13. Shadow Flicker & Reflected Light

Introduction & Background

13.1 In sunny conditions, any shadow cast by a wind turbine will mirror the movement of the rotor. When the sun is high, any shadows will be confined to the wind farm area but when the sun sinks to a lower azimuth moving shadows can be cast further afield and potentially over adjacent properties. Shadow flicker is generally not a disturbance in the open as light outdoors is reflected from all directions. The possibility of disturbance is greater for occupants of buildings when the moving shadow is cast over an open door or window; since the light source is more directional.

13.2 Whether shadow flicker is a disturbance depends upon the observer's distance from the turbine, the direction of the dwelling and the orientation of its windows and doors from the wind farm, the frequency of the flicker and the duration of the effect, either on any one occasion or averaged over a year.

13.3 In any event and irrespective of distance from the turbines, the flickering frequency will depend upon the rate of rotation and the number of blades. It has been recommended (Clarke, 1991) [1] that the critical frequency should not be above 2.5 Hz, which for a three-bladed turbine is equivalent to a rotational speed of 50 rpm. The candidate turbines proposed at Carnbuck Wind Farm would rotate at between 11 and 14 rpm, which is well below this threshold.

13.4 This chapter presents the outcome of the shadow flicker analysis for the proposed Carnbuck Wind Farm, hereinafter referred to as the Proposed Development. The assessment has been carried out by RES Ltd. RES has undertaken shadow flicker assessments for the majority it its UK wind farm developments since 2010.

13.5 Figure 13.1 is referenced in the text where relevant.

Reflected Light

13.6 A related visual effect to shadow flicker is that of reflected light. Theoretically, should light be reflected off a rotating turbine blade onto an observer then a stroboscopic effect would be experienced. In practice a number of factors limit the severity of the phenomenon and there are no known reports of reflected light being a significant problem at wind farms.

13.7 A limiting factor is that wind turbines have a semi-matt surface finish which means that they do not reflect light as strongly as materials such as glass or polished vehicle bodies.

13.8 Secondly, due to the convex surfaces found on a turbine, light will generally be reflected in a divergent manner.

13.9 Thirdly, as with shadow flicker, certain weather conditions and solar positions are required before an observer would experience this phenomenon.

13.10 It is therefore concluded that Carnbuck Wind Farm will not cause a material reduction to amenity owing to reflected light.

Policy and Guidance

13.11 The update to Shadow Flicker Evidence Base (2011) [2], published by the then Department for Energy and Climate Change (DECC), states that assessing shadow flicker effects within ten times the rotor diameter of wind turbines has been widely accepted across different European countries, and is deemed to be an appropriate area.

13.12 The Best Practice Guidance to Planning Policy Statement 18 "Renewable Energy" (2009) [3] further describes that, *"…at distances greater than 10 rotor diameters from a turbine, the potential for shadow flicker is very low"*.

Assessment Methodology

13.13 This shadow flicker assessment is based on turbines with a 138 m rotor diameter and the planning application includes a 50 micro-siting distance for infrastructure. As such, this 50 m distance is added to the ten-rotor diameter (1380 = 10 * 138) m distance to give a total distance of (1430 = 1380 + 50) m from any turbine.

13.14 Analysis was undertaken for shadow flicker at all properties within 1430 m from any wind turbine.

13.15 This analysis takes into account the motion of the Earth around the Sun, the local topography and the turbine locations and dimensions. The analysis was performed using the 12 turbine layout, each with maximum tip heights of 180 m, as described in the Proposed Development.

Results

13.16 With due reference to the DECC report, the potential shadow flicker is given in the Table below:

Table 13.1: Predicted maximum annual potential shadow flicker

RES Property ID	Property Address	Maximum Hours of Flicker Per Year
H6	CORKEY ROAD CLOUGHMILLS BT44 9JB	18.1
H10	210 CORKEY ROAD CLOUGHMILLS BT44 9JB	23.8
H11	206 CORKEY ROAD CLOUGHMILLS BT44 9JB	17.6
H12	208 CORKEY ROAD CLOUGHMILLS BT44 9JB	18.9
H13	212 CORKEY ROAD CLOUGHMILLS BT44 9JB	20.3
H14	216 CORKEY ROAD CLOUGHMILLS BT44 9JB	18.5
H16	214 CORKEY ROAD CLOUGHMILLS BT44 9JB	17.7

H22	GRUIG LANE BALLYMENA BT44 9JD	9.3
H27	34A SKERRY ROAD WEST BALLYMENA BT43 6RT	29.2
H33	52 OLD CUSHENDUN ROAD BALLYMENA BT43 6RJ	5.5
H34	218 CORKEY ROAD CLOUGHMILLS BT44 9JB	22.5
H45	16 GRUIG LANE BALLYMENA BT44 9JD	38.7
H49	33 SKERRY ROAD WEST BALLYMENA BT43 6RT	21.4
H52	32 OMERBANE ROAD CLOUGHMILLS BT44 9PE	0.0
H58	14 GRUIG LANE BALLYMENA BT44 9JD	26.28
H59	15 GRUIG LANE BALLYMENA BT44 9JD	13.93
H94	44 TULLYKITTAGH ROAD CLOUGHMILLS BT44 9PA	28.48
H164	196 CORKEY ROAD CLOUGHMILLS BT44 9JB	16.43
H165	198 CORKEY ROAD CLOUGHMILLS BT44 9JB	16.93
H168	12a GRUIG LANE BALLYMENA BT44 9JD	21.78
H173	18 GRUIG LANE BALLYMENA BT44 9JD	47.60
H209	34 SKERRY ROAD WEST BALLYMENA BT43 6RT	32.75
H222	OLD CUSHENDUN ROAD BALLYMENA BT43 6RJ	0.00
H224	SKERRY ROAD WEST BALLYMENA BT43 6RS	16.72

13.17 The above predictions in Table 13.1 represent a worst-case scenario for the following reasons:

- The analysis assumes that there is always sufficient lack of cloud cover, for there to be sufficient sunlight for shadows to be cast by the turbine.
- The analysis assumes that there is always enough wind for the turbine blades to be turning.
- The analysis assumes that the wind is always coming from the right direction for the turbine rotor to be facing towards the house, to thus cast a shadow.
- The analysis assumes that the property has windows and/or glazed doors facing towards the turbine.
- The analysis assumes there is no shielding, e.g. in the form of trees or outbuildings, between the turbine and the property.

Likely Significant Effects

Operational Effects

13.18 Table 13.1 summaries the predicted total hours of shadow flicker at each of the properties within the study area. The Best Practice Guidance to PPS18 recommends that, “shadow flicker at neighbouring offices and residential properties within 500m should not exceed 30 hours per year or 30 minutes per day”. There are no offices or residential properties within 500 m of the Proposed Development turbines, so the Proposed Development is in compliance with this recommendation.

13.19 Table 13.1 shows that there are three properties (H45, H173 and H209) where the total predicted hours exceed 30 per year. However, at over 1000 m from the nearest turbine all the properties are located far beyond the 500 m distance referenced in the guidance, so the effects are likely to be reduced. This is because at distance, when all other conditions allow, the wind turbine blades do not cover the sun but only partly mask it, substantially weakening any potential shadow.

13.20 Further, as described in paragraph 13.17, the results in Table 13.1 are a theoretical worst case and therefore the actual incidence of shadow flicker experienced will be less.

Mitigation

13.21 In the event of shadow flicker causing a nuisance a range of mitigation measures can be incorporated into the operation of the wind farm to reduce the instance of shadow flicker. Mitigation measures include planting tree belts between the affected dwelling and the responsible turbine(s) or installing blinds at the effected property. In the unlikely event that there is extreme nuisance mitigation could include shutting down individual turbines during periods when shadow flicker could theoretically occur.

13.22 Mitigation has not been accounted for within the predictions presented in this chapter and, if required, should further significantly reduce the impact of potential shadow flicker predicted. Taking all this into account the effects of shadow flicker are not considered to be significant.

Cumulative Effects

13.23 There are two wind farms, Gruig (operational) and Corkey Repower (consented), located to the north of the Proposed Wind Farm Development, which have been considered in the cumulative assessment. Details of these are summarised in Table 13.2 including distance to properties. It is assumed that the operational Corkey Wind Farm will be replaced by the consented Corkey Repower.

13.24 The 10 rotor diameter distance for the Gruig Wind Farm is 800 m and for Corkey Repower it is 1170 m.

Table 13.2: Summary of Cumulative wind farms

Site	Number of Turbines	Status	Distance to the nearest house (m)
Gruig	10	Operational	1528
Corkey Repower	5	Consented	771

13.25 The closest Gruig turbine to a house is 1528 m from H10. The closest Corkey Repower turbine to a house is 771 m from H1.

13.26 There are no houses in the shadow flicker study area for Carnbuck that also fall within the 10 rotor diameter distance of Gruig Wind Farm and/or Corkey Repower, as shown in Figure 13.2.

13.27 Predictions of shadow flicker do not increase at Carnbuck when the consented Gruig Wind Farm or Corkey Repower are considered. As such the operational Gruig turbines and consented Corkey Repower turbines will not contribute to a cumulative shadow flicker impact at any of the residential properties considered within this assessment.

References

[1] Clarke A.D (1991), A case of shadow flicker/flashing: assessment and solution, Open University, Milton Keynes

[2] Brinckerhoff, Parsons (2011) 'Update of UK Shadow Flicker Evidence Base', Department of Energy and Climate Change, UK Government

[3] Planning Policy Statement 18 "Renewable Energy" (including Best Practice Guidance to Planning Policy Statement 18) August 2009