15 Shadow Flicker

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15 Shadow Flicker

15.1 Executive Summary

15.1.1 This chapter presents an assessment of the potential shadow flicker effects from the Proposed Development on residential receptors.

15.1.2 Within the study area for shadow flicker effects (within 130 degrees either side of north from each turbine and out to 10 rotor diameters), there are ten identified receptors with potential to experience flicker effects.

15.1.3 Calculations have shown that the realistic scenario modelling of shadow flicker at eight of these receptors is found to be within the accepted guidelines and therefore not significant. The theoretical duration of shadow flicker exceeded thresholds at two receptor locations. These receptors are both financially involved with the Proposed Development and there are existing blocks of forestry between the receptors and the turbines which have not been accounted for in the assessment, which will reduce the shadow flicker experienced in reality. It is also important to stress the theoretical and conservative nature of the model, and the absence of any consideration of local screening from vegetation, blinds or curtains at the properties, or true window orientation relative to the turbines, which in reality will reduce further the potential time receptors are likely to experience shadow flicker over the course of the year. For these reasons it is unlikely the number of hours predicted in the 'realistic' scenario would actually occur or be experienced by inhabitants at the sensitive receptors. Notwithstanding these points and the financial involvement of the properties, the Applicant is committed to providing a Shadow Flicker Mitigation Protocol to be engaged should any concerns in relation to shadow flicker effects from the turbines be raised by neighbouring properties during the operational period.

15.1.4 A cumulative assessment indicated that of the one receptor identified, the maximum occurrence of shadow flicker is anticipated to be within the accepted limits of 8 hours per year (realistic) and does therefore not experience significant effects.

15.1.5 Therefore, shadow flicker is expected to be not significant for all receptors during the operational phase of the Proposed Development.

15.2 Introduction

15.2.1 This chapter describes and assesses potential shadow flicker effects resulting from the Proposed Development on neighbouring residential properties. This chapter (and its associated figures and appendices) is not intended to be read as a standalone assessment and reference should be made to the description of the Proposed Development in Chapter 3: Proposed Development.

15.2.2 Shadow flicker occurs when, *"[In] certain combinations of geographical position, time of day and time of year, the sun may pass behind the rotor and cast a shadow over neighbouring properties. When the blades rotate, the shadow flicks on and off; the effect is known as "shadow flicker". It occurs only within buildings where the flicker appears through a narrow window opening"* (Scottish Government, 2014, Onshore Wind Turbines).

15.2.3 Any receptors which may potentially be affected have been identified and the risk of shadow flicker calculated.

15.2.4 The magnitude of shadow flicker effects varies both spatially and temporally, and depends on a number of environmental conditions coinciding at a particular point in time, which include:

- time of day and year;
- wind direction;
- height of wind turbine and blade length;
- position of the sun in the sky;
- weather conditions;
- proportion of daylight hours in which the turbines operate;
- type and frequency of use of the affected space; and
- distance and direction of the wind turbine from the receptor.

15.2.5 The flickering effect caused by shadow flicker also has the potential to induce epileptic seizures in people with photosensitive epilepsy. The National Society for Epilepsy (NSE) advises that around 1 in 131 people have epilepsy and up to 5 % of these have photosensitive epilepsy (NSE, 2011). The common rate or frequency at which photosensitive epilepsy might be triggered is between 3 and 30 hertz (Hz, flashes per second). Large commercial turbines rotate at low speeds resulting in less than 3 flashes per second and are therefore unlikely to cause epileptic seizures (Harding et al., 2008: Smedley et al., 2010). Therefore, there are not considered to be any health effects associated with the Proposed Development and this assessment will address the effects of shadow flicker related only to local amenity.

15.2.6 Turbines can also cause flashes of reflected light, which can be visible for some distance. It is possible to ameliorate the flashing but it is not possible to eliminate it. Careful choice of blade colour and surface finish can help reduce the effect and all modern turbine manufacturers use light grey semi-matt finishes to reduce this effect.

15.2.7 A wind development of more than one turbine can also result in more than one turbine affecting a specific receptor at any time, potentially increasing the overall shadow flicker intensity or frequency. This potential effect has been taken into account within this assessment as well as the cumulative effect with other operational wind farms in the local area.

15.2.8 This chapter is supported by the following figures and technical appendices:

- Figure 15.1 Shadow Flicker Study Area
- Figure 15.2 Shadow Flicker Map (Realistic Scenario)
- Figure 15.3 Cumulative Shadow Flicker Study Area
- Figure 15.4 Cumulative Shadow Flicker Map (Realistic Scenario)

- Appendix 15.1 Shadow Flicker Meteorological Data
- Appendix 15.2 Shadow Flicker Graphs

15.3 Legislation, Policy and Guidelines

Legislation

15.3.1 There is no applicable legislation that directly deals with the assessment or control of shadow flicker.

Planning Policy

15.3.2 Chapter 5 of the EIA Report sets out the planning policy framework that is relevant to the EIA. The policies set out below include those from the South Lanarkshire Local Development Plan (LDP) (2015) and the proposed LDP 2 (2020), expected to be adopted in early 2021. This section also considers the relevant aspects of Scottish Planning Policy (SPP), Planning Advice Notes and other relevant guidance. Of relevance to the shadow flicker assessment presented within this chapter, regard has been had to the following policies:

- LDP (2015) Policy 19: Renewable Energy;
- LDP 2 (2020) Policy 18: Renewable Energy; and
- Paragraph 169 of SPP.

15.3.3 SLC LDP 2: Supporting Planning Guidance on Renewable Energy (2020) sets out policies and other advice in support of wind developments in South Lanarkshire. Paragraph 5.75 states that the SLC would expect a shadow flicker assessment to be undertaken for residential development within 10 rotor diameters of the proposed turbine locations.

Guidance

15.3.4 The Update of UK Shadow Flicker Evidence Base (DECC, 2011) reviews international legislation relating to the assessment of shadow flicker for wind turbine development and concludes 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.

15.3.5 This assessment also takes into consideration the Scottish Government Online Renewables Planning Advice: Onshore Wind Turbines (Scottish Government, 2014).

15.4 Consultation

15.4.1 The intent to undertake a shadow flicker assessment for this project was outlined to Scottish Ministers within the Scoping Report in June 2020 (refer to Appendix 4.1: Cumberhead West Scoping Report). The Energy Consents Unit's Scoping Opinion received September 2020 (refer to Appendix 4.2: ECU Scoping Opinion) made no reference to shadow flicker specifically but does state that "*Scottish Ministers are satisfied with the scope of the EIA set out".*

15.4.2 The SLC Environmental Health Officer (EHO) was reconsulted in October 2020 to confirm the proposed shadow flicker assessment methodology (refer to Appendix 4.3: Further Consultation). The EHO responded on 27 October 2020 confirming the proposed methodology and that financially involved properties should still be included in the assessment for completeness.

15.5 Assessment Methodology and Significance Criteria

Study Area

15.5.1 The shadow flicker assessment has been carried out for the proposed 21 turbines at the locations identified in Chapter 3: Proposed Development. As no specific turbine model has been identified by the Applicant, this assessment has chosen the worst-case scenario model from a short list of

candidate turbines that could be installed at the site. Dimensions of the chosen model used for the purposes of the shadow flicker assessment can be found in Table 15.1.

Table 15.1 - Details of the Turbine Model Used for the Shadow Flicker Assessment (Siemens SG-6.0-155)

Hub height	122.5 m
Rotor diameter	155 m
Swept Area	18,869 m²

15.5.2 The study area within which receptors could potentially be affected by shadow flicker has been set at a distance of 10 rotor diameters from each turbine and 130 degrees either side of north (relative to each turbine), as noted within Update of UK Shadow Flicker Evidence Base report (DECC, 2011) and agreed with the EHO (refer to Appendix 4.3: Further Consultation). In this assessment the study area extends to 1.55 km from each turbine. Figure 15.1 shows the extent of this area and those receptors that could potentially be affected by shadow flicker.

Desk Study

15.5.3 The desk-based assessment identified 10 occupied residential properties within the study area that have the potential to be affected by shadow flicker (refer to Figure 15.1).

15.5.4 Of the identified properties, Logan Farm, North Cumberhead Farm, and Broomknowe are financially involved with the Proposed Development.

15.5.5 Blackhill Cottage, held in the same land ownership as a number of the turbines within the Proposed Development, is abandoned and unoccupied and has therefore been scoped out of the shadow flicker assessment.

15.5.6 South Cumberhead is an additional property within the study area however this is in ruined condition and considered to be uninhabitable therefore has been discounted from the assessment and is therefore not considered further.

15.5.7 Table 15.2 below summaries the locations of the potential receptors and the distance from each property to the nearest turbine.

Table 15.2 – Receptor Locations

Shadow Flicker ID	Address	Easting	Northing	Elevation (m)	Approx. Distance to Nearest Turbine (km)	Turbine
1	Logan Farm*	273977	635240	335	0.76	T10
2	Dunside	274924	637253	308	1.58	T16
3	1 Dunside Waterworks Cottage	275248	637177	297	1.39	T16
4	2 Dunside Waterworks Cottage	275222	637176	297	1.39	T16
5	Cleughead	277186	637077	274	1.44	T19

Shadow Flicker ID	Address	Easting	Northing	Elevation (m)	Approx. Distance to Nearest Turbine (km)	Turbine
6	Waterside View Birkenhead	277657	636541	276	1.55	T19
7	Birkenhead Farm	277718	636496	271	1.60	T19
8	Todlaw	277942	635530	295	1.55	T17
9	Broomknowe*	277875	634590	290	1.28	T20
10	North Cumberhead*	277620	634566	289	1.03	T20

**Properties with financial involvement in Proposed Development.*

Assessment of Potential Effect Significance

15.5.8 There is no UK statutory guidance relating to the acceptable levels of shadow flicker. The DECC 2011 report identifies best practice guidelines across Europe and this assessment will adopt the generally accepted quantitative guidance which adopts two maximum limits to define significant effects:

- A worst-case scenario limit of 30 hours per year or 30 minutes on the worst affect day; and
- a realistic scenario taking account of meteorological parameters limited to 8 hours per year.

15.5.9 Within this assessment the sensitivity of the receptors is assumed to be high in all cases as all receptors are residential dwellings.

Assessment Modelling

15.5.10 In assessing the effect of shadow flicker, the commercial software model WindPro 3.2 was used to calculate the expected number of hours shadow flicker that could occur at each receptor. The model takes into account the movement of the sun relative to the time of day and time of year and predicts the time and duration of expected shadow flicker at a window of an affected receptor. The input parameters used in the model are as follows:

- the turbine locations;
- the turbine dimensions;
- the location of the receptors to be assessed; and
- the size of windows on each receptor and the direction that the windows face.

15.5.11 The WindPro model is based upon a Zone of Theoretical Visibility (ZTV) analysis, which in this case was based upon a Digital Terrain Model (DTM) of 5 m resolution.

15.5.12 Calculations were undertaken for predicted shadow hours at each of the receptors for two scenarios: a theoretical (worst-case) and a realistic scenario. For the worst-case scenario the following assumptions were made:

- all receptors have a 1 m x 1 m window facing directly towards the turbine;
- the turbine blades were assumed to be rotating for 365 days per year;
- there is a clear sky 365 days per year;

- the turbine blades were assumed to always be positioned towards each receptor;
- more than 20 % of the sun was covered by the blade; (in practice, at a distance, the blades do not cover the sun but only partly mask it, substantially weakening the shadow);
- the receptor is occupied at all times; and
- no screening (e.g. forestry or curtains) was present.

15.5.13 The effect of shadow flicker was not calculated where the sun lies less than 3 degrees above the horizon due to atmospheric diffusion, low radiation (intensity of the sun's rays is reduced) and high probability of natural screening. It is generally accepted that below 3 degrees shadow flicker is unlikely to occur to any significant extent (Nordhein-Westfalen, 2002).

15.5.14 These assumptions result in a highly conservative assessment for the following reasons:

- in reality, many of the houses within the study area may not directly face the turbines;
- the turbine blades will not turn for 365 days of the year and will turn to face into the direction of the wind, in order to maximise the energy generating potential from the wind;
- it is unlikely that there will be clear skies 365 days a year;
- receptors may not be occupied at the time that the shadow flicker impact is experienced; and
- screening, such as vegetation or curtains between the window and the turbine is not accounted for within the DTM and model which will prevent any shadows from being cast onto the window and therefore prevent any flickering effect.

15.5.15 In addition, the distance between the turbine and a window has an impact on the intensity of any shadow flicker that is experienced. The study area has been set at 10 rotor diameters as the effects of shadow flicker are shown to be greatly reduced outside this distance.

15.5.16 The assessment carried out is limited to the effects of shadows within buildings. Moving shadows will also be apparent out of doors; however, these do not result in flicker in the same manner or to the same extent, as the light entering windows. Therefore, shadow flicker effects outdoors have been scoped out of further assessment.

Theoretical Scenario

15.5.17 The modelling results for the theoretical scenario are typically considered to be an over estimation of the actual impacts experienced, and use the assumptions listed in paragraph 15.5.9.

Realistic Scenario

15.5.18 In actuality, for much of the year weather conditions will be such that shadows will not be cast or will be weak and would therefore not give rise to shadow flicker effects. WindPro calculations most likely overestimate the duration of effects as outlined above. Other factors such as the potential for screening by vegetation or structures will also reduce or prevent flicker incidence in practice. To create a more realistic scenario for the potential impact of shadow flicker on receptors, it was necessary to identify the expected meteorological conditions at the site and take into account any significant shielding of receptors by buildings and vegetation between the receptors and the turbines.

15.5.19 In order to estimate the impact of cloud cover, information available from the Met Office (1929-2019) was used to consider the likelihood of sunshine at different times of the year, and therefore allow calculations of the 'expected' values for shadow flicker occurrence. As part of the WindPro calculation it is possible to upload data from the nearest climatic station to the site. In the case of the Proposed Development this is the Eskdalemuir Met Office, situated approximately 50 km to the south-east (summarised data from the Met office website can be found in Appendix 15.1: Shadow Flicker Meteorological Data, Table A15.1.1).

15.5.20 Given the largely dynamic status of woodland over the lifetime of the Proposed Development and between seasons, no vegetative screening was incorporated into the model.

15.5.21 The realistic scenario represents a long-term average as it is based on long-term historic metrological data. The variation between individual years can be significant and may lead to future observations differing from the predicted results.

15.5.22 A single 16 degree sector was calculated for 7,446 hours of wind (assumes the Proposed Development is operational for 85% of the year) based on meteorological mast data from the nearby Douglas West Wind Farm site (refer to Appendix 15.1: Shadow Flicker Meteorological Data, Table A15.1.2). The WindPro model also employs a slightly simplistic assumption that sunshine probability and turbine operational probability are independent parameters. The model is therefore expected to yield conservative results; as bright and sunny weather conditions and low wind speeds generally tend to show some degree of correlation.

Limitations to Assessment

15.5.23 All assumptions made by the WindPro 3.2 model are outlined within Section 15.5 of this chapter.

15.5.24 Given the absence of UK guidance on shadow flicker, the assessment has adopted the generally accepted industry practised limit of 30 hours per year or 30 minutes per day (worst case scenario) for permanent dwellings within 10 rotor diameters of the proposed turbines.

15.5.25 The realistic scenario results represent a long-term average as they are based on long-term historic metrological data (91 years, from 1929 to 2020). The variation between individual years can be significant and may lead to future observations differing from the predicted results.

15.6 Baseline Conditions

15.6.1 Ten receptors have been identified within the study area with the potential to experience shadow flicker (refer to Figure 15.1 and Table 15.2) and are located from the north-west to the east of the proposed turbine locations.

15.6.2 The receptors are largely farm dwellings with screening from the existing forestry. However, as noted in the assumptions in Section 15.5 above, due to the largely dynamic status of the woodland over the lifetime of the Proposed Development, for the purposes of the assessment it is assumed that no local screening is present. It is also assumed that all properties face onto the Proposed Development.

15.6.3 Within this assessment the sensitivity of receptors is assumed to be high in all cases.

15.7 Potential Effects

Construction

15.7.1 No shadow flicker will occur during construction of the Proposed Development.

15.7.2 Given that any occurrence of shadow flicker during the short commissioning period would replicate itself during operation of the Proposed Development, albeit more frequently, it is considered appropriate to consider the commissioning activities as part of the operational stage of the Proposed Development.

Operation

Theoretical Modelling of Shadow Flicker Occurrence

15.7.3 The modelling results presented below represent the theoretical worst-case scenario discussed in Section 15.5. The results of the modelling are shown in Table 15.3.

Table 15.3 – Worst-Case Scenario Shadow Flicker Occurrence at each Receptor

Shadow Flicker ID	Address	Shadow Hours per Year	Max Shadow Hours per Day	Significance
1	Logan Farm*	145:47	1:06	**Significant**
2	Dunside	19:54	0:22	Not Significant
3	1 Dunside Waterworks Cottage	23:42	0:26	Not Significant
4	2 Dunside Waterworks Cottage	23:33	0:26	Not Significant
5	Cleughead	18:27	0:26	Not Significant
6	Waterside View Birkenhead	20:24	0:24	Not Significant
7	Birkenhead Farm	18:37	0:23	Not Significant
8	Todlaw	14:47	0:23	Not Significant
9	Broomknowe*	49:59	0:28	**Significant**
10	North Cumberhead*	87:27	0:50	**Significant**

**Properties with financial involvement in Proposed Development*

15.7.4 Graphs A15.2.1 to A15.2.10 within Appendix 15.2: Shadow Flicker Graphs summarise the occurrence of shadow flicker at the receptors and illustrate the times of year and times of day when shadow flicker could theoretically occur. In reality, the duration of shadow flicker at each location is likely to be considerably less than that indicated above for the reasons outlined in Sections 15.5 and 15.6.

15.7.5 The theoretical duration of shadow flicker calculated is indicated to be **significant** at receptors 1, 9 and 10. These are the three properties financially involved with the Proposed Development.

15.7.6 The duration of shadow flicker at the remaining seven receptors (2-8) is indicated to not be significant and these receptors are likely to experience shadow flicker less than 30 hours per year or less than 30 mins per day.

Realistic Modelling of Shadow Flicker Occurrence

15.7.7 The modelling results presented in Table 15.4 represent the realistic scenario discussed in paragraph 15.5.15. The inclusion of indicative wind data and average sunshine hours into the shadow flicker calculations has greatly reduced the potential of shadow flicker occurrence at all of the receptors (refer to Figure 15.2).

Table 15.4 - Realistic Scenario Shadow Flicker Occurrence for each Receptor

Shadow Flicker ID	Address	Shadow Hours per Year	Shadow Hours per Day	Significance
1	Logan Farm*	16:01	00:07	**Significant**
2	Dunside	1:44	00:02	Not Significant
3	1 Dunside Waterworks Cottage	2:04	00:03	Not Significant
4	2 Dunside Waterworks Cottage	2:04	00:03	Not Significant
5	Cleughead	2:07	00:03	Not Significant
6	Waterside View Birkenhead	2:30	00:03	Not Significant
7	Birkenhead Farm	2:19	00:03	Not Significant
8	Todlaw	1:54	00:03	Not Significant
9	Broomknowe*	6:46	00:04	Not Significant
10	North Cumberhead*	11:46	00:07	**Significant**

**Properties with financial involvement in Proposed Development*

15.7.8 The model still does not take into consideration any local screening from vegetation, blinds or curtains, or true window orientation relative to the turbines, which in reality will reduce further the potential time receptors are likely to experience shadow flicker over the course of the year.

15.7.9 The realistic duration of shadow flicker calculated is now only indicated to be at **significant** levels at receptors 1 and 10, with a duration greater than 8 hours per year. These receptors are both financially involved with the Proposed Development and there are existing blocks of forestry between the receptors and the turbines which have not been accounted for in the assessment which will reduce the shadow flicker experienced in reality. It is also important to stress the theoretical and conservative nature of the model, and the absence of any consideration of screening in the model as explained in paragraph 15.7.8. For these reasons it is unlikely the number of hours predicted in the 'realistic' scenario would actually occur at the sensitive receptors. In reality the expected total shadow hours will be less than modelled. Notwithstanding these points and the financial involvement of receptors 1 and 10, the Applicant is committed to providing a Shadow Flicker Mitigation Protocol to be engaged should any concerns in relation to shadow flicker effects be raised and shadow flicker subsequently be found to be causing nuisance in certain atmospheric conditions.

15.7.10 The realistic duration of shadow flicker calculated is indicated to be at non-significant levels at the remaining eight receptors (2-9), with a duration less than 8 hours per year.

Decommissioning

15.7.11 Given that any occurrence of shadow flicker during the short decommissioning period would replicate itself during operation of the Proposed Development, it is considered appropriate to

consider the decommissioning activities as part of the operational stage of the Proposed Development.

15.7.12 No shadow flicker impact can occur post-decommissioning of the Proposed Development.

15.8 Cumulative Assessment

15.8.1 In order to assess the potential for cumulative impact from other wind developments in the surrounding area or from turbines within the Proposed Development, any turbines within 3.1 km of the turbine locations were reviewed. Shadow flicker impacts are considered to extend to 10 rotor diameters from turbine locations, therefore a 3.1 km search area for cumulative developments considers any potential for overlap between the Proposed Development study area (1.55 km) and a cumulative development with at least an equivalent rotor diameter.

15.8.2 Shadow flicker study areas were calculated for the below developments based on the dimensions and locations detailed within the planning applications. There is one development located within 3.1 km of the proposed turbine locations which has a shadow flicker study area that overlaps with, or is within very close proximity to, ten identified receptors for the Proposed Development. This is shown on Figure 15.3 and is the operational Auchrobert Wind Farm which lies to the north of the Proposed Development.

15.8.3 Receptor 2 lies within the area of overlap between the study area of the Proposed Development and Auchrobert Wind Farm. As such, a cumulative shadow flicker assessment was undertaken.

15.8.4 Table 15.5 details the expected total realistic hours of shadow flicker per year on this receptor as a result of the two developments being operational.

Table 15.5 – Cumulative Shadow Hours (Realistic Scenario) at Receptors

Shadow Flicker ID	Address	Shadow Hours per Year
2	Dunside	7:18

15.8.5 The total number of cumulative shadow hours per year is indicated to be at non-significant levels at receptor 2, with a duration less than 8 hours per year (refer to Figure 15.4). This total figure is likely to be conservative for the reasons noted in paragraph 15.7.7 and that this receptor is on the upper limit of the distance from turbines beyond which shadow flicker can be experienced.

15.9 Mitigation

Construction

15.9.1 No mitigation measures are required during the construction phase of the Proposed Development.

Operation

15.9.2 Although the realistic scenario takes into consideration expected operational time for the turbines and average sunshine hours for the region, the results are likely to still be conservative due to local vegetation, dwelling orientation and internal screening from blinds, curtains or furniture that are not included in the model. Additionally, while shadow flicker may potentially occur at these locations it is possible that flicker will not be 'experienced' at all locations due to the time of day during which it may potentially occur.

15.9.3 There are a number of forms of mitigation available to developers to mitigate the effects of shadow flicker further, with one of the most effective means being selective automatic turbine shutdown during certain times of year and during certain weather conditions. This level of mitigation is, however, not always required.

15.9.4 In order to minimise the potential shadow flicker effects and to mitigate potential exceedances of acceptable limits at any property, the Applicant proposes that prior to the erection of the first

turbine a written scheme (known as the 'Wind Farm Shadow Flicker Protocol') shall be submitted to and approved in writing by SLC. The protocol would be engaged if a founded shadow flicker complaint is received and investigations indicate that significant effects may occur in certain atmospheric conditions.

15.9.5 This would set out mitigation measures to alleviate shadow flicker attributable to the Proposed Development, for example shut down periods of certain turbine(s) during meteorological conditions when shadow flicker is predicted, as well as a protocol for addressing a complaint received from a receptor within the study area. Operation of the turbines would be required to take place in accordance with the approved Shadow Flicker Protocol and any mitigation measures that have been agreed through the protocol would require to be implemented as appropriate. This matter could be secured by way of an appropriately worded condition of consent.

Decommissioning

15.9.6 No mitigation measures are required during the decommissioning phase of the Proposed Development.

15.10 Residual Effects

15.10.1 On the basis that any potential shadow flicker effects can be mitigated through matters secured through the agreement of the Wind Farm Shadow Flicker Protocol, the residual effects predicted during the operational, construction or decommissioning phases of the Proposed Development are **not significant**.

15.11 Summary

15.11.1 This assessment considers whether the effect known as 'shadow flicker' is likely to be caused by the Proposed Development and assesses the potential for impact on sensitive receptors. Shadow flicker is the effect of the sun passing behind the moving rotors of the turbines casting a flickering shadow through the windows and doors of neighbouring properties. This occurs in certain combinations of geographical position, time of day, time of year and specific weather conditions.

15.11.2 The study area within which properties could potentially be affected by shadow flicker covers a distance of 10 rotor diameters from each turbine and lies 130 degrees either side of north (relative to each turbine). In the case of the Proposed Development, this area extends to 1.55 km from each turbine.

15.11.3 No shadow flicker impact can occur during the construction or the decommissioning of the turbines.

15.11.4 A shadow flicker assessment of the operational phase of the Proposed Development was undertaken at the ten identified receptors within the study area with potential to experience flicker effects. Realistic scenario calculations have shown that receptors 1 and 10 have the potential to experience shadow flicker for a duration exceeding the significance criteria of 8 hours per year. Therefore, the effect of shadow flicker is reported as significant at these receptors. Both receptors are financially involved with the Proposed Development.

15.11.5 Cumulative assessment identified that receptor 2 is within the cumulative study area with the Auchrobert Wind Farm development. The assessment indicated that the potential shadow flicker experienced at receptor 2 would be less than 8 hours per year and therefore **not significant**.

15.11.6 It is important, however, to note that these results do not take into account existing screening features (structures and vegetation), dwelling orientation and local mitigation measures such as blinds or curtains which will reduce potential effects further. Receptors may also be in rooms that are not generally used at the affected times, therefore, the amount of time when shadow flicker is actually 'experienced' will likely be significantly less than what has been predicted.

15.11.7 Proposed mitigation measures in this case relate to the imposition of a Wind Farm Shadow Flicker Protocol to be agreed with SLC which could include a programme of selective automatic shutdown of certain turbine(s) under certain conditions if any founded shadow flicker complaints from residents are received, and all other mitigation options have been fully explored.

15.11.8 The residual effect of shadow flicker is, therefore, expected to be **not significant** for all receptors during the operational phase of the Proposed Development.

15.11.9 Table 15.6 below provides a summary of effects with regards to the shadow flicker effects resulting from the Proposed Development.

Table 15.6 – Summary Table

Description of Effect	Significance of Potential Effect		Mitigation Measure	Significance of Residual Effect	
	Significance	Beneficial/ Adverse		Significance	Beneficial/ Adverse
During Construction & Decommissioning					
No shadow flicker effects during construction or decommissioning.					
During Operation					
Shadow flicker nuisance on residential receptors 1 & 10	Significant	Adverse	Implementation of a Wind Farm Shadow Flicker Protocol if founded complaints from residents are received, to be agreed with South Lanarkshire Council	Not Significant	N/A
Cumulative Effects					
Cumulative shadow flicker nuisance on receptor 2 from Auchrobert wind farm.	Negligible	Adverse	Implementation of a Wind Farm Shadow Flicker Protocol if founded complaints from residents are received, to be agreed with South Lanarkshire Council	Not Significant	N/A

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