14 SHADOW FLICKER

14.1 INTRODUCTION

This chapter describes and assesses the potential Shadow Flicker effects of the proposed Spicer Hill Wind Farm ('the Development').

Shadow flicker is an effect that can occur when the shadow of a moving wind turbine blade passes over a small opening (window), briefly reducing the intensity of light within the room, and causing a flickering to be perceived.

The likelihood and duration of this flickering depends upon certain combinations of relative sun, turbine and window locations, turbine orientation, times of day, days of the year and weather conditions.

The flickering may have the potential to cause disturbance and annoyance to residents if it affects occupied rooms of a house. Persons with photosensitive epilepsy are usually sensitive to flickering light that is usually between 3 - 60 (Hz) [1]. The frequencies of flicker caused by modern wind turbines (less than 1.5 Hertz)[2,3] are well below the frequencies known to trigger effects in these individuals.

14.2 GUIDANCE AND ASSESSMENT METHODOLOGY

14.2.1 Relevant Guidance

The following guidance and information source has been considered in carrying out this assessment.

'Planning for Renewable Energy, A Companion Guide to PPS22' ("The Companion Guide") was published by the Office for the Deputy Prime Minister (ODPM) in 2004 to provide additional information to assist in the implementation of Planning Policy Statement 22: Renewable Energy (PPS22). The Companion 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.

14.2.2 Assessment Methodology

Properties with the potential to be affected by shadow flicker have been identified using GIS (Geographical Information Systems) by mapping the area around each proposed turbine location within a distance of ten rotor diameters (700 m) and 130 degrees either side of north (the 'shadow flicker study area'). The resulting map showing was then used to identify properties (as shown on Ordnance Survey 1:10,000 scale digital mapping) within the shadow flicker study area, as shown in Figure 14.1. Three properties were identified in this way. This was confirmed during a site visit.

1 Epilepsy Action (2007), 'Photo-sensitive Epilepsy' (http://www.epilepsy.org.uk/info/photo.html)
2 Epilepsy Action (2007), 'Other Possible Epilepsy Triggers' (http://www.epilepsy.org.uk/info/photo_other.html)
3 ODPM, (2004) 'Planning for Renewable Energy: A Companion Guide to PPS22', pp. 17

A recognised computer software package[4] was then used to calculate theoretical specific times and durations of flicker effects for each property. Details of the assumptions made about the properties are given section 14.3: *Baseline Description* of this Chapter.

This software creates a mathematical model of the Development and its surroundings, based on:

- The turbine locations, hub height and rotor diameter;
- Topography (obtained from OS elevation data on a 50 m horizontal grid); and
- The latitude and longitude of the Development site (used in calculating the position of the sun in relation to time of day and year).

A cut-off distance of 700 m (10 rotor diameters) from each turbine was employed during this calculation.

Certain worst-case assumptions are made in the calculation, including:

- weather conditions are such that shadows are always cast during each of 365 days of the year, *i.e.* bright sunshine every day;
- the turbine rotor will always be facing directly towards a given window, maximising the size of the shadow and duration of the effect;
- the turbines will always be rotating; and
- there will not be intervening structures or vegetation (other than topography) that may restrict the visibility of a turbine, preventing or reducing the effect.

The above calculations are intended to indicate a theoretical maximum in potential duration of effects and to provide an approximation of the times of day and year rather than an accurate prediction. This is sufficient for the purposes of this assessment. If deemed necessary, calculations which are more detailed will be carried out for the purposes of developing detailed mitigation measures.

In practice, for much of a given year weather conditions will be such that shadows would not be cast, or would be weak and thus would not give rise to flicker effects. In the UK, bright sunshine typically occurs for around 30% of daylight hours per annum. This means that the computer model calculation most likely overestimates the duration of effects by as much as three times. Other factors such as the potential for screening by vegetation or intervening structures and the varying orientation of the turbines due to varying wind direction will also reduce or prevent flicker incidence in practice as compared to the theoretical maximum suggested by the calculation.

No guidance is available regarding those levels of shadow flicker, which might be considered acceptable in the UK. Therefore, this assessment it has assumed that any shadow flicker effects that are predicted to occur will be significant.

14.3 BASELINE DESCRIPTION

Table 14.1 details the three properties identified within 700 m and 130 degrees either side of north of the proposed turbine locations. These are also shown in Figure 14.1.

[4] WindFarm by ReSoft, Release 4.1.1.1

Table 14.1: Potential Shadow Flicker Receptors

Reference	Name	Easting	Northing	Nearest Turbine No.	Approximate distance from nearest turbine (m)
1	Annat Royd	421319	404955	1	699
2	Spicer House	420481	405587	2	433
3	Brown's Edge	420431	405746	2	599

The following assumptions have been made for all potential receptors:

- All windows have been assumed to measure 1 m by 1 m, to be situated at a height of 3 m above ground level, to the window's centre (representing an average of ground and first floor levels) and to be located at the grid references given in Table 14.1;
- Each property is assumed to have one window on each façade that faces towards a proposed turbine location. The orientations assumed are detailed in Table 14.2; and
- The orientation of the properties' facades has been estimated from OS 1:10,000 scale digital mapping, to the nearest 15 degrees.

The foregoing assumptions provide a level of accuracy consistent with the assumptions discussed in Section 14.2.2: *Assessment Methodology* of this Chapter.

14.4 ASSESSMENT OF POTENTIAL EFFECTS

Table 14.2 details the results of the calculations carried out of the theoretical maximum shadow flicker effects at the identified receptors, and the likely duration (assuming 30% per annum bright sunshine).

Table 14.2 Potential Shadow Flicker Effects

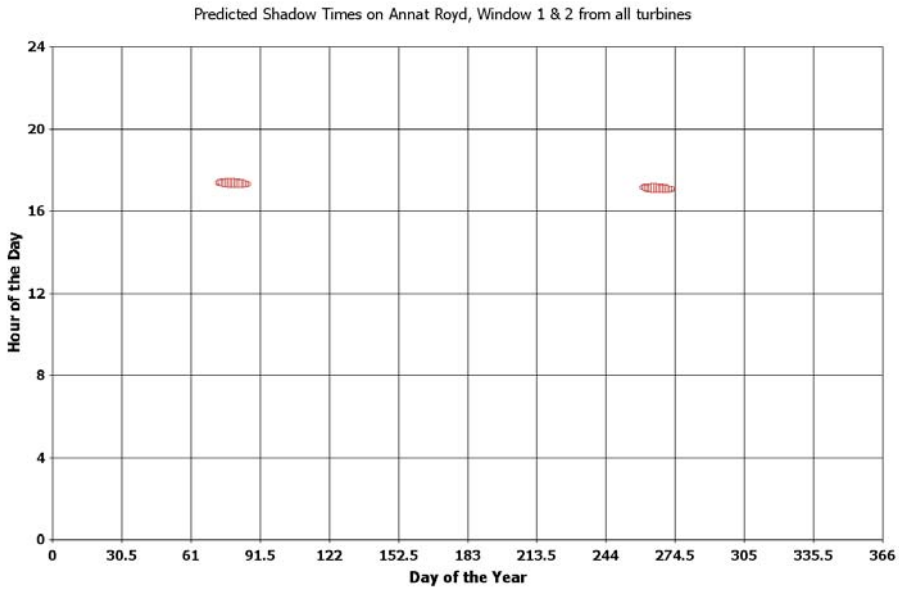
Reference	Name	Window	Orientation	Days per year	Max hours per day	Mean hours per day	Theoretical hours per annum	Likely hours per annum
1	Annat Royd	1	335	32	0.42	0.33	10.6	3.2
		2	245	32	0.42	0.33	10.6	3.2
2	Spicer House	1	135	75	0.64	0.57	43.0	12.9
		2	225	76	0.64	0.56	42.9	12.8
3	Brown's Edge	1	135	36	0.40	0.32	11.5	3.4
		2	225	36	0.39	0.32	11.6	3.4

Charts showing the times of day and year that effects are predicted to occur (for the worst-affected window in each case) and a discussion of the results for each property are presented below.

Property 1: Annat Royd

Chart 14.1 shows the times that shadow flicker has been predicted to occur at Annat Royd on window 1, which faces west. As shown on the graph, effects could occur for short periods during evenings in the months of March and September.

Chart 14.1: Shadow Times at Annat Royd

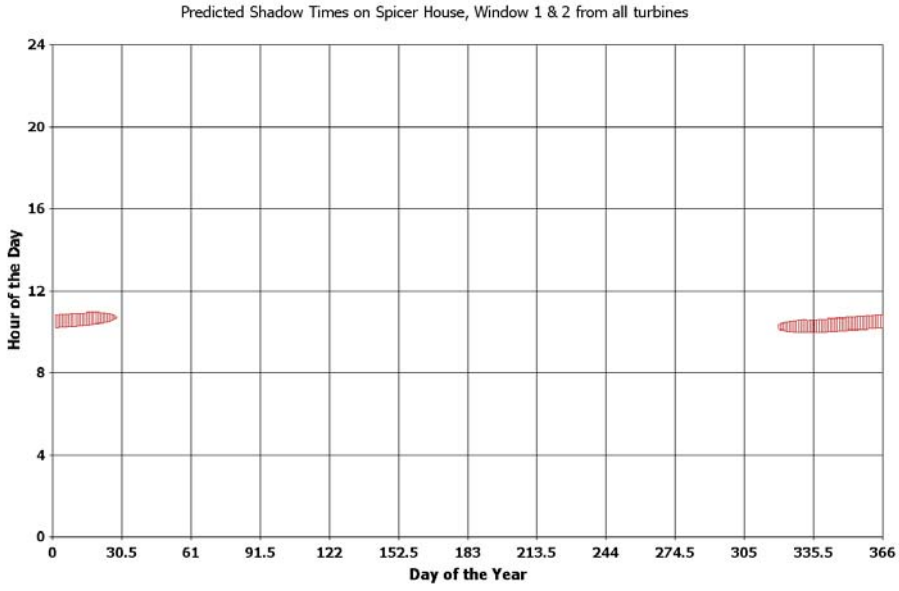


Day 0-366 indicates January 1st to December 31st (taking into account any leap years)

Property 2: Spicer House

Chart 14.2 shows the times that shadow flicker has been predicted to occur at Spicer Hill on window 1, which faces south-east. As shown on the graph, effects could occur during mornings from November till January.

Chart 14.2: Shadow times at Spicer House

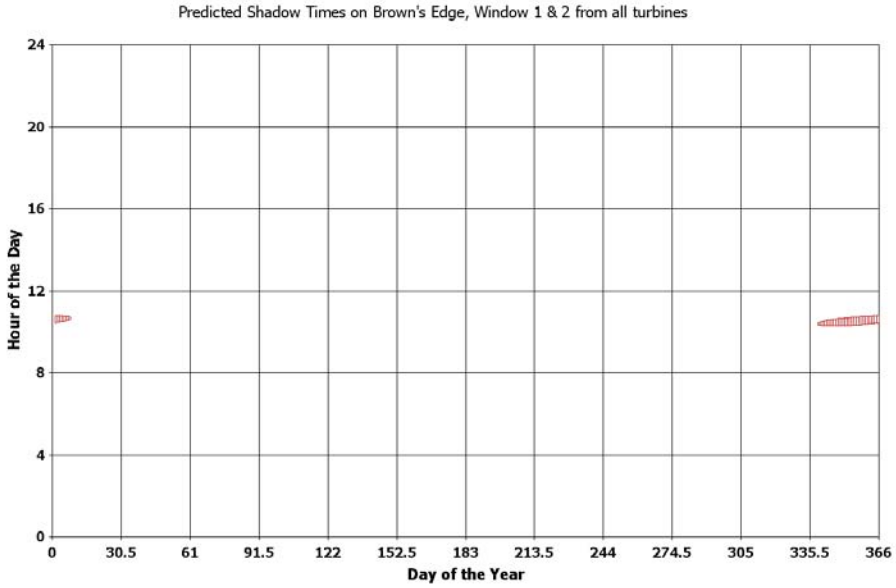


Day 0-366 indicates January 1st to December 31st (taking into account any leap years)

Property 3: Brown's Edge

Chart 14.3 shows the times that shadow flicker have been predicted to occur at Brown's Edge on window 1, which faces approximately south-east. As shown on the graph, effects could occur for short periods during mornings from December till early January.

Chart 13.3: Shadow times at Brown's Edge



Day 0-366 indicates January 1st to December 31st (taking into account any leap years)

It should be noted that in practice the effects are likely to be less than those here predicted due to the factors previously identified.

The assessment carried out merely addresses 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 intensity of effects is amplified indoors due to the periodic interruption of light entering windows.

Any effects that occur in practice would only do so during the operational phase of the wind farm. No effects will occur during construction or decommissioning.

14.5 MITIGATION

A control system would be employed[5] 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 the Developer or an independently appointed third party, and if a complaint is found to be justified additional control measures of the types identified above will be implemented.

[5] An example can be found at Windtest ' Shadow Impact' (http://www.windtest.de/WTK/WTK-Englisch/wtk_index_eng.htm)

14.6 RESIDUAL EFFECTS

Implementation of the identified mitigation will ensure that properties will not be affected by shadow flicker from the proposed turbines.