Chapter 8: Shadow Flicker and Light Reflection

8. SHADOW FLICKER AND LIGHT REFLECTION

8.1 Introduction

This chapter of the ES describes and assesses the potential shadow flicker effects of the Lancaster University wind turbines. It also addresses the matter of potential Light Reflection which has been identified by the Local Planning Authority in their Scoping Response.

Computer modelling has been carried out for the proposed wind turbine at Lancaster University. This has identified a number of potentially sensitive receptors which may experience shadow flicker from the proposed development. While the number of affected days and the duration of such effects would be limited, the possibility of nuisance arising may not be entirely ruled out.

The scope of the shadow flicker and light reflection assessment has been discussed with Lancaster Council at pre application and Scoping stages.

Discussions have also taken place with turbine manufacturers regarding the technical mitigation options currently available.

8.1.1 Nuisance Arising from Shadow Flicker

Shadow flicker effects will be largely attributable to a certain combination of conditions coinciding in specific locations at particular times of the day and year. Factors determining the occurrence and/or perception of shadow flicker nuisance at a receptor include:

- Time of day and year;
- Weather conditions – clear and sunny ;
- Wind direction;
- Position of the Sun e.g. when the sun is low in the sky, directly behind a turbine and in line with the property;
- Height of the turbine and rotor diameter size;
- Distance of the turbine from the property – shadow flicker effect diminishes with distance. At distances greater than ten times the rotor diameter the effect is unlikely to occur[1];
- Type and frequency of use of the affected space within the receptor;
- Size of window apertures and type of curtain or blind fitted (vertical blinds will exacerbate the effect);
- Duration of shadow flicker effects; and
- Presence of mitigating factors such as screening effects from vegetation near windows.

8.2 Relevant Guidance and Legislation

Planning for Renewable Energy, A Companion Guide to PPS22[1] has been considered in carrying out this assessment. The Companion Guide document was published by the Office for the Deputy Prime Minister in 2004 to provide additional information to assist in the implementation of Planning Policy Statement 22: Renewable Energy (PPS22). The Guide provides additional technical information on a range of renewable energy technologies, including onshore wind power, which is universally applicable.

The companion guide describes the conditions under which flicker may occur and states that the effect diminishes with distance and that "flicker effects have been proven to occur only within ten rotor diameters of a turbine. It also confirms that effects only occur within 130 degrees either side of north relative to the turbines''.

Technical advice regarding blade colour and reflections is available directly from the turbine manufactures. The Influence of Colour on the Aesthetics of Wind Turbine Generators' – ETSU W/14/00533/00/00) was also consulted for advice.

[1] Planning for Renewable Energy, A Companion Guide to PPS22Office of the Deputy Prime Minister, 2004

8.3 Assessment Methodology

The shadow flicker assessment has been carried out for two wind turbines, with an approximate mast height of 59m, a blade length of 41 m and a blade diameter of 82 m. The grid reference for the turbine is T1 349175, 457789.

In order to assess ‘expected’ values for receptors which were identified as potentially vulnerable to shadow flicker, it was necessary to identify the likely meteorological conditions which are expected to be experienced at the site.

In order to estimate the impact of cloud cover, freely available information from the Met Office[2] was used to consider the likelihood of sunshine (the sunshine probability) at different times of the year, and thus allow the determination of ‘expected’ values for shadow flicker occurrence. This is achieved by the below equation, in which ‘long term average sunshine hours’ refers to data collected by the Met Office, and ‘potential sunshine hours’ refers to the intervening time period between modelled sunrise and sunset:

Sunshine probability = Long Term Average Sunshine Hours / Potential Sunshine Hours

In the absence of sufficient wind data for the site, a single 360 degree sector was assumed with 8760 hours of wind as a substitute for estimated rotor azimuth and wind speed, which is a very conservative assumption. This analysis also employs the slightly simplistic assumption that sunshine probability and turbine operational probability (derived from the operational hours per year and sector) are independent parameters.

The sunshine probability is multiplied with a values for potential (“worst case”) shadow flicker occurrence at each of the receptors, in order to estimate the ‘expected’ hours per year which could be experienced at these locations.

In reality these ‘expected’ values are expected to yield conservative results; as bright and sunny weather conditions and low wind speeds generally tend to show some degree of correlation, and due to the nature of the assumed simplified wind speed and distribution.

The aforementioned mathematical model is based upon a Zone of Theoretical Visibility (ZTV) analysis, which in this case was based upon a Digital Terrain Model (DTM) at 50 m resolution. A DTM does not account for surface features such as buildings or trees and, as a result, will demonstrate an overly conservative result, giving shadow flicker values in areas which, in reality, will be screened from these effects by surface features.

No guidance is available regarding what levels of shadow flicker may be considered acceptable in the UK. In the absence of UK guidance towards Shadow Flicker mitigation [3and 4] , this chapter will adopt the generally accepted maximum figure of 30 minutes per day; 30 hours per year; or 30 days per year: whichever is greatest. These figures are derived from guidelines applicable in Germany[5], which suggest limiting shadow flicker to an astronomical maximum of 30min per day and 30 hours per year for rooms within residential dwellings, offices, lecture halls, hotels/hospitals or other accommodation, work places (if they are indoors), etc. Therefore for the purposes of this assessment significance effects are categorised to occur where expected shadow flicker results exceed a maximum of 30 minutes per day; 30 hours per year; or 30 days per year: whichever is greatest.

8.4 Baseline Description

21 receptors were placed in areas which were identified as potentially affected by shadow flicker. These are listed in Table 8.1 and shown on a map in Figure 8.1 (Section 8.6.1). These receptors were analysed for “worst case” and “expected” shadow hours per year using the above methodology, which yielded the values displayed in Table 8.2 in Section 8.7.1.

[2] http://www.metoffice.gov.uk/climate/uk/averages/19712000/index.html
[3] Onshore Wind Energy Planning Conditions Guidance Note: A report for the Renewables Advisory Board and BERR, TNEI Services Ltd., 2007
[4] Circular 11/95: Use of Conditions in Planning Permission, DCLG 2006
[5] Hinweise zur Ermittlung und Beurteilung der optischen Immissionen von Windenergieanlagen, Länderausschuss für Immissionsschutz, (2002)

Table 8.1 Potential Shadow Flicker Receptors

Reference	Easting	Northing	Elevation (m)	Name
A	349194	457350	64.0	Farm at Hazelrigg facing North
B	349201	457307	61.4	Farm at Hazelrigg facing West
C	349268	457296	60.4	Cottage at Hazelrigg Facing North.
D	349265	457285	59.8	Cottage at Hazelrigg Facing West.
E	349409	457767	89.5	Farm Buildings near met. station
F	349570	458211	102.2	Blea Tarn Farm
G	349723	458673	107.0	Sunnymede Farm
H	348621	458205	56.3	Bailrigg Farm Residences Facing South
I	348613	458910	56.0	Bailrigg Farm Residences Facing East
J	348662	456593	33.5	Northern-most residence on Green Lane
K	348592	456185	25.0	Northern-most residence in Ellel
L	349056	456729	33.6	Barrow Greaves facing NE
M	349310	456457	32.8	Lower Kit Brow
N	349572	456597	59.3	Higher Kit Brow facing West
O	349600	456606	60.9	Higher Kit Brow Facing North
P	349621	457171	43.8	Banton House facing NW (Golf Club??)
Q	348657	457046	54.8	University South (Grizedale College)
R	348767	457319	59.7	University Middle (Furness College)
S	348764	457710	66.7	University North (County College)
T	348882	457765	46.3	Motorway South (Southbound)
U	348935	457066	71.8	Motorway North (Southbound)

8.5 Information Gaps

In the absence of any data collection with reference to the slope dimensions of windows existing at any of the receptor locations, a standard measurement of a 1x1m window perpendicular to the Earth's Surface was assumed.

8.6 Assessment of Potential Effects

8.6.1 Potential Effects of Shadow Flicker

21 receptors were placed in areas which were identified as potentially affected by shadow flicker. These are listed in Table 8.1 and shown on a map in Figure 8.2. These receptors were analysed for "worst case" and "expected" shadow hours per year using the above methodology, which yielded the values displayed in Table 8.2.

Table 8.2 The 'worst case' (potential), and 'expected' shadow hours per year for each of the shadow receptors

References	Name	Potential Hours/ Year	Potential Hours/ Day	Expected Hours/ Year
A	Farm at Hazelrigg facing North	00:00	00:00	00:00
B	Farm at Hazelrigg facing West	00:00	00:00	00:00
C	Cottage at Hazelrigg Facing North.	00:00	00:00	00:00
D	Cottage at Hazelrigg Facing West.	00:00	00:00	00:00
E	Farm Buildings near met. station	143:08	01:21	04:28
F	Blea Tarn Farm	30:31	00:35	04:48
G	Sunnymede Farm	00:00	00:00	0:00
H	Bailrigg Farm Residences Facing South	15:22	00:28	02:25
I	Bailrigg Farm Residences Facing East	15:03	00:28	02:20
J	Northern-most residence on Green Lane	00:00	00:00	00:00
K	Northern-most residence in Ellel	00:00	00:00	00:00
L	Barrow Greaves facing NE	00:00	00:00	00:00
M	Lower Kit Brow	00:00	00:00	00:00
N	Higher Kit Brow facing West	00:00	00:00	00:00
O	Higher Kit Brow Facing North	00:00	00:00	00:00
P	Banton House facing NW (Golf Club??)	00:00	00:00	00:00
Q	University South (Grizedale College)	00:00	00:00	00:00
R	University Middle (Furness College)	00:00	00:00	00:00
S	University North (County College)	46:53	00:47	03:44
T	Motorway North (Southbound)	00:00	00:00	00:00
U	Motorway South (Southbound)	90:32	01:05	03:24

The "worst case" analysis demonstrates the times in which shadow flicker could potentially occur, were the correct meteorological conditions in place. Of the 21 receptors, 4 were above the aforementioned threshold values for worst case shadow flicker, which were derived from the German Guidance as described in the methodology in this report. These receptors are E, F, S and U; of which receptor U refers to a location on the motorway, and as such should not be considered as a shadow flicker receptor in the conventional sense. It (along with receptor T) was included in this analysis at the request of the client and the reasons for this will be dealt with in more detail later in this report. As to the remaining 3 receptors, these comprise a location at the Northern extremity of the university residences (County College); Lune Valley Kennels, which are located to the East of the proposed site; and a farmhouse to the North-East of the proposed site (Blea Tarn Farm). The two receptors at Bailrigg Farm (H and I) may also receive shadow flicker, but below the threshold, with both being at a potential maximum of approximately 15 hours per year, or 28 minutes in a day.

As is illustrated in the Graphical Calendars located in section 7 of this report; The shadowing at receptor E could only potentially occur only in the early evening, between 6 and 8 PM during part of the Summer (late March to early June, and July to mid September). Receptor F, in contrast, could potentially experience shadow flicker between the hours of approximately 3:30 and 5:00 PM during the winter (mid November to February). It could be suggested, in the case of receptor F, that the 'experience' of shadow flicker at this location could be reduced by possibility of residents being at work during these hours.

Much of the potential shadow flicker at Lancaster University Campus (receptor S) is both early in the morning (prior to 7:30AM), and often during periods which are 'out of term time' (around Easter and the summertime). As such, there is a reduced potential to be experienced by people living or working at the University. This is once again illustrated in the Graphical Calendars located in Appendix 8.1.

It is important to re-iterate at this stage that these values represent those times in which shadow flicker could potentially occur.

The “expected” values, on the other hand, suggest that none of the 21 receptors will exceed 5 hours of shadow flicker per year, with 15 receptors expected to receive none at all. The expected values are listed in Table 8.1 and are illustrated in Figure 8.1. The lack of UK guidance leaves little to put this value in context, as the aforementioned German guidance refers only to worst case values.

It is important to note that the ‘expected value’ predictions represent a long-term average as they are based on long-term historic meteorological observations. The variation between individual years can be significant and may lead to observations in the future which could differ from the results predicted here.

Whilst two receptors were placed upon the Motorway at the request of the client for the production of this report, the Highways Agency Wind Farm Good Practice Guidance[6] states “It is largely agreed that shadow flicker does not affect motorists because of the large amount of glass in the vehicle which reduces the effect” and that “vehicles are moving so any shadow flicker will only last a very short period”, meaning that the figures assessed here are not appropriate to assess the effect upon a vehicle or motorist at this location.

It is often incorrectly assumed that Shadow Flicker may be used as a proxy for driver distraction. This is inappropriate as, once again, the results given by this analysis are not appropriate to the experience of a motorist, and at any rate do not necessarily correlate with distraction. It should also be noted that PPS22[1] states:

“Concern is often expressed over the effects of wind turbines on car drivers, who may be distracted by the turbines and the movement of the blades. Drivers are faced with a number of varied and competing distractions during any normal journey, including advertising boardings, which are deliberately designed to attract attention. At all times drivers are required to take reasonable care to ensure their own and others safety. Wind Turbines should therefore not be treated any differently from other distractions a driver must face and should not be considered particularly hazardous. There are now a large number of wind farms adjoining or close to road networks and there has been no history of accidents at any of them.”

This clearly indicates that driver distraction should not be of special concern for wind turbines. The two motorway receptors were, however, included in this report nonetheless at the request of the client.

8.6.2 Potential Effects of Light Reflection

Generally turbine blade are coloured a light grey anti reflective coating which is a pale industry standard colour. This reduces the effects of reflection efficiently whilst having no influence on the power curve.

8.7 Mitigation

8.7.1 Shadow Flicker

A control system would be employed' as part of the wider turbine control systems to calculate, in real time, whether shadow flicker may affect a property, based on pre-programmed co-ordinates for the properties and wind turbines, and the intensity of sunlight, as measured by a device attached to a turbine tower. When the control system calculates that the sunlight is bright enough to cast a shadow, and that a turbine shadow falls on a property, it automatically shuts the turbine down, re-starting it when the shadow has moved away from the property.

In the highly unlikely event that shadow flicker is experienced at properties other than those identified in this assessment, these would be investigated by Lancaster University or an independent third party, and if a complaint is found to be justified additional control measures of the types identified above will be implemented.

A programme of monitoring will also ensure the effectiveness of the proposed mitigation and allow for it to be adapted to allow for any inaccuracies in the calculation.

8.7.2 Light Reflection

An anti-reflective paint coating would be applied to the turbines to mitigate the possible impacts of light reflection.

[6] CRS 558501 Wind Farm Good Practice Guide, Highways Agency, June 2007.

8.7.3 Cumulative Effects

There are no anticipated cumulative effects with other known developments in the vicinity.

8.8 Residual Effects

The passage of the sun, the size and location of the turbine and the location of the affected receptor will all be known, so the validity of any complaint of shadow flicker is relatively easy to verify by means of commercially available computer models.

Of the 21 identified potentially vulnerable receptors, 7 may experience shadow flicker, 4 of which could potentially exceed the German guideline upper threshold (referred to in the absence of UK guidance). None of these receptors, however, are expected to experience ‘large amounts’ of shadow flicker. 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.

For the locations which could potentially be affected at a level greater than the accepted threshold, the suggested course of action would be to await any complaint before mitigating (given that these are potential effects which could only occur in the event of appropriate atmospheric conditions). Mitigation methods should be decided on a case by case basis, and can range from installation of blinds and planting of trees and bushes to delimiting the wind turbine based on calculations as to the potential for shadow flicker occurrence.