17. SHADOW FLICKER

Executive Summary

This chapter provides an assessment of the potential shadow flicker impacts on residential amenity resulting from the proposed development. TNEI Services Ltd completed a desk-based study to identify potential receptors, followed by a site survey in March 2018 to confirm conditions on site.

The shadow flicker assessment has been undertaken to consider the maximum tip height of 149.9m and rotor diameter of 130 m. An assessment area of 1,300 m around each turbine was considered (based on a study area of 10 rotor diameters) and seven receptors were found within the area potentially susceptible to shadow flicker.

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, and for consistency with the approach taken for the assessment for Tangy III (Tangy III ES (2014)), 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 within 500 m 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 all seven shadow flicker assessment location (SFAL), taking into account typical sunshine hours for the area, is below 30 hours per year. The highest predicted likely level of shadow flicker at any SFAL is 15.4 hours per year (at Killarow Farm – SFAL2).

The maximum amount of shadow flicker which could theoretically occur in a single day, not taking into account cloud coverage, is approximately 31 minutes (experienced at Tangy Mill – SFAL4).

It is recommended that, in order to protect the amenity of local residents, the turbines be programmed to shut down during periods when shadow flicker could occur. Accordingly, the impact from shadow flicker is predicted to be **not significant**.

17.1 Introduction

17.1.1 This chapter considers the potential shadow flicker effects at nearby buildings associated with the operation of the proposed development. The specific objectives of the chapter are to:

- describe the baseline;
- describe the assessment methodology and significance criteria used in completing the impact assessment;
- describe the potential effects, including direct, indirect and cumulative effects;
- describe the mitigation measures proposed to address likely significant effects; and
- assess the residual effects remaining following the implementation of mitigation.

17.1.2 The assessment has been carried out by TNEI Services Ltd.

17.1.3 This chapter is supported by:

- Appendix 17.1: Shadow Flicker Assessment.

17.1.4 Figure 17.1 is referenced in the text where relevant.

17.2 Scope of Assessment

Project Interactions

17.2.1 Under certain combinations of geographical position, times of day and year, the sun may pass behind the turbine rotor and cast a shadow flicker over the windows of neighbouring buildings. 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'. This phenomenon occurs only within buildings where the flicker appears through a window aperture and in the UK typically occurs only in buildings within 130 degrees either side of north relative to a turbine.

Study Area

17.2.2 A study area of 1,300m from each turbine, 130 degrees either side of north, was selected for this assessment. This is based upon ten times the maximum rotor diameter (130 m) that would be used within the proposed development in order to present a worst case scenario (i.e. the largest possible study area).

Scoping and Consultation

17.2.3 A summary of the consultation response in relation to shadow flicker is included within Table 17.1 below.

17.2.4 Full details on the consultation responses can be reviewed in Appendix 7.1: Consultation Register.

Table 17.1: Consultation Responses

Consultee and Date	Summary of Response	Comment/Action Taken
The Scottish Governments Energy Consents Unit, 16 October 2017	A shadow flicker assessment should be undertaken to assess the *'consequences for the occupiers of property.'*	This chapter summarises the findings of the shadow flicker assessment which is included in full in Appendix 17.1: Shadow Flicker Assessment

Effects to be Assessed

17.2.5 This chapter summarises the potential shadow flicker effects at properties located within the study area detailed above and shown on Figure 17.1.

Effects Scoped Out of Assessment

17.2.6 Where moving shadows are cast over the ground, rather than through the windows of a building, this is known as 'shadow throw'. There are no guidelines to quantify the effect and no requirement to assess 'shadow throw'. Therefore, 'shadow throw' has not been considered further in this assessment.

17.2.7 There are no other nearby wind turbines which may result in shadow flicker at the seven SFALs identified in Table 17.1, therefore cumulative shadow flicker could not occur and has not been considered further in this assessment.

17.3 Methodology

Overview

17.3.1 The specialist computer software 'WindFarm' (ReSoft, 1997-2014) has been used to identify the potential area susceptible to shadow flicker. The software identifies the study area for the assessment based on candidate turbine dimensions and orientations.

17.3.2 As outlined above, the study area where shadow flicker could potentially occur has been limited to 1,300m and 130 degrees either side of north around the proposed turbine locations, as illustrated on Figure 17.1. Buildings located outside 130 degrees either side of north have been excluded from the analysis, as there is no direct path between the sun, the turbine and these buildings where shadow flicker could occur.

17.3.3 There is no standard for the assessment of shadow flicker in Scotland and there are no guidelines which quantify what exposure levels would be acceptable. In assessing the potential shadow flicker impacts of the proposed development, the following guidance and policy documents have been considered:

- Scottish Planning Policy (SPP) (June 2014);
- Web Based Renewable Advice: 'Onshore Wind Turbines' (last updated May 2014); and
- Department of Energy and Climate Change (DECC): 'Update of UK Shadow Flicker Evidence Base'.

17.3.4 The documents outlined above are discussed in detail within the Shadow Flicker Assessment Technical Report (refer to Appendix 17.2).

Method of Baseline Characterisation

Following the identification of the study area a desktop assessment was undertaken in order to identify all potential buildings within that area. This information formed the basis for the site survey which was undertaken in order to assess all of the receptors identified.

Effects Evaluation Methodology

17.3.5 In order to quantify the effect of shadow flicker, the results of the building survey and desktop analysis were input into 'WindFarm' along with the latitude and longitude of the proposed development. The shadow flicker module of WindFarm calculates times throughout the year when a turbine viewed from the window of a house is in line with the sun and therefore when the potential for shadow flicker exists.

17.3.6 As detailed above, there is no standard for the assessment of shadow flicker in Scotland and there are no guidelines which quantify what exposure levels would represent a significant versus not significant effect. In the absence of specific guidelines, and for consistency with the approach taken for the assessment for Tangy III (Tangy III ES (2014)), 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:

17.3.7 'It is recommended that shadow flicker at neighbouring offices and dwellings within 500 m should not exceed 30 hours per year or 30 minutes per day.'

17.3.8 As such, properties where shadow flicker would potentially exceed these thresholds would be subject to significant effects.

17.4 Baseline Conditions

Current Baseline

17.4.1 A site survey was undertaken on 14 March 2018 in order to identify all buildings (located within the study area and determine the number of windows, their size and orientation in relation to the proposed development. Where two or more receptors were located in very close proximity all the windows were modelled as a single shadow flicker assessment location (SFAL), seven SFALs were included in the assessment. Details of the Shadow Flicker Assessment Locations are included within Table 17.1 below and are also shown on Figure 17.1. A more detailed description of each SFAL is included in Table 4.1 of Appendix 17.1.

Table 17.1 Shadow Flicker Assessment Locations

Shadow Flicker Assessment Location	Easting	Northing	Approximate distance to nearest turbine*
SFAL1 - Tangymoil	166244	628594	1148
SFAL2 – Killarow Farm	166269	628025	1053
SFAL3 – Tigh Na Mara	166079	628171	1236
SFAL4 – Tangy Mill	166275	627740	1117
SFAL5 - Tangylee	167489	627768	419
SFAL6 – Tangy Glen Cottages	166067	627768	1305
SFAL7 – Tangy Mill Croft	166125	627650	1290

*distance as measured to the closest point to the facade on the building.

17.5 Effects Evaluation

17.5.1 Table 17.2 summarises the shadow flicker modelling results and details the predicted frequency of occurrence of shadow flicker at the worst case window for each SFAL. Figures A1.3 to A1.9 within Appendix 17.2: Shadow Flicker Assessment illustrate the times of the year and times of the day when shadow flicker could theoretically occur at the most affected window of each property where shadow flicker was predicted to occur.

Table 17.2 Maximum Theoretical Shadow Flicker Occurrence for each Property

Location (Window ID)	Times when Shadows May Occur (GMT)	Months when Shadows May Occur	Maximum Minutes of Shadow per Day	Mean Minutes of Shadow per Day	Maximum Theoretical Hours per Year	Likely Hours per Year
SFAL1 - Tangymoil (12)	05:09 - 08:13	February - May, July - October	28:12	21:36	45	14.4
SFAL2 - Killarow Farm (03)	04:48 - 06:29	April - August	30:36	24:36	48.2	15.4

Table 17.2 Maximum Theoretical Shadow Flicker Occurrence for each Property						
SFAL3 - Tigh Na Mara (01)	06:18 - 06:48	April, August - September	26:24	21:00	9.8	3.1
SFAL4 - Tangy Mill (04)	05:02 – 05:44	May - August	31:12	27:00	36.6	11.7
SFAL5 - Tangylee (NA)	N/A	N/A	00:00	00:00	0	0
SFAL6 - Tangy Glen Cottages (07)	05:16 – 05:55	May, July - August	26:24	20:24	18.4	5.9
SFAL7 - Tangy Mill Croft (08)	04:57 – 05:35	May - July	27:36	24:00	30.7	9.8

17.5.2 A detailed list of potential for shadow flicker occurrence at each receptor is included in Annex 3 of Appendix 17.2: Shadow Flicker Assessment.

17.5.3 The calculations do not take account of certain factors that would reduce the duration of shadow flicker:

- No account of climatic conditions such as clouds or precipitation has been made;
- Objects surrounding the windows may block the view to the turbines such as trees or buildings have been disregarded;
- The turbine rotors may not always be aligned to face-on to the window; and
- The rotors may not always be turning (i.e. no account has been taken of calm winds or shut-down periods).

17.5.4 When the sun is close to the horizon, at dawn and dusk, the intensity of the sun's rays is reduced and is less likely to cast distinct shadows. It is generally considered that when the sun is lower than 2° above the horizon, that shadow flicker is unlikely to occur. This parameter has been included in the calculations.

17.5.5 The maximum theoretical occurrence of shadow flicker at any of the SFALs amounts to 48.2 hours per year at the most affected window at Killarow Farm (SFAL2); at all other SFALs the maximum theoretical occurrence of shadow flicker will be below this value.

17.5.6 The times of day when shadow flicker could occur at all SFALs are between 04:48 and 06:48 (GMT) during the months of April through to September. At all SFALs, shadow flicker could only occur early in the morning between these times; the effects of shadow flicker will therefore be potentially less or not noticeable to inhabitants at these times if there is overlap with periods of sleep.

17.5.7 The distribution of shadow flicker occurrence for the other seven SFALs is illustrated in Figures A1.3 to A1.9 within Appendix 17.1: Shadow Flicker Assessment.

17.5.8 The instances of shadow flicker would always be less than that predicted by the model as these are based on a worst case scenario. The occurrence of shadow flicker is only possible during the operation of the wind turbine (i.e. when the rotor blades are turning) and when the sky is clear enough for the sun to cast shadows. It is important to consider the following facts when making an assessment:

- Climatic conditions dictate that the sun is not always shining. Met Office data gives actual sunshine hours for the area to be 32% of total daylight hours[1]. Cloud cover during other times may obscure the sun and prevent shadow flicker occurrence. While some shadow may still be

[1] Calculated based on figures available at https://www.metoffice.gov.uk/public/weather/climate/ for Campbelltown, 1412.5 hours of sunshine a year (1412.5/4380*100 = 32%) (last accessed 16/03/2018).

cast under slightly overcast conditions, no shadow at all would be cast when heavy cloud cover prevails; and

- Objects such as trees or walls may surround windows and obscure the view of the turbine and hence prevent or limit shadow flicker. At the assessed locations, woodland and farm buildings may obstruct the view of the turbines, which has not been considered in this assessment. During operation, the turbine rotors would automatically orientate themselves to face the prevailing wind direction. This means the turbine rotors would not always be facing the affected window and in fact would sometimes be 'side-on' to the window. Very little of the blade movement would be visible during such occurrences and therefore the potential for shadow flicker is reduced.

17.5.9 As detailed above, shadow flicker can only occur during daylight hours and when the sky is clear. The total theoretical hours per year given in Table 17.2 above assume all hours of daylight are with clear skies. For the most affected window at Killarow Farm (SFAL2), the total theoretical shadow flicker hours are 48.2 hours per year. Using historical data provided by the Met Office, the total theoretical hours can be adjusted to reflect a more realistic case. Actual sunshine hours are given to be 32% of all daylight hours; therefore, the potential 'likely' hours of shadow flicker per year may be reduced to approximately 15.4 hours. This value does not take account of other factors listed in Section 17.5.8 above which would reduce levels further. The figure is given only as a guide to illustrate the difference between theoretical and 'likely' hours and does not account for other factors which may reduce the levels further.

17.5.10 A comparison has been undertaken of the predicted shadow flicker hours against values included in the *'Best Practice Guidance for Planning Policy Statement 18 (PPS18) Renewable Energy'* (Department of Environment Northern Ireland, 2009) and it was found that there is the potential for the maximum theoretical predictions of shadow flicker to exceed the thresholds of 30 hours per year and 30 minutes per day.

17.5.11 The highest likely level of shadow flicker (taking into account climactic conditions discussed above) that may occur at the most affected receptor (Killarow Farm - SFAL2) is approximately 15.4 hours per year (at the most affected window), which is below the threshold of 30 hours per year. Likely levels of shadow flicker occurrence are below 30 hours per year at all seven SFALs.

17.5.12 The likely levels of yearly shadow flicker occurrence are determined based on annual average climate data, and it would therefore not be appropriate to apply these same factors to daily predicted levels. Both Killarow Farm (SFAL2) and Tangy Mill (SFAL4) could potentially experience maximum levels of shadow flicker in excess of 30 minutes per day.

17.6 Mitigation and Monitoring

17.6.1 In the absence of any Scottish guidelines on acceptable levels of shadow flicker, the thresholds outlined in the *'Best Practice Guidance for Planning Policy Statement 18 (PPS18) Renewable Energy'* (Department of Environment Northern Ireland, 2009) have been adopted.

17.6.2 Mitigation measures are available to counteract shadow flicker occurrence to reduce the possibility of nuisance. One of the most effective mitigation strategies is shutting down selected turbines using turbine control systems during periods when shadow flicker could theoretically occur and during certain weather conditions. Therefore, in order to protect the amenity of local residents, the turbines would be programmed to shut down during periods when shadow flicker could occur.

17.7 Residual Effects

17.7.1 No significant effects have been identified, however proposed mitigation would be implemented, such that there would be no shadow flicker effects and accordingly the impact from shadow flicker would be **not significant.**

17.8 Summary

17.8.1 This chapter has assessed the potential shadow flicker effects associated with the proposed development. It has been identified that the maximum theoretical occurrence of shadow flicker amounts to 48.2 hours per year, although taking into account climactic conditions would reduce this to 15.4, at the most affected window at Killarow Farm (SFAL2). The times of day when shadow flicker could occur are between 04:48 and 06:48 (GMT) during the months of April through to September. At all SFALs, shadow flicker could only occur early in the morning between these times; the effects of shadow flicker will therefore be potentially less or not noticeable to inhabitants at these times if there is overlap with periods of sleep. However, in order to protect the amenity of local residents, the turbines would be programmed to shut down during periods when shadow flicker could occur, accordingly the impact from shadow flicker would be **not significant**.

List of Figures

Figure 17.1 – Shadow Flicker Assessment Area

17.9 References

Scottish Government 'Onshore Wind Turbine' Guidance, 28 May 2014

Department of Energy and Climate Change (2011). Update of UK Shadow Flicker Evidence Base. Parsons Brinkerhoff on behalf of the Department of Energy and Climate Change

Best Practice Guidance for Planning Policy Statement 18 (PPS18) Renewable Energy (Department of Environment Northern Ireland, 2009

Met Office Website