CHAPTER 10 - SHADOW FLICKER

Introduction

10.1 "Shadow flicker" refers to the effects that can be caused when the blades of a turbine cast shadows across a narrow opening in a building such as a window. Whether an effect occurs and the intensity of the effect depends on a number of factors. Primarily, the turbine needs to be in a line in between the sun and the window; in northern latitudes this means that the turbine position needs to be between 130^{o} and 230^{o} from north relative to the affected building.

10.2 The severity of the effect also depends on distance the house is from the turbine as the sun changes altitude throughout the day and at certain times of day may be too high in the sky to cast long shadows, which are generally only experienced close to sunrise and sunset.

10.3 Other factors also affect the severity of the the effect, such as topography, the direction of the wind (affecting the orientation of the rotor), the wind speed (affecting to rotational speed of the blades) and intensity of the sunlight as these affect the intensity of contrast between sunlight and shade and the size of the shadow cast.

10.4 Shadow flicker is generally experienced only inside buildings as this is where there is greater contrast between the normal light levels and the shadows. The further a turbine is from the building, the less intense the shadow is as the disc formed by the rotor blades does not wholly obscure the sun, so the shadows are less pronounced.

Alternative Turbines

10.5 The assessment was originally carried out for the V90 turbine, but is now repeated for the Vestas V105 turbine, as this represents the worst case turbine described in **Chapter 2**. The rotor diameters for these turbines are indicated in the figures in their names, and are 90m and 105m respectively. When considering V90 turbines no properties lay within the 10 turbine diameter recommended limit. However when considering possible 105m turbine that extends to 1050m. In this case one property (Maesnant at 943m) would theoretically be affected. Shadow flicker control equipment will be fitted to the two turbines involved and utilised as necessary.

Assessment Guidelines

10.6 Renewable Energy National Policy Statement EN-3 (Section 2.7), in addition to stating policy, gives guidance to applicants and decision makers about the technical issues to be taken into account with onshore turbines, and how these should be assessed. In relation to shadow flicker it states (2.7.66):

> *"The IPC should anticipate that the intensity of the shadow of the rotating blades from turbines at distances from such buildings of 10 rotor diameters and beyond is sufficiently diminished so as to have no significant impact on occupied buildings".*

10.7 EN- 3 specifically references (footnote 36 P71) research quoted in technical annexe 8 of 'Planning for Renewable Energy: A Companion Guide to PPS22' (ODPM, 2004) and "Update of Shadow Flicker Evidence Base" for DECC, 16 March 2011. It is noted that the Companion Guide to PPS22 has been cancelled following the publication of 'Planning

Practice Guidance for Renewable and Low Carbon Energy' in July 2013. Therefore the recently published national guidelines and "Update of Shadow Flicker Evidence Base" have been used for methodological guidance about the conduct of shadow flicker assessments. There are no specific Welsh guidelines.

10.8 Planning Practice Guidance for Renewable and Low Carbon Energy states in paragraph 35 that shadow flicker only occurs when the sun shines from behind a turbine onto a house. Therefore, houses to the south of turbines would not be affected. Houses within the sector 130º to 230º would not be affected and also shadow flicker does not have an impact at distances greater than 10 times the rotor diameter (i.e. 820m) from the turbine.

10.9 The Department of Energy and Climate Change commissioned Parsons Brinckerhoff in November 2010, to produce a report to update the government's evidence base on shadow flicker. The report was published in March 2011 and states that:

> *"It has become clear that there is no standard methodology that all developers employ when introducing environmental and site specific data into shadow flicker assessments. The three key computer models used by the industry are WindPro, WindFarm and Windfarmer. It has been shown that the outputs of these packages do not have significant differences between them. All computer model assessment methods use a "worst case scenario" approach and don't consider "realistic" factors such as wind speed and cloud cover which can reduce the duration of the shadow flicker impact".*

10.10 These two documents and the research they refer to have been used in the conduct of the assessment.

Assessment of Significance

10.11 The effects of shadow flicker can be divided into potential health effects and nuisance effects. The health effects are due to a rare condition known as Photo Sensitive Epilepsy which affects 5% of the epileptic population (which is 0.5% of the national population). Health effects are accepted not to occur at flicker rates of less than 2.5 hertz (Hz) (flickers per second) as reported by the Department of Trade and Industry (now the Department for Business, Innovation and Skills). Health guidance issued by the Health and Safety Executive ("HSE") indicates that for strobe lights in clubs, flicker rates of below 4 hertz would affect less than 5% of sufferers from Photo Sensitive Epilepsy. Clearly any rate of flicker below 2.5 Hz would not be considered significant.

10.12 Nuisance effects are more difficult to quantify because the intensity of the effect changes with distance from the turbine and is also dependent on the time of day and the room affected, the wind speed and the intensity of the sun. Above 10 rotor diameters (1,050m in this case) the effects would not be considered significant based on the instructions in EN-3. Below this distance the severity of the effect would depend on the number of days per year when the properties would be affected, the length of time per day, the time of day and the season.

10.13 There are no recognised significance criteria that relate to shadow flicker. With regard to the quantitative guidance, the Parsons Brinckerhoff report (2011) states:

"England's Companion Guide to PPS22 (2004), Northern Ireland's Best Practice Guidance to PPS18 (2009), and Scotland's PAN45 (2002) (among others) require shadow flicker impacts to be quantified by the assessor, however only Northern Ireland's Best Practice Guidance to PPS18 (2009) and Irish Planning Guidelines (undated) set quantitative limits for acceptable duration at 30 hours per year or 30 minutes per day at neighbouring offices and dwellings. In addition, Predac (2004) recommends that shadow flicker should not exceed an astronomic worst case figure of 30 hours per year or 30 minutes per day at neighbouring offices and dwellings, however there is considerable variation between the limits set in Germany, Denmark, and the Netherlands.

German guidance (2002) adopts two maximum limits:

- *An astronomic worst case scenario limit of 30 hours per year or 30 minutes on the worst affected day; and*
- *A realistic scenario taking account of meteorological parameters limited to 8 hours per year".*

10.14 In research quoted by Parsons Brinkerhof, Verkuijlen & Westra postulated, based on experimental data for lighting effects that flicker rates below 2.5 Hz (flickers per second) were less likely to cause nuisance:

"Various experiments for the lighting of traffic tunnels led to the conclusion that most persons (tested) feel flicker frequencies from 5-10 Hz as a nuisance (8-9) [Collins & Hopkinson (1957); Schreuder (1964)]. From other research projects, too, men have found to be maximally sensitive to flickers between 8 and 14 Hz. Below 2.5 Hz and beyond 40 Hz hardly any nuisance is caused" (Page 357).

10.15 These factors have been taken into account when assessing significance.

Assessment Method

10.16 Properties within 1,050m from turbines were identified (see **Figures 10.1 and 10.2**) and outside the 130º to 230º sector identified in **Table 10.1**.

10.17 For the properties identified within the sector of potential effects, calculations were carried out to determine potential impacts using the Shadow and Flicker module of WindFarm (a specific wind farm design tool package that is commonly used throughout the industry).

10.18 In the absence of specific information on window locations, numbers, sizes or designs, a simple 'glass box' analysis was performed (i.e. one which assumes that the building has windows of equal dimensions on each of four sides). This provides the analysis software with receptors for shadows cast across the location of the house. A four-sided glass box was specified, with dimensions half the size as the house (as measured from plan) and oriented in the same direction as the house. This effectively assumes that half of the houses external area is occupied by glass. Given the nature of the vernacular architecture in the area, which typically has minimal fenestration, this represents an effect well beyond the likely worst case.

Description of Baseline Conditions

10.19 There are no existing sources of shadow flicker in the area at present.

10.20 **Figures 10.1 and 10.2** identify the location and ownership of properties within and circa 1,050m of a turbine and outside the 130º to 230º sector.

10.21 **Table 10.1** and **Figures 10.1 and 10.2** show the sectors between 130° and 230° where the effects of shadow flicker would not be experienced. Properties 2, 3, 5 and 6 lie too far south of the turbines to be affected. To the south of the site two properties (No. 1 Bont Isaf and No. 4 Glanrhyd) are outside the 130º to 230º sector of Turbine 27 but within 1,050m of it. They potentially could be affected by shadow flicker. Properties 7 and 8 lies outside the 130º to 230º sector of Turbine 27 but at greater than 10 rotor diameters from the turbine.

Table 10.1: Properties Within and Circa 1,050m from Turbines and Outside the 130º to 230º Sector of at Least One Turbine

Properties within 1,050m (as shown on Figure 10.1 & 10.2)	Distance from Turbine with Potential for Shadow Flicker Effects	Results of Assessment
1. Bont Isaf	807m from Turbine 27	No effect
4. Glanrhyd	936m from Turbine 27	No effect
9. Maesnant	943m from Turbine 12 974m from Turbine 11	Outside 10 rotor diameters for V90, but affected by V105 turbines

10.22 North east of the site **Figure 10.2** shows that effects of shadow flicker could be experienced by a property know as Maesnant, which lies 943m from Turbine 12 and 974m from Turbine 11. In the previous study for the V90, the property was too far away to be affected, however if a 100m or worst case a 105m diameter turbine such as the V105 were installed Maesnant falls within the 10 rotor diameter guidance.

Description of Construction Period Effects

10.23 Shadow flicker only occurs when the turbines have been erected and are turning: there would therefore be no effect during the construction period.

Description of Operational and Long-term Effects

10.24 Bont Isaf and Manod are within 1,050m circle of influence but are owned and occupied by the landowner and members of his direct family. The results of the 'Glass Box' screening assessment indicate that Bont Isaf is not affected (see **Appendix 10.1**). House No. 8 Penrhiwgaled was also subjected to screening analysis as it was only just outside of the 1,050m circle of influence and it was unaffected. As Glanrhyd lies between the two properties it has been assumed that it too would not be affected.

10.25 The only property within ten rotor diameters and outside of the 130º to 230º sector is Maesnant. Based on the screening analysis, this property will be subject to shadow flicker

on the elevation that faces south east at approximately 165 degrees from north. The west facing elevation would also be affected but there are no windows on this elevation, as a large barn is attached here. The effects would be experienced on up to 78 days per year between the 1st and 28th of January and the 12th November and the 31st December.

10.26 The output from the Wind Farm shows that the property would be affected by Turbines 11 and 12 at slightly different times of the day. The effect from Turbine 12 would occur between 12:50 and 13:20 in January and about 10 minutes earlier in November and December. The average duration of the effect would be 25 minutes and would be experienced on 53 days of the year. The effect from Turbine 11 would occur about an hour later over the full period of 78 days. The total effect is summarised in **Table 10.2** below.

Table 10.2: Summary Results for Maesnant

Turbine	Worst Case Shadow Duration (hr:mins:secs)	Average Duration (hr:mins:secs)	Shadow Days	Total Hours (hrs: mins)
11	0:28:55	0:24:40	78	32:03
12	0:29:35	0:24:59	53	22:03
Total				54:06

Description of Decommissioning Period Effects

10.27 There would be no effects during the decommissioning phase, as the turbines would have stopped rotating, and would be dismantled.

Assessment of Effects

10.28 Effects only occur during the operational phase of the wind farm. The assessment has assumed that the house is made of glass, is 5m wide and 5m high, and that the disc described by the turbine blades is parallel to the house; this is very much a worst case effect. The effect calculated for Maesnant indicates that there is a potential to exceed the German and Northern Irish guidance described in **Paragraph 10.13**. However, this does not mean an effect would necessarily occur as the calculated effect has been based on a worst case scenario. Factors that would reduce the effect are:

- the view of the turbines is currently occluded by trees. While it cannot be assumed that these trees will remain throughout the life of the scheme, they currently provide a total screen;
- the period of the effect is during winter when sunlight levels are low and the risk of shadows is reduced, therefore the maximum possible figure calculated in the assessment would reduce significantly; and
- the prevailing winds are from 210 to 240 degrees, while the affected elevation faces 165 degrees. For much of the period the disc described by the rotor blade, will not be parallel with the façade of the house and the extent of the shadow cast will be

smaller than the model has calculated and the duration of the effect would be diminished.

10.29 Given the possible exceedance of the 30 hour, or 30 minutes per day threshold and the possibility that the existing trees that provide screening may disappear, the effect is classed as potentially significant adverse and mitigation is planned.

Mitigation

10.30 No mitigation is required during the construction period. Further, no mitigation will be required as long as trees continue to provide a total screen of the view of the turbines from Maesnant.

10.31 For the operational period, mitigation will only be required for Maesnant. Mynydd y Gwynt proposes before construction begins to carry out a detailed assessment of the potential effects on Maesnant. During manufacture Turbines 11 and 12 will be fitted with equipment that will park the turbines during the period identified by the detailed study when shadow flicker could occur, if the levels of sunlight are bright enough to throw shadows. Whilst this equipment will be fitted during manufacture, it will be deployed, in accordance with the detailed assessment, if changes to the forestry mean that Maesnant ceases to be totally screened. Use of these measures will completely mitigate the effect.

10.32 No mitigation is required during decommissioning.

Residual Effect

10.33 If shadow flicker control equipment is fitted to the turbines the effect would be totally mitigated and there would be no effect.

References

DCLG (July 2013) Planning practice guidance for renewable and low carbon energy. (Ref-10-001)

Parsons Brinckerhoff, (2011). Update of UK Shadow Flicker Evidence Base: Final Report. Department of Energy and Climate Change. (Ref-10-002)

Verkuijlen E. & Westra C.A. (1984). Shadow Hindrance by Wind Turbines. (Ref-10-003)

DECC, (2011) National Policy Statement for Renewable Energy Infrastructure (EN-3). (Ref-3-010)