14. Shadow Flicker

14.1 Summary

14.1.1 This chapter addresses shadow flicker. Wind turbines, in common with all structures, cast shadows in sunny conditions. The shadows vary in position and length according to the direction of the sun and its height in the sky. Rotating turbine blades cast moving shadows. If the moving shadow is cast on to a building it can appear to flick on and off as the blades rotate. If this flicking shadow is viewed through a narrow opening such as a window or doorway an effect known as shadow flicker can occur.

14.1.2 Experience has shown that shadow flicker has the potential to cause annoyance to occupants of affected properties under certain circumstances. A study has therefore been undertaken to identify whether shadow flicker is likely to occur at residential properties in the vicinity of the proposed wind turbines at the Proposed Development.

14.1.3 An introduction to shadow flicker is set out within the Scottish Government's web based renewables guidance on Onshore Wind Turbines[1]. However, there are no statutory or advisory limits in this or other UK legislation or policy to determine what levels of shadow flicker are acceptable. However, the guidance is consistent with the findings of a DECC report[2], *Update of UK Shadow Flicker Evidence Base,* published in 2011.

14.1.4 For this chapter, potential receptors were screened in accordance with the web based renewables guidance note on Onshore Wind Turbines, i.e. only those within ten times the rotor diameter of turbines and within 130° either side of north relative to the turbines.

14.1.5 Since the nearest residential property is approximately 1.5 km away, shadow flicker was not predicted to occur at any of the nearby residential properties as a result of the Proposed Development. Furthermore, due to the local topography, no proposed turbine would be visible from this property.

14.2 Introduction and overview

14.2.1 Shadow flicker can cause a nuisance to residential amenity where people are sitting within the rooms affected by the phenomenon. In order to quantify this effect, it is possible to calculate the number of hours per year that shadow flicker may occur at a dwelling. The approach and results from such an assessment for the Proposed Development are presented in this chapter.

14.2.2 Shadow flicker only occurs when certain conditions coincide at particular times of the day and year. It can only occur when the sun, wind turbine and the receptor (residential property) are aligned. The occurrence and duration of shadow flicker effect thus depends on:

- The direction of the property in relation to the wind turbines: in the UK only properties within 130 degrees either side of north, relative to the wind turbine, can be affected as the sun is always to the south in the UK;
- The height of the wind turbine and diameter of the rotor;
- The time of year and time of day (the elevation and position of the sun); and

[1] http://www.gov.scot/Resource/0045/00451413.pdf last accessed on 29/06/2018

[2] http://www.decc.gov.uk/assets/decc/What%20we%20do/UK%20energy%20supply/Energy%20mix/Renewable%20energy/ORED/1416-update-uk-shadow-flicker-evidence-base.pdf (last accessed 29/06/2018)

- Weather conditions – shadows are only cast when the sun is not occluded; shadow flicker can only occur when blades are turning – wind turbines typically operate when the wind speed is between 3.5 m/s and 25 m/s at hub height. The wind direction will determine the angle of the rotor and therefore the view of the rotor can vary from 'full-on' to 'side-on – when the rotor is side on to the affected property shadow flicker effects do not generally occur.

14.2.3 The intensity of shadow flicker and consequent effect on residential amenity is also influenced by the distance between the wind turbines and the property: the further the observer is from the wind turbine the less pronounced the effect will be.

14.2.4 As a result of these factors, experience has shown that shadow flicker effects do not occur at a distance greater than ten rotor diameters from the wind turbine. The web based renewables guidance on Onshore Wind Turbines refers to shadow flicker in relation to wind turbines and states the following:

> *'Where this could be a problem, developers should provide calculations to quantify the effect.'*

14.2.5 With respect to the distance over which this effect should be considered, the document states:

> *'where separation is provided between wind turbines and nearby dwellings (as a general rule 10 rotor diameters), "shadow flicker" should not be a problem.'*

14.3 Methodology

Assessment scope and approach

14.3.1 The purpose of the shadow flicker assessment was to identify whether shadow flicker is likely to occur at any neighbouring properties, and if so to predict approximate times of day and year, and duration of these effects. The distance between a wind turbine and a potential shadow flicker receptor affects the intensity of the shadows cast by the blades, and therefore the intensity of flickering. Shadows cast close to a turbine will be more intense, distinct and 'focused'.

14.3.2 The guidance on shadow flicker included in the web based renewables guidance on Onshore Wind Turbines, states that within 10 rotor diameters:

> 'shadow flicker should not be a problem'

14.1.1 In addition, The Update of the UK Shadow Flicker Evidence Base (DECC, 2011) reviewed 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.

14.3.3 At the Proposed Development the wind turbines have a rotor diameter of 114 m; therefore potential shadow flicker effects could occur, subject to the conditions set out above, out to 1140 m from the turbines.

14.4 Baseline information

Sources of data

14.4.1 Baseline conditions were established through desk-based examination of Ordnance Survey mapping at scales of 1:25,000 and 1:10,000.

14.4.2 In accordance with the web based renewables guidance on Onshore Wind Turbines, the scope of this assessment is restricted to properties within 10 rotor diameters of the turbines (1140 m) and 130º either side of north.

14.4.3 At the Proposed Development, there are no residential properties within ten rotor diameters (i.e. 1140 m, based upon the 114 m rotor diameter turbines proposed for this scheme) of the proposed turbine locations.

14.4.4 An additional micro-siting distance of 50m around each turbine was also considered, but as this additional area did not include any further properties, no further consideration has been given to micro-siting of the turbines.

Effects not requiring further consideration

14.4.5 Shadow flicker has also been associated with the potential to cause epileptic seizures, as a result of a condition known as photosensitive epilepsy. Approximately 1 in 131 people in the UK have been diagnosed with epilepsy, although only up to 5% of these individuals suffer from photosensitive epilepsy (National Society for Epilepsy, 2007), a number which equates to around 0.025% of the UK population.

14.4.6 The frequency at which photosensitive epilepsy is triggered varies between individuals, generally from between 5 and 30 flashes per second (Hertz). While some people are sensitive at higher frequencies, it is not common for photosensitivity to be triggered below 5 Hertz (National Society for Epilepsy, 2007).

14.4.7 The turbines at the Proposed Development will operate from around 6.5 to 12.1 revolutions per minute (RPM). Given the turbines will have three blades, the frequency at which a blade will pass a particular point will be in the order of between 23.4 and 37.5 times a minute which equates to between 0.4 and 0.6 Hertz. This is significantly less than the 5 - 30 Hertz frequency range generally thought to induce photosensitive epilepsy. Therefore the issue of photosensitivity epilepsy is not considered further in this assessment.

14.5 Trends and projected future baseline

14.5.1 On the basis of the information currently available, there are not anticipated to be any changes to the baseline conditions in the event that the Proposed Development does not proceed.

14.6 Topic specific design evolution

14.6.1 The proposed locations of the turbines have been determined primarily on technical requirements such as topography and wind resource but also, to an extent, on preliminary environmental constraints known at the time. The final location of the turbines has been chosen to maximise the distance to residential properties given other environmental constraints and thereby minimise effects on residential amenity.

14.7 Predicted effects of the scheme

14.7.1 Since there are no residential properties within 1140 m 130º either side of north, there are no predicted shadow flicker effects associated with the Proposed Development.

14.8 Mitigation and enhancement measures

14.8.1 No mitigation measure will be required since no predicted shadow flicker effects have been identified.

14.9 Assessment of residual effects

During construction

14.9.1 Shadow flicker is only an issue during operation of the wind turbines therefore there can be no effect during construction of the proposed wind turbines.

During operation

14.9.2 As no shadow flicker effects are predicted for any residential properties surrounding the Proposed Development there should be no residual effects during the operation of the proposed wind turbine.

Effects during decommissioning

14.1.2 Shadow flicker is only an issue during operation of the wind turbines therefore there can be no effect during de-commissioning of the proposed wind turbines.

14.2 Safety

This section considers safety issues relating to the operation of the Proposed Development.

Wind turbine technology is now well proven with many years of safe turbine operation across the world, particularly in Germany, Holland, Spain and Denmark, but also across the UK.

14.2.1 Context for appraisal

Relevant guidance on wind energy is provided in the Scottish Government's Online Planning Advice on Onshore Wind Turbines (May 2014), whilst wind turbine manufacture, installation and operation is undertaken in accordance with the relevant European and British Standards.

Renewable UK has also published health and safety guidelines for the operation of wind developments which will be fully adhered to during this project. By adhering to such guidance operational health and safety risks will be minimised and fully mitigated.

14.2.2 Baseline

The application site is located within an area of upland moor, with turbines and related infrastructure located away from existing built development and footpaths.

14.2.3 Potential effects

Notwithstanding the above, the following section briefly considers some of the frequently raised health and safety questions regarding wind turbine operations.

14.2.4 Electrical risk

A wind turbine is, in effect, a power station with high voltage equipment. To minimise injury by electrocution, the turbine and the associated external substation and switch house will be secured against intruders. Electrical equipment will be contained within the tower structure and external transformers and all cables will be underground.

14.2.5 Mechanical risk

A possible but rare source of danger to human or animal life from a wind turbine would be the loss of a piece of the blade or, in the most exceptional circumstances, of the whole blade. Many blades are composite structures with no bolts or other separate components. Even for blades with separate control surfaces on or comprising the tips of the blade, separation is most unlikely.

Wind turbines have an exemplary safety record with no recorded instances of fatalities to any member of the public anywhere in the world. The turbines are also designed to shut down automatically during high wind speed conditions, typically in excess of 60 mph.

14.2.6 Ice throw

There is a risk of ice accumulation on turbine blades, nacelles and towers under certain conditions such as periods of very cold weather with high humidity. In those instances where icing of blades does occur, fragments of ice might be released from blades, particularly when the machine is started.

Research indicates that the maximum potential disturbance for ice falling from turbines is approximately 1.5 times rotor diameter plus hub height. This equates to 245m for the proposed scheme. There are no properties or roads within this distance of a turbine.

The wind turbines would in any event be fitted with vibration sensors to detect any imbalance which might be caused by icing of the blades. This enables the operation of machines with iced blades to be inhibited.

14.2.7 Lightning risk

The possibility of attracting lightning strikes applies to all tall structures and wind turbines are no different. Appropriate lightning protection measures are incorporated in wind turbines to ensure that lightning is conducted harmlessly past the sensitive parts of the nacelle and down into the ground.

14.2.8 Aviation safety

Aviation safety issues have been fully assessed within chapter fifteen 'Infrastructure'.

14.2.9 Risk to road users, railways and members of the public

The Online Renewables Planning Advice on Onshore Wind Turbines states: 'Although wind turbines erected in accordance with best engineering practice should be stable structures, it may be advisable to achieve a set-back from roads and railways of at least the height of the turbine proposed, to assure safety.

The distance between the nearest proposed turbines and public roads is well in excess of tip height. In respect of footpaths, many wind farms in Scotland are open access and allow members of the public to walk close to the turbine towers.

14.2.10 Conclusion

The assessment of shadow flicker has established that there would not be significant adverse effects. The study of safety considerations has confirmed that appropriate mitigation measures have been incorporated during the site selection and design stages to minimise safety risks, and that adherence to the relevant British and European Standards will ensure that risks can be managed during the operational stage.

References

Department of Energy and Climate Change (2011) Update of UK Shadow Flicker Evidence Base Prepared by Parsons Brinckerhoff.

PREDAC, 2004, European Actions for Renewable Energies, Spatial Planning of Wind Turbines

BOREAS (2003) Seifert, Westerhellvig and Kroning: Risk Analysis of Ice Throw from Wind Turbines.

Epilepsy Action, 2007. *Photo-sensitive Epilepsy:* Available from: http://www.epilepsy.org.uk/info/photo.html

Scottish Government Online Renewables Planning Guidance: Onshore Wind Turbines (Scottish Government, 2014).