12 SHADOW FLICKER

Executive Summary

This chapter provides an assessment of the potential impacts on residential amenity resulting from shadow flicker from the proposed varied development. The shadow flicker assessment has been undertaken to consider the maximum tip height of 155 m and rotor diameter of 120 m for the proposed varied development. The parameters for the consented Viking Wind Farm considered in the assessment include a maximum tip height of 145 m and rotor diameter of 110 m. An assessment area of 10 rotor diameters around each turbine was considered and two receptors were found within the area potentially susceptible to shadow flicker for both study areas.

There is no standard for the assessment of shadow flicker in Scotland and there are no guidelines with which to quantify what exposure levels would represent a significant versus not significant effect. In the absence of specific guidelines, the assessment has considered the *'Best Practice Guidance for Planning Policy Statement 18 (PPS18) Renewable Energy'* (Department of Environment Northern Ireland, 2009) from Northern Ireland, which states: *"It is recommended that shadow flicker at neighbouring offices and dwellings…should not exceed 30 hours per year or 30 minutes per day"*. As such, properties where shadow flicker would potentially exceed these thresholds would be subject to significant effects.

The assessment has demonstrated that the likely number of shadow flicker hours experienced at the two shadow flicker assessment locations, taking into account typical sunshine hours for the area, is below 30 hours per year and 30 minutes per day.

Notwithstanding the fact that no significant effects are predicted, in order to protect the amenity of local residents, the turbines would be fitted with suitable controls that would, in the event of a complaint to the planning authority, allow the causal turbines to be shut down during periods when shadow flicker could occur. Accordingly, the impact from shadow flicker is predicted to be **not significant for both the consented Viking Wind Farm and the proposed varied development**. There would be no difference in the effects associated with the proposed varied development when compared to the consented Viking Wind Farm.

12.1 Introduction

12.1.1 This chapter provides a review of the predicted shadow flicker effects associated with the proposed varied development. The specific objectives of the chapter are to:

- describe the baseline;
- summarise the assessment methodology and significance criteria used in completing the impact assessment;
- describe the effects of the consented Viking Wind Farm;
- describe the effects of the proposed varied development;
- describe the mitigation measures proposed to address likely significant effects; and
- provide an assessment of how the likely significant effects of the proposed varied development differ from the effects identified for the consented Viking Wind Farm.

12.1.2 This chapter has been prepared by Ramboll Environment and Health UK Limited (Ramboll).

12.1.3 Figure 12.1 is referenced in the text where relevant.

12.2 Assessment Methodology and Significance Criteria

Scope of the Assessment

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

12.2.2 This chapter summarises the potential shadow flicker effects at properties located within both the consented Viking Wind Farm and proposed varied development study areas (Figure 12.1) not including those beyond 130 degrees either side of north, relative to the turbine.

Study Area

12.2.3 A study area of 1,100m has been applied to the consented Viking Wind Farm (Figure 12.1). The study area for the proposed varied development was calculated with respect to the 120m rotor diameter, resulting in a study area of 1,200m from each turbine (Figure 12.1) as per Scottish Government guidance[1].

Scoped Out Effects

12.2.4 Properties Located beyond 130 degrees either side of north, relative to the turbine were excluded, per the UK Government's Planning Practice Guidance for Renewable and Low Carbon Energy (2013)[2], this is because turbines do not cast long shadows on their southern side.

12.2.5 People with photosensitive epilepsy are usually sensitive to flickering light that is between 3 – 60 Hertz (Hz); according to the NPS EN-3: Renewable Energy Infrastructure (2011) "the maximum frequency of the shadowing effect from commercial scale wind turbines is less than 1 hertz". Therefore, any potential shadow flicker effects arising from the proposed varied development are purely an effect on residential amenity, rather than having the potential to affect the health or well-being of residents.

[1] URL: https://www.gov.scot/publications/onshore-wind-turbines-planning-advice/

[2] NB. The authors note that these standards were published for use in England, however in the absence of Scottish planning advice on this topic, they are considered to be a reasonable basis for informing this assessment.

12.2.6 Under certain combinations of geographical position, time of day and year, the sun may pass behind the turbine's rotor and cast a shadow over neighbouring buildings' windows. When the blades rotate, and the shadow passes a window, to a person within that room the shadow appears to flick on and off; this effect is known as shadow flicker. Where moving shadows are cast over the ground (rather than a building's windows), this is known as 'shadow throw'. There are no guidelines to quantify the effect and there is no requirement to assess 'shadow throw', therefore 'shadow throw' has not been considered further in this assessment.

Baseline Conditions

12.2.7 A site survey desktop assessment was undertaken in August 2018, using Royal Mail address data and publicly available aerial and satellite images, in order to identify all residential properties located within the study areas. Computer modelling was used to present the extent of predicted shadow flicker to those properties, both for the consented Viking Wind Farm and proposed varied development, assuming a worst-case scenario and providing a very conservative (i.e. high) estimate. These conservative estimates would then be translated to a more realistic estimate, particularly in respect to when the sunshine would be bright enough to cast a shadow. Data for this was calculated using Met Office data from the nearest station to the site in Lerwick, comparing hours of sunlight relative to daylight hours for a calendar year, to find the percentage of hours on sunshine per year. The realistic estimate of both the consented Viking Wind Farm and proposed varied development would then be compared to the NI PPS18 standard[3] to determine its significance.

Modelling Methodology

12.2.8 Two new models were carried out for both the consented Viking Wind Farm and proposed development, using 110 m and 120 m rotor diameters respectively. The computer software 'WindFarm' (ReSoft, 2017) was used to identify the potential areas susceptible to shadow flicker and the extent of shadow flicker impact caused. This software identifies the study area for the assessment based on candidate turbine dimensions and orientations, as well as model periods of predicted shadow flicker. The following model parameters were used:

- Wind turbine hub height of 90 m, a rotor diameter of 110 m and a tip height of 145 m for the consented Viking Wind Farm;
- Wind turbine hub height of 95 m, a rotor diameter of 120 m and a tip height of 155 m for the proposed varied development;
- Maximum distance of shadow flicker influence considered is 10 times the rotor diameter of the proposed varied development (1,200 m);
- The centre of the window is 3 m above ground level;
- Each window is offset 5 m from the centre of the house, in the direction to which it faces;
- Each window is 1 m by 1 m;
- The calculation year of 2018;
- Maximum sun height of 2° above the horizon; and
- Topography has been considered using 10 m grid spaced digital terrain model (DTM) data and the Earth's curvature has been accounted for.

Assessment of Effects

12.2.9 No formal guidance is available regarding what levels of shadow flicker may be considered acceptable in Scotland. In absence of this the Best Practice Guidance for Planning Policy Statement

[3] Department of Northern Ireland (2009): Practice Guidance for Planning Policy Statement 18 (PPS18) – in the absence of any specific guidance for Scotland, this document is considered to be a valid reference for this impact assessment.

18 (PPS18) Renewable Energy (Department of Environment Northern Ireland, 2009, pg. 29) provides an indication of what may be an acceptable duration of shadow flicker, stating that:

'It is recommended that shadow flicker at neighbouring offices and dwelling…should not exceed 30 hours per year or 30 minutes per day'.

12.2.10 For the purpose of this chapter, values greater than 30 hours per year or 30 minutes per day are considered significant.

Assumptions and Limitations

12.2.11 The following worst-case assumptions were made in the assessment:

- weather conditions are such that shadows are always cast during each day of the year, i.e. bright sunshine every day;
- each property has 4 windows, one facing North, East, South and West;
- the turbine rotor will always be facing directly towards a given window, maximising the size of the shadow and hence the frequency and duration of the effect;
- the turbines will always be turning; and
- there will not be any intervening structures or vegetation (other than topography) that may restrict the visibility of a turbine.

12.2.12 It should also be noted that even if shadow flicker impact does occur at a specific location this does not imply that it would be witnessed. Potential witnesses may be sleeping or occupied in a room on another side of the house which is not impacted, or indeed absent from the location altogether (e.g. at work, on holiday, etc) during the time of shadow flicker events. Furthermore, trees, outbuildings and other obstacles may screen an observer from shadow flicker effects, although it is noted that Shetland has very limited trees cover.

12.2.13 The use of these assumption is considered to be provide a robust and precautionary basis for the purpose of this assessment.

12.3 Baseline Conditions

Current Baseline

12.3.1 The site survey identified six properties across both of the consented Viking Wind Farm and proposed varied development study areas. Two properties were excluded as they were beyond 130 degrees either side of north (see Figure 12.1). The property labelled as Fern (to the east) is derelict and as such has not been included within this assessment. The building at 'Upper Kergord' (located within the southern part of the wind farm) is not used for residential purposes and therefore is not included in this assessment. The two remaining properties are shown in Figure 12.1.

Assessment of Effects

Consented Viking Wind Farm

12.3.2 The results of the shadow flicker model for the consented Viking Wind Farm study area are detailed in Table 12.1. The model was configured to carry out a worst-case scenario assessment ('Theoretical Maximum Hours per Year'). Table 12.1 includes both the worst-case assessment and a 'Realistic Scenario'. The realistic scenario was calculated to take into account daylight hours and typical sunlight hours (when sunshine would be bright enough to give rise to shadows and therefore flicker).

Table 12.1: Shadow Flicker (Consented Viking Wind Farm)								
House	**Easting**	**Northing**	**Days per Year**	**Max mins per Day**	**Mean Mins per Day**	**Theoretical Maximum Hours per Year**	**Realistic Scenario (hours per year)**	**Realistic Scenario (Max Mins per Day)**
1	441732	1155184	89	28.8	20.4	30.6	8.0	7.5
2	445947	1159638	111	28.2	20.4	38.2	10.0	7.3

12.3.3 The realistic case scenario was calculated using Met Office Data from the Lerwick station (taken from the ES) (Table 12.2), from which it was concluded that sunny daylight hours are only expected to be present 23.6% of the time on average over a year.

Table 12.2: Lerwick Met Office Data			
Month	**Daylight Hours**	**Met Office Typical Sunlight Hours at Lerwick**	**Monthly Percentage of Daylight Hours which are Sunny**
January	209	22.6	10.8%
February	254.31	52.3	20.6%
March	365.33	85.6	23.4%
April	437.84	129.9	29.7%
May	534.18	168.3	31.5%
June	564.94	148.2	26.2%
July	560.30	120	21.4%
August	485.54	124.6	25.7%
September	387.53	100.8	26%
October	314.50	65.4	20.8%
November	225.67	33	14.6%
December	184.03	14.9	8.1%
Full Year	**4523.16**	**1065.6**	**23.6%**

Proposed Varied Development

The results of the shadow flicker model completed for the two properties based on the rotor diameter for the proposed varied development are detailed in Table 12.1. The realistic scenario was calculated using the same reduction factor (23.6%) as per the proposed varied development.

Table 12.1: Shadow Flicker (Proposed Varied Development)								
House	**Easting**	**Northing**	**Days per Year**	**Max Mins per Day**	**Mean Mins per Day**	**Theoretical Maximum Hours per Year**	**Realistic Scenario (Hours per Year)**	**Realistic Scenario (Max Mins per Day)**
1	441732	1155184	117	31.2	20.4	39.9	10.4	8.1
2	445947	1159638	119	30.6	22.2	44.3	11.5	8.0

12.4 Comparative Assessment of Effects

12.4.1 Following the calculation of a 'Realistic Scenario' for both the consented Viking Wind Farm (Table 12.1) and the proposed varied development (Table 12.3) at both properties the shadow flicker predictions fall below the significance threshold levels, thus it can be concluded that these properties are not predicted to receive significant effects from either the consented or proposed varied development.

12.5 Cumulative Impacts

12.5.1 No cumulative windfarm developments were identified with the potential to influence shadow flicker in the relevant study areas.

12.6 Mitigation

12.6.1 Notwithstanding the fact that no significant effects are predicted, in order to protect the amenity of local residents, the turbines would be fitted with suitable controls that would, in the event of a complaint to the planning authority, allow the causal turbines to be shut down during periods when shadow flicker could occur.

12.7 Summary and Conclusions

12.7.1 Accordingly, the impact from shadow flicker is predicted to be **not significant for both the consented Viking Wind Farm and the proposed varied development**. There would be no difference in the effects associated with the proposed varied development when compared to the consented Viking Wind Farm.

List of Figures

References

- Department of Northern Ireland (2009): Practice Guidance for Planning Policy Statement 18 (PPS18)
- The NPS EN-3: Renewable Energy Infrastructure (2011)
- The UK Government's Planning Practice Guidance for Renewable and Low Carbon Energy (2013)

Glossary and Abbreviations

Abbreviation	Expanded Term / Definition
PAN 45	Scottish Government (2002): Planning Advice Note 45
Hz	Hertz
PPS18	Department of Northern Ireland (2009): Practice Guidance for Planning Policy Statement 18