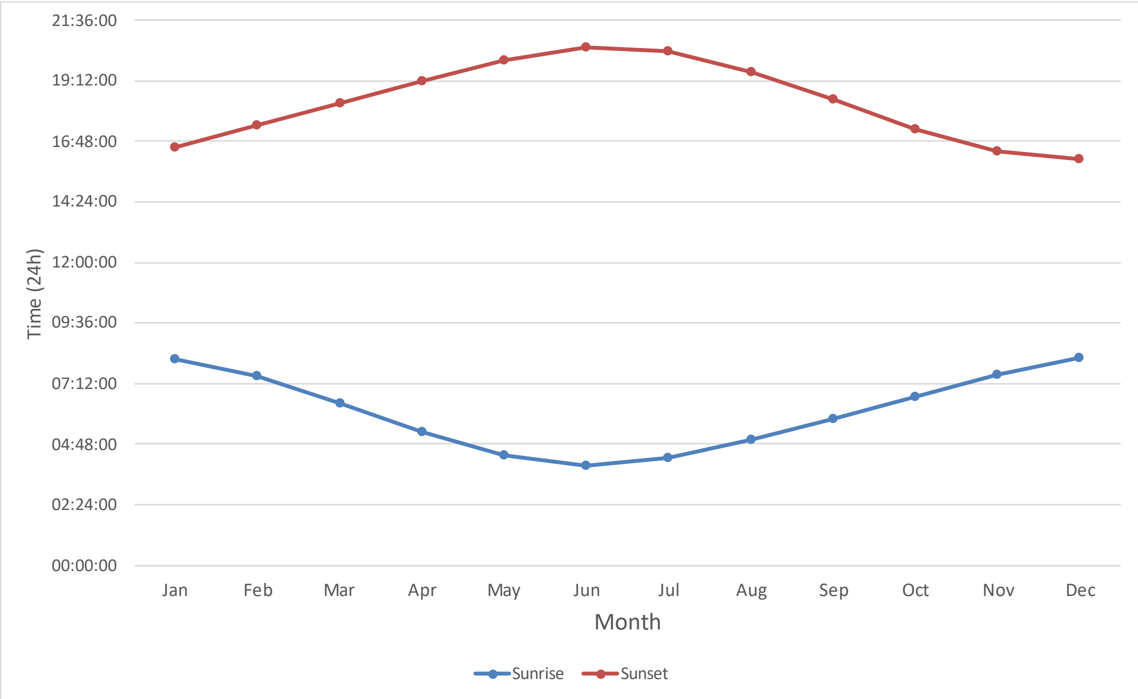

Figure 19.1: Sunshine and sunset times for 2023 at the site location.

19.3.29 The total number of daylight hours available each month, based on the site location, is shown in Figure 19.2 below. Also shown is the average number of hours of sunshine each month taken from Met Office data recorded at Ross-On-Wye weather station between 1930 and 2023, which one of the closest weather stations with historical data available and is at a similar latitude to the site.

19.3.30 Additionally, Figure 19.2 shows the ratio of sunshine to daylight displayed as a percentage for each month. The data illustrates that even in the sunniest month, which, based on sunshine hours, is June, there will be a large number of days when clouds and adverse weather conditions obscure direct sunlight. Based on the proportion of time that is actually sunny, compared to the daylight hours, the actual incidence of shadow flicker events in June is expected to be around just 39.4 % of that indicated by the model. During less sunny months, such as December, only 19.8 % of the predicted shadow flicker events may be expected to occur. On average, over the course of a year only around 33.23 % of modelled shadow flicker is likely actually to occur once weather conditions have been accounted for.

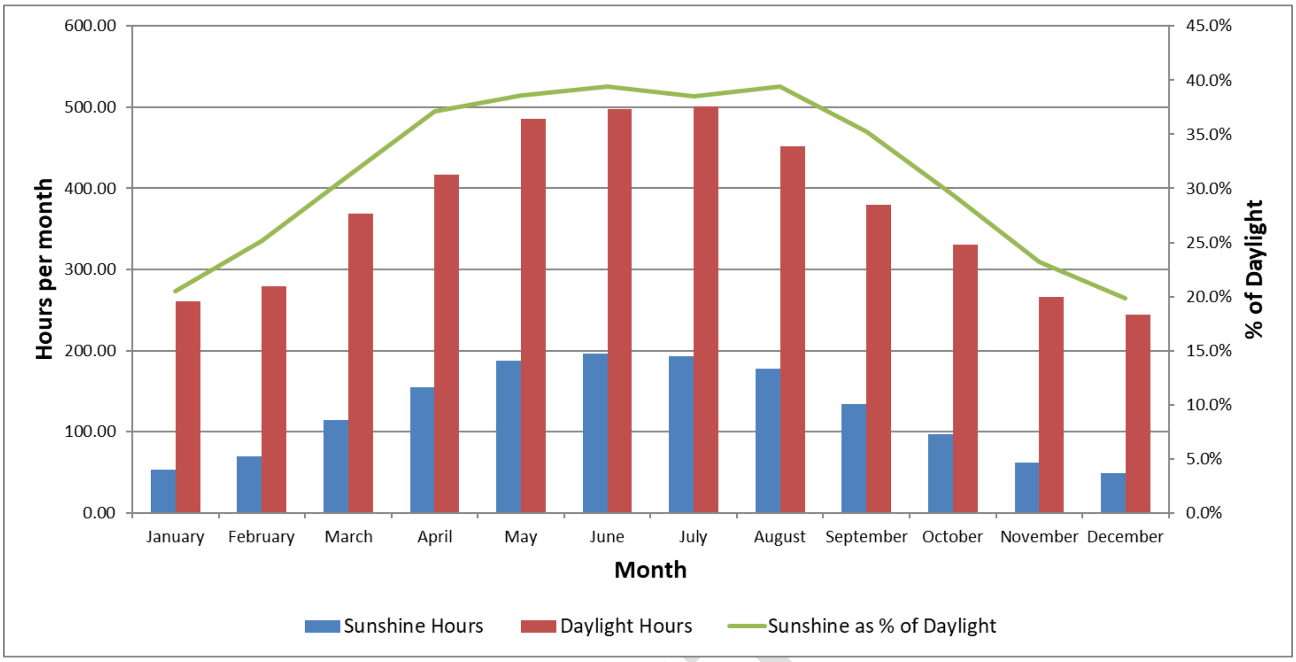

Figure 19.2: Number of sunshine and daylight hours per month in Ross-on-Wye.

19.3.31 There is no clear definition in policy or guidance as to what constitutes significant shadow flicker, but in the absence of a better definition, any shadow flicker within 11RD is considered to be significant and requires mitigation. For the purpose of the assessment shadow flicker beyond 11RD from the relevant turbines is considered to be weaker in strength, and effects are considered to be not significant.

Assessment Limitations

19.3.32 It is important to note that while the methodology presented here follows the best practice guidelines for undertaking a shadow flicker assessment, there are some restrictions on the way the results should be used and interpreted. The digital terrain data used in the RESOFT Windfarm model assumes a bare-earth situation. This presents a worst-case scenario as it ignores the potential for screening from intervening hedges, trees, and buildings, all of which could serve to reduce the amount of shadow flicker that will theoretically be observable at some properties.

19.3.33 Furthermore, the results are based on the sun's path for 2023, and subsequent years will vary slightly, although not significantly. Shadow flicker times are indicative and represent approximate times of events and duration. This study should not be used post-planning to implement shutdown times for any affected wind turbines. If accurate off/on times are required, subject to investigation following a complaint, a more detailed Digital Terrain Model (DTM), OS Master Map base map, and window/

screening survey would need to be undertaken, and the shadow flicker assessment would be repeated.

19.3.34 As discussed above, the absence of a site survey of windows on nearby properties has led to the assumption that all properties have windows facing directly towards any turbine within 11RD. Given that not all dwellings will have windows facing directly towards the turbines, this is likely to exaggerate the shadow flicker effects that will actually be observable from these properties. If the Proposed Development is consented, it will be preferable to undertaking a window survey before implementing any mitigation strategy to confirm that those effects are correct.

19.3.35 Another limitation is that the model does not account for the proportion of daylight hours in which the turbines operate. It assumes the wind turbine will be fully available throughout the whole year with no downtime or maintenance periods, and it does not account for calm weather and very high wind speeds, both of which could result in turbine shutdowns.

19.3.36 Although the model itself does not account for weather directly, an attempt has been made within the assessment to indicate how these would vary based on historical weather records.

19.3.37 The prevailing wind direction is another important factor that the model does not take account of. In estimating the potential hours of shadow flicker for each property, it assumes that the rotor-swept path would be facing directly toward each house at all times throughout the year. Clearly, this is not possible as the turbines will yaw into the wind, and at any particular time, the wind will only be coming from one direction. Shadow flicker effects will only be observable when the wind causes the turbines to align with the relevant properties, so the total duration predicted by the model will be an overestimate.

19.3.38 There is also potential for screening from other buildings, walls, and vegetation in the landscape, especially near the dwellings themselves. The model does not directly account for this, but if any surface features interrupt the line of sight between the turbines and the dwellings, this will prevent effects from being visible.

19.4 Scoping Responses and Consultation

19.4.1 Relevant consultees have been invited to provide feedback and on the Proposed Development. Table 19.2 outlines the consultation responses received to date in relation to Shadow Flicker.

Table 19.2: Consultation			
Consultee	**Details**	**Response**	**Where addressed in the EIA Report**
Principal Planner, Caerphilly CBC on behalf of Council's Rights of Way Officer	*"It is agreed that a shadow flicker assessment should be undertaken for this proposal. Public Rights of Way need to be considered in assessing shadow flicker as well as dwellings."*	Shadow Flicker can only occur through a narrow aperture, such as a window or an opening, and as such, Public Rights of Way (due to their open nature) would not have the capacity to receive shadow flicker effects. However, Figure 19.3 includes Public Rights of Way, such that the extent of shadow flicker effects on these receptors is shown.	Figure 19.3
Council's Countryside and Rights of Way Assistant	*"Although RHYM/BR99/1 (a bridleway) crosses the site, it is a cul-de-sac route and only enters the site by approximately 50 metres. There are however bridleways to the North, and the needs of users should be examined – specifically in relation to shadow flicker etc. but this will depend on the location of the proposed turbines within the red line boundary."*		

19.5 Baseline conditions

19.5.1 There are a number of existing receptors in the surrounding locality within the study area. These include dwellings, which are predominantly located within the town of Rhymney itself to the east of the Site, but also include scattered dwellings and farmsteads through the remaining directions.

19.5.2 The Heads of the Valleys Road (A465) lies to the north of the Site, while the A469 runs in the bottom of the valley to the east of the Site, between Convatec's plant and the town of Rhymney. There is a network of smaller roads serving Rhymney itself, which primarily lie on the eastern side of the valley, facing towards the development on the western side.

19.5.3 The Rhymney Branch line runs from Ystrad Mynach to the south of the Site, northwards, terminating on arrival at the town. A second section of branch line (Taff Bargoed Branch) runs slightly to the west, the main purpose of which was to service

Ffos-y-fran coal mine until it shut in November 2023. It terminates to the southwest of the Site.

19.5.4 There are no aerodromes in close proximity (i.e. within 15km) of the Site.

19.5.5 There is a network of rights of way including footpaths and bridleways, which extend to the south and east of the Site. It is important to note that shadow flicker is an effect that arises when viewing the sun through a narrow aperture, such as a window, where the light is regularly interrupted by the passing rotor blades. It is therefore not possible to observe shadow flicker from an open location, although there may still be a discernible change in the light pattern when in close proximity to turbines.

19.5.6 There are no shadow flicker effects onsite prior to the deployment of wind turbines within the Proposed Development. Nor are there any other similar devices that could potentially break the path of sunlight to a receptor in a similar rhythmic pattern to a rotating turbine. The baseline conditions in the absence of turbines would, therefore, comprise natural lighting and show zero shadow flicker effects.

19.5.7 Effects from other nearby wind farms are considered in the cumulative effects section, but no dwelling in the study area is within 10RD of the cumulative sites, so any baseline effects that were to exist from those turbines would be very weak.

19.6 Assessment of Potential Effects

19.6.1 All of the representative houses that have been assessed for shadow flicker effects lie within 11RD of at least one of the three turbines. However, of forty-three representative receptors selected for analysis, nineteen lie more than 11RD from Turbine T1, and two lie more than 11RD from T2, as shown in Table 19.1. In total 37 representative dwellings have been determined to have the potential to experience some shadow flicker effects. Some of these 37 receptors represent clusters of multiple nearby houses, especially in the more built-up areas of Rhymney.

19.6.2 The results of the shadow flicker assessment are summarised in Table 0.1 and presented graphically in Appendix 19.1. Six of the representative dwellings (Houses 30, 32, 33, 34, 42, and 43), lie within 11RD but are predicted to receive no shadow flicker because of their location towards the north of the turbines is outside of the zone of influence for shadow flicker. These are shaded grey below.

Table 0.1: Summary of Shadow Flicker Times on Each House

House ID	Days Per Year	Affected Months	Earliest Time (GMT)	Latest Time (GMT)	Max hours per day	Mean hours per day	Total hours
1	87	May-August	18:56	19:35	0.48	0.37	32.2
2	147	January – March September – December	14:25	17:19	1.03	0.64	94.1
3	117	January – March September – November	15:06	17:32	0.81	0.59	68.9
4	113	February – April September – November	15:29	17:44	0.79	0.59	67
5	105	February – March September – November	15:38	17:45	0.72	0.54	56.9
6	95	March – April August – October	16:24	18:41	1	0.62	58.8
7	91	March-May August - September	17:17	18:41	1.19	0.75	68.2
8	83	March – April August - September	16:54	18:17	0.97	0.59	48.9
9	86	February – April September – October	16:25	18:00	0.73	0.5	43
10	71	March – April August – September	17:31	18:37	0.81	0.51	36.1
11	82	April – August	18:27	19:33	0.78	0.55	44.8
12	53	May July – August	18:57	19:33	0.43	0.34	17.8
13	92	May – August	18:51	19:40	0.66	0.55	50.3
14	83	February – March September – October	16:09	17:46	0.58	0.42	35.1
15	73	February – March September – October	16:23	17:50	0.5	0.36	26.6
16	78	February – March September - October	16:01	17:36	0.51	0.38	29.5
17	84	January – March October – November	15:43	17:24	0.52	0.39	32.6
18	84	January – March October – November	15:43	17:24	0.52	0.39	32.6
19	68	May – July	19:16	19:51	0.46	0.41	28.1
20	101	January – March October – November	15:23	17:27	0.7	0.48	48.8
21	119	January – February October - December	14:52	16:43	0.52	0.42	50.1
22	115	January – February October - December	14:57	16:43	0.5	0.41	46.7
23	113	January – February October - December	15:02	16:45	0.49	0.39	43.8
24	117	January – February October - December	15:12	16:52	0.48	0.38	44.9
25	67	April – May July – August	18:25	19:19	0.72	0.48	32.5
26	72	February – March September – October	06:29	08:06	1.16	0.77	55.4

27	82	February – March September – October	06:35	08:24	1.31	0.83	68.1
28	96	January – February November – December	08:13	10:51	1.14	0.78	75.1
29	55	January November – December	14:36	15:18	0.47	0.39	21.4
30	0	N/A	N/A	N/A	N/A	N/A	N/A
31	17	December	14:26	14:41	0.2	0.16	2.8
32	0	N/A	N/A	N/A	N/A	N/A	N/A
33	0	N/A	N/A	N/A	N/A	N/A	N/A
34	0	N/A	N/A	N/A	N/A	N/A	N/A
35	59	January November – December	14:06	15:28	0.46	0.38	22.4
36	118	January – February October – December	11:45	15:58	1.54	1.13	133.5
37	123	January – February October – December	11:50	16:06	1.55	1.15	141.5
38	139	February – April August – November	06:26	09:27	2.51	1.75	242.6
39	108	January – March October – December	07:08	09:09	1.05	0.61	65.6
40	95	January – March October – November	15:25	17:09	0.52	0.38	36.5
41	75	March – April August – October	16:54	18:13	0.6	0.45	33.9
42	0	N/A	N/A	N/A	N/A	N/A	N/A
43	0	N/A	N/A	N/A	N/A	N/A	N/A

	Shaded cells represent dwellings more than 11RD from the turbines.

19.6.3 As discussed in Paragraph 19.3.12, Figure 19.3 shows a shadow flicker contour map indicating the total duration of potential shadow flicker events per annum. This has been calculated using a different method to the modelling of the individual representative building, which, for the assessment, has been configured to have windows facing directly towards all turbines within 11RD. The contour map has no constraints but rather models theoretical effects out to their maximum distances. These effects will be of very intensity, and most are unlikely to be visible at all, significantly larger distances, but the inclusion of these lower intensity events in the contour plots means that the total duration of shadow flicker presented in Figure 19.3 can potentially exceed the duration predicted in Table 19.3 for an individual representative building.

Table 0-2: Weather - Compensated Summary of Shadow Flicker

House ID	Days Per Year	Affected Months	Earliest Time (GMT)	Latest Time (GMT)	Max hours per day	Mean hours per day	Total hours
1	87	May -August	18:56	19:35	0.48	0.12	10.70
2	147	January – March September – December	14:25	17:19	1.03	0.21	31.27
3	117	January – March September – November	15:06	17:32	0.81	0.20	22.90
4	113	February – April September – November	15:29	17:44	0.79	0.20	22.26
5	105	February – March September – November	15:38	17:45	0.72	0.18	18.91
6	95	March – April August – October	16:24	18:41	1	0.21	19.54
7	91	March – May August - September	17:17	18:41	1.19	0.25	22.66
8	83	March – April August - September	16:54	18:17	0.97	0.20	16.25
9	86	February – April September – October	16:25	18:00	0.73	0.17	14.29
10	71	March – April August – September	17:31	18:37	0.81	0.17	12.00
11	82	April – August	18:27	19:33	0.78	0.18	14.89
12	53	May July – August	18:57	19:33	0.43	0.11	5.91
13	92	May – August	18:51	19:40	0.66	0.18	16.71
14	83	February – March September – October	16:09	17:46	0.58	0.14	11.66
15	73	February – March September – October	16:23	17:50	0.5	0.12	8.84
16	78	February – March September - October	16:01	17:36	0.51	0.13	9.80
17	84	January – March October – November	15:43	17:24	0.52	0.13	10.83
18	84	January – March October – November	15:43	17:24	0.52	0.13	10.83
19	68	May – July	19:16	19:51	0.46	0.14	9.34
20	101	January – March October – November	15:23	17:27	0.7	0.16	16.22
21	119	January – February October - December	14:52	16:43	0.52	0.14	16.65
22	115	January – February October - December	14:57	16:43	0.5	0.14	15.52
23	113	January – February October - December	15:02	16:45	0.49	0.13	14.55
24	117	January – February October - December	15:12	16:52	0.48	0.13	14.92
25	67	April – May July – August	18:25	19:19	0.72	0.16	10.80
26	72	February – March September – October	06:29	08:06	1.16	0.26	18.41

27	82	February – March September – October	06:35	08:24	1.31	0.28	22.63
28	96	January – February November – December	08:13	10:51	1.14	0.26	24.96
29	55	January November – December	14:36	15:18	0.47	0.13	7.11
30	0	N/A	N/A	N/A	N/A	0.00	0.00
31	17	December	14:26	14:41	0.2	0.05	0.93
32	0	N/A	N/A	N/A	N/A	0.00	0.00
33	0	N/A	N/A	N/A	N/A	0.00	0.00
34	0	N/A	N/A	N/A	N/A	0.00	0.00
35	59	January November – December	14:06	15:28	0.46	0.13	7.44
36	118	January – February October – December	11:45	15:58	1.54	0.38	44.36
37	123	January – February October – December	11:50	16:06	1.55	0.38	47.02
38	139	February – April August – November	06:26	09:27	2.51	0.58	80.62
39	108	January – March October – December	07:08	09:09	1.05	0.20	21.80
40	95	January – March October – November	15:25	17:09	0.52	0.13	12.13
41	75	March – April August – October	16:54	18:13	0.6	0.15	11.26
42	0	N/A	N/A	N/A	N/A	0.00	0.00
43	0	N/A	N/A	N/A	N/A	0.00	0.00

19.6.4 Any shadow flicker modelled to occur at an inhabited property within 11RD of the site is considered to be significant, even if the landowner owns that property. Therefore, all the representative houses identified within 11 RD will need mitigation applied to those dwellings.

19.6.5 In order to consider the shadow flicker effects on vehicles passing close to the Proposed Development on the road, it is necessary to consider what shadow flicker is. It has the potential to cause 'nuisance' but is not considered to be a health and safety issue, given the frequency of rotation that would be present. To experience shadow flicker from a turbine, you would need to be sufficiently close to the turbines and, in a particular location, be shadowed by the rotor for a period of time. Some roads lie within 11RD of some of the wind turbines, mainly from Rhymney town to the east, A465 to the north, and some countryside and private roads to the west-northwest of the Site. However, as cars will generally be moving along a road, they would pass out of any shadow zone from a particular turbine very quickly. There would be some potential for successive turbines on the same side of a road to cast shadows over the road, but turbines on the opposite side of that road would not as the shadows would be cast away to the other side. To receive shadow flicker for an extended period of time whilst travelling along a road, the driver would need to be facing towards the sun with the rotors interrupting the light from the sun to the vehicle. In this situation, given the relatively low rotational speed of the candidate turbine, the momentary respite from the sun's intensity may actually be beneficial for the driver, who would otherwise be subjected to its continuous glare.

19.7 Assessment of Cumulative Effects

19.7.1 There are six other wind farms at varying stages of development in close proximity to the Site, and these turbines have the potential to cause effects that could potentially interact with the effects of the Proposed Development. These wind farms are Pen Bryn Oer, Unit 29 Tafaranaubach Industrial Estate, Plot 5 Pengarnddu Industrial Estate, and St Merryn Meat Factory, Pengarnddu Industrial Estate, at land adjacent to Unit 3 and Valley Heights Filling Station.

19.7.2 When considering an area of influence equivalent to 11RD around the cumulative windfarm sites, **Table 0.1** shows that 11RD will of the Proposed Site will intersect with cumulative sites; however, none of the receptors that have been assessed in detail in the shadow flicker assessment fall directly within this area. Beyond 10RD, any effects are considerably weakened and unlikely to be significant. As none of the dwellings within 11RD of the Proposed Development are also expected to experience shadow flicker arising from other wind farms, it is not considered that there will be any cumulative shadow flicker effects.

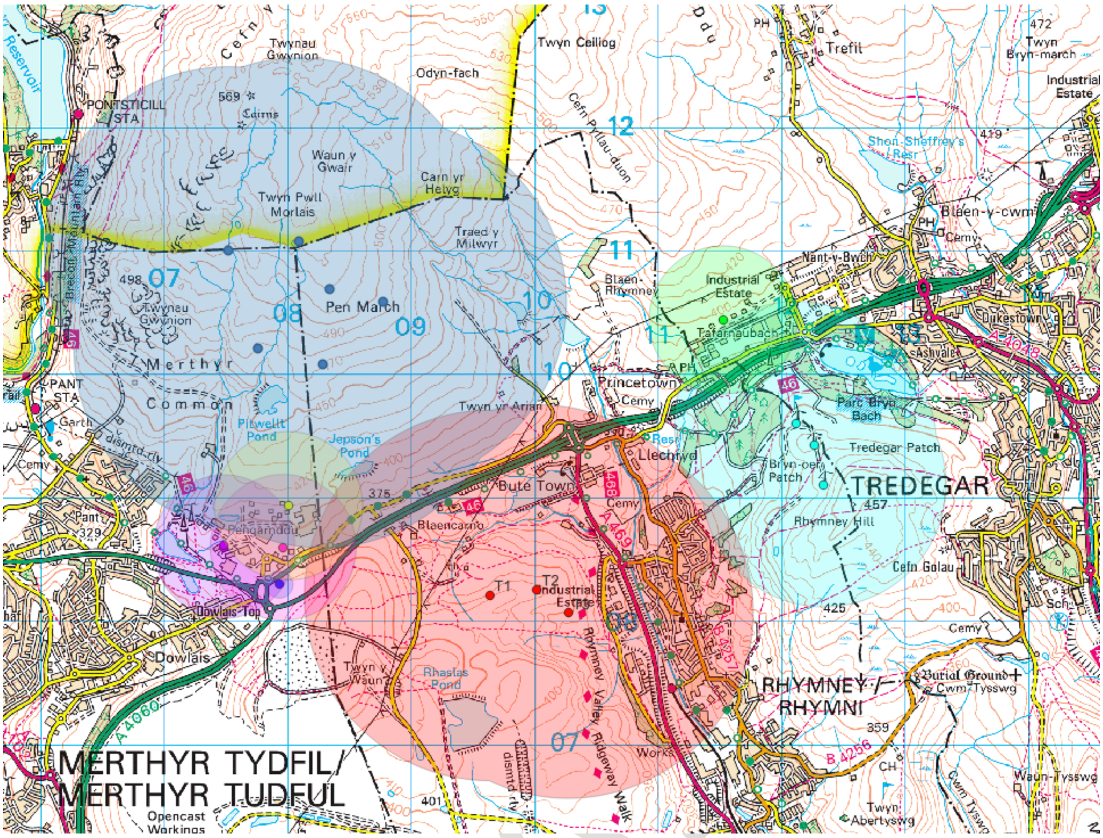

Figure 0.1: Intersection of 11RD Buffers Around Proposed Development and Nearest Cumulative sites

(Contains OS Open Data © 2024)

19.8 Mitigation Measures

19.8.1 Mitigation will be delivered by programming the turbines with the potential to generate shadowing effects to switch off during times when shadow flicker could occur.

19.8.2 This will be achieved by installing a light meter at the wind turbine and then switching off the turbine at times when shadow flicker has been predicted and natural light levels on that day are sufficiently strong to cause the potential for shadow flicker.

19.8.3 If consented, a detailed survey of windows on the properties at risk of experiencing shadow flicker will be carried out, prior to commissioning of the Proposed Development. This would enable the operational shutdown plan to be designed, and the relevant wind turbines will be programmed to shut down at those times when shadow flicker has been modelled as possible and when climatic conditions are such to enable the effects to manifest.

19.8.4 Shutting down the turbines in this way is expected to slightly reduce the output of the entire wind farm each year but, after accounting for the effects of adverse weather in limiting flicker effects it is not expected to compromise the viability of the windfarm to provide significant energy generation to the Convatec Green Manufacturing Hub.

19.8.5 Following mitigation, no shadow flicker will be experienced at any of the inhabited properties considered in this assessment.

19.9 Residual Effects

19.9.1 Following mitigation, there are not expected to be any residual effects.

19.10 Summary

19.10.1 For the purpose of this assessment any shadow flicker at an inhabited property within 11RD is considered significant.

19.10.2 Representative dwellings have been identified and the shadow flicker they are likely to experience has been modelled. It should be noted that these representative buildings are often part of clusters of individual units and, in many cases, visibility to the turbines will be wholly or partially obscured by other houses within the cluster.

19.10.3 Shadow flicker modelling of the 43 representative dwellings within 11 rotor diameters of the turbine locations has been undertaken, and this shows that 37 of these properties would likely have potential to experience shadow flicker effects. A further six representative dwellings lie to the north of the turbines within 11RD but outside of the shadow flicker zone and will not experience any effects.

19.10.4 The worst affected of these 37 representative dwellings has been modelled to have the theoretical potential experience up to 2.5hrs of flicker a day during Spring and Autumn, with a worst-case scenario of receiving up to 243hrs of shadow flicker a year (falling to approximately 80hrs after considering the effects of weather events). Flicker predicted at other locations varies depending on distance and location but are typically affected for 20-50hrs a year. The limitations in the modelling discussed in the chapter above could see instances reduced even further.

19.10.5 Mitigation will be employed to shut down the relevant turbines and prevent shadow flicker from occurring at the correct time and if the meteorological conditions exist for shadow flicker are present. Following mitigation, no properties within 11RD will experience shadow flicker, and therefore, there will be no significant residual effect.