Chapter 17:

Other Considerations

Contents

17 Other Considerations

17.1 Introduction

17.1.1 This chapter assesses the potential effects of the Proposed Development in relation to:

- Shadow Flicker.
- Carbon Balance.
- Major Accidents and Disasters.
- Population and Human Health.
- Eskdalemuir Seismic Array.
- Air Quality.
- Television and Telecommunications.

17.1.2 Elements relating to major accidents and disasters have also been addressed in the individual technical discipline chapters where relevant.

17.1.3 Impacts on population and human health have also been addressed in the individual EIA topic chapters where relevant.

17.1.4 This assessment has been undertaken by SLR Consulting.

17.1.5 The chapter is supported by Figures 17.1 and 17.2, and Technical Appendix 17.1 that are referenced in the text where appropriate.

17.2 Shadow Flicker

Introduction

17.2.1 This section of the chapter summarises the potential effect of shadow flicker associated with the Proposed Development.

17.2.2 Under certain combinations of geographical position and time of day, when the sun passes behind the rotors of a wind turbine and casts a shadow over neighbouring properties, as the blades rotate, the shadow may appear to flick on and off, when viewed through a narrow aperture such as a window. The phenomenon occurs only within buildings where shadows are cast across a window aperture, and the effects are typically considered to occur up to a maximum distance of 10 times the rotor diameter from each wind turbine. This effect is known as shadow flicker.

Policy and Guidelines

17.2.3 The following policy and guidance documents have been referred to in undertaking the assessments:

- Scottish Government - Onshore wind policy statement 2022 (and its predecessor Onshore wind turbines: planning advice);
- Northern Ireland, Planning Policy Statement 18: Renewable Energy (2009); and
- Department of Energy & Climate Change (DECC) guidelines.

17.2.4 A report on shadow flicker from the Department of Energy & Climate Change (DECC) indicates a general rule of ten rotor diameters should be used for separation distance from a wind turbine position to a dwelling. Scottish Government guidance advocates that beyond this distance there should be no adverse impact from shadow flicker.

Consultation

17.2.5 Consultation was undertaken through the EIA Scoping Report. No further consultation has been undertaken.

17.2.6 Scottish Borders Council (SBC) requested that the shadow flicker assessment be undertaken out to 2 km in line with their Supplementary Guidance: Renewable Energy (2018) rather than limited to 10 times the rotor diameter from each wind turbine.

Assessment Methodology and Significance Criteria

<u>Study Area</u>

17.2.7 The update to Shadow Flicker Evidence Base (2011), published by the then Department for Energy and Climate Change (DECC), states that assessing shadow flicker effects within ten times the rotor diameter of wind turbines has been widely accepted across different European countries and is deemed to be an appropriate area. It also states that shadow flicker effects on receptors in the UK are generally restricted to 130 degrees either side of north of the turbine, based on a review of policy and guidance in place at the time the document was written.

17.2.8 The Scottish Government's Onshore wind turbines: planning advice (2014) document states that:

"Under certain combinations of geographical position, time of day and time of year, the sun may pass behind the rotor and cast a shadow over neighbouring properties. When the blades rotate, the shadow flicks on and off; the effect is known as 'shadow flicker'. It occurs only within buildings where the flicker appears through a narrow window opening. The seasonal duration of this effect can be calculated from the geometry of the machine and the latitude of the potential site.
Where this could be a problem, developers should provide calculations to quantify the effect. In most cases however, where separation is provided between wind turbines and nearby dwellings (as a general rule, 10 rotor diameters), 'shadow flicker' should not be a problem. However, there is scope to vary layout/reduce the height of turbines in extreme cases".

17.2.9 Neither National Planning Framework 4 (NPF4) (2023), the Scottish Governments Onshore Wind Policy Statement (2022) nor SBC Local Development Plan Supplementary Guidance: Renewable Energy (2018) contain technical details regarding the assessment of shadow flicker.

17.2.10 SBC Supplementary Guidance: Renewable Energy (2018) states that:

"… there is some recent evidence that shadow flicker can be experienced at greater than 10 rotor diameter distance and that the modelling of those residences within 10 rotor diameter may not capture all homes where people experience shadow flicker effects .Where requested by the Council, the developer will be required to produce shadow flicker assessments modelled to take into account all residential property within 2km of a wind turbine. This distance threshold should take into account any screening of turbines offered by topography."

17.2.11 The assessment was therefore carried out based on a 2 km study area following the EIA Scoping response from SBC.

17.2.12 Shadow flicker effects are only considered during the operational phase of a wind farm development, and do not occur if the turbines are not rotating or if the sun is not shining.

<u>Assessment Methodology</u>

17.2.13 The shadow flicker assessment comprises numerical modelling of the proposed turbines and receptors within the defined study area. It is noted that whilst there are a number of computer models available, the DECC study (2011) confirms that there are limited differences between outputs of the various packages. For shadow flicker assessments, SLR Consulting use one of the industry standard software packages, ReSoft Wind Farm software (version 5.1.2.1).

17.2.14 The calculations from this assessment process assumes a worst-case scenario based on the sun shining during all daylight hours over the course of a year, no obscuring features (such as trees, hedges, other buildings) being present, the face of the rotor always being aligned towards the dwelling, and that the rotor is always turning (i.e. the wind is always blowing between 4 m/s and 25 m/s, and no account is taken of shut down periods for maintenance). This methodology yields a theoretical maximum indication of potential shadow flicker incidence, together with the times of day, and dates during the year when potential incidence may occur.

17.2.15 The levels of shadow flicker at each receptor have been calculated based on a 'greenhouse' modelling approach, where the full length of each façade of a building is modelled as a window (and is therefore sensitive to shadow flicker). Each modelled window is assumed to have a mid-point height of 2 m. This approach has been taken in order to present a worst-case estimate of shadow flicker, in the absence of any detailed window location data. In reality, only the glazed area of each façade would be sensitive to shadow flicker effects, therefore modelling the full façade will result in higher predicted levels than will actually be possible.

17.2.16 The software performs calculations to determine the position of the sun throughout the year, and thus during what times of day it will theoretically cast a shadow across the windows of nearby houses within the defined study area (plus 100 m micrositing). Data input into the model where shadow flicker assessment is required is as follows.

- The locations of all properties within 2 km of the turbine locations (plus an allowance of 100 m for micrositing).
- The dimensions and orientations of windows facing the Proposed Development – for the purpose of this model, a window centre point height of 2 m has been assumed.
- The surrounding topography (Ordnance Survey Digital Terrain Model).
- The locations and dimensions of the turbines.

17.2.17 The following sources of information outlined in Table 17.1 were used to inform this assessment.

Table 17.1 – Sources of Information

Topic	Sources of Information
Residential properties Location in relation to the Proposed Development and identification of windows.	Ordnance Survey (OS) 1:25,000 Mapping Google Earth Street View Bing Maps Birds Eye View
Topography Height data	OS 5 m DTM data

17.2.18 In practice, it is likely that shadow flicker effects would occur for considerably less time than the worst-case predictions, for the following reasons.

- In the UK, sunshine typically occurs for approximately 30 % of daylight hours. At other times, the wind turbines are unlikely to cast shadows sufficiently pronounced to cause shadow flicker effects to occur.
- At times when the wind turbine rotor is not oriented directly towards the property, the duration of shadow flicker effects would be reduced due to the elliptical shape of the shadow cast.
- The assessment has been undertaken assuming a worst-case scenario which does not take into consideration the screening effect of anything located between the wind turbines (e.g., intervening structures or vegetation) and the property. The assessment also assumes that the property does have windows facing the wind turbines which may not always be the case.

17.2.19 A "likely-case" scenario of shadow flicker effects has therefore also been included in the results section, based on the average sunshine hours experienced at the Proposed Development location.

17.2.20 Only those properties within 2,100 m of the proposed turbines have been included in the calculations. The model has been run using OS terrain 5 m DTM data which is the most accurate digital terrain data available for the site.

Limitations to Assessment

17.2.21 There are several additional factors that can influence the amount of shadow flicker actually experienced and these cannot be readily included in a computer-based assessment.

17.2.22 Climatic conditions dictate that the sun is not always shining. The closest Met Office location is Camps Reservoir, located approximately 6 km from the Proposed Development. Historic Met Office data (over the period 1991 - 2020) gives actual sunshine hours for the Camps Reservoir Met Station to be on average 26.2 %[1] of total daylight hours. Cloud cover during other times may obscure the sun and prevent shadow flicker occurrence. While some shadows may be cast under slightly overcast conditions, no shadow at all would be cast when heavy cloud cover prevails.

17.2.23 During calm periods, or very high winds, the wind turbine blades would not rotate, and shadow flicker would not occur. Turbines would also be periodically shut down for maintenance or repair work.

17.2.24 Wind turbines automatically orientate themselves to face the prevailing wind direction. This means that the turbine rotors would not always face directly towards the occupied buildings. Under some wind conditions, the proposed turbines would face 'side-on' to properties, and in these conditions only a very small area of blade movement would be visible.

17.2.25 Any screening provided by vegetation or structures has not been incorporated as the analysis has been run on bare ground terrain data as a worst-case scenario. The inclusion of a 100 m micrositing allowance has also been added to the worst-case nature of the assessment, as for some properties this means additional turbines are considered to cause shadow flicker if they moved 100 m towards the property.

Assessment of Potential Effect Significance

17.2.26 Whilst the time and duration of shadow flicker events can be predicted accurately, the level of the effect is difficult to quantify as this would depend on the location of windows within a property, the use of the rooms affected, the level of shading surrounding the property and how susceptible the receptor is to light flicker.

17.2.27 As confirmed by the DECC study (2011), there is no standard Scottish or UK guidance relating to a limit for shadow flicker, and this remains the case. The only guidance providing additional recommendations is the Northern Irish PPS 18 (2009) guidance which recommends that for properties within 500 m of the turbines, shadow flicker should not exceed 30 hours per year.

[1] Average sunshine hours of 1,150.36 / total number of daylight hours 4,380 = 26.2%. Data from Met Office Climate Averages site available at https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/gcv7wm5dw

17.2.28 The assessment has therefore adopted a criterion of 30 hours of shadow flicker (under the likely-case assessment scenario outlined in 17.2.9) in one year as a significance threshold. Where less than 30 hours of shadow flicker is predicted to occur in one year at a particular property, this is considered to be a minor effect (not significant), with significance increasing in relation to the number of hours (over 30) of shadow flicker per year, in accordance with best practice guidance.

17.2.29 Whilst the distance between turbine and property does not affect the calculated shadow flicker exposure times, it does mean that the actual effect (i.e. the total exposure time and flicker intensity combined) of the Proposed Development would, in reality, be less than that calculated as a worst-case.

Requirements for Mitigation

17.2.30 Mitigation will be proposed to minimise or remove predicted effects, if levels of shadow flicker are deemed to be significant in practice in line with the Northern Irish PPS 18 (2009) guidance.

Cumulative Assessment

17.2.31 Whilst there are a number of wind farms in the local area, only one, Glenkerie Wind Farm, is located such that cumulative effects could potentially be experienced by any identified receptors. Therefore, a cumulative assessment including Glenkerie Wind Farm has been undertaken.

Baseline Conditions

17.2.32 A number of residential properties have been identified which fall within the 2,100 m study area. These properties could theoretically be affected by shadow flicker from the Proposed Development (Figure 17.1). Details of these properties are identified in Table 17.2.

Table 17.2 – Receptors within the Study Area

Shadow Flicker Property ID	Receptor Name	Easting	Northing	Distance to Nearest Turbine (m)
1	Menzion Farm	309114	623612	1050
2	Oliver Farm	309472	624414	1095
3	Oliver Bank West	309587	624444	1197
4	The Toll House	309631	624436	1240
5	Lilybank	309788	624318	1410
6	Oliver House	309816	624863	1347
7	The Bield	309976	624782	1508
8	Riverview	310040	624814	1579
9	Tweedholm Cottage	310035	624843	1576
10	Carngorm	310069	624906	1622
11*	Hawkshaw Farmhouse	307537	622436	1361
12	Hopehead	307923	625762	1053
13	Oliver Bank East	309594	624450	1202
14	Schoolhouse	309823	624332	1449
15	Dorran House Tweedside	309859	624362	1481
16	Tweedscape	309899	624389	1510
17	Carlowse Cottage	309922	624427	1521
18	Glebe House	309990	624508	1566
19	Dykehead Cottage	309865	624311	1491
20	Gairlat	309888	624331	1514
21	Heatherlea	309909	624357	1530
22	Tallahaugh	309905	624276	1532
23	Hillhall	309923	624249	1551
24	Forest Lodge	309939	624221	1569
25	Menzion Farmhouse	309109	623567	1058
26	Menzion House	309155	623587	1076
27*	Hawkshaw Cottage	307536	622412	1394
28	The Old Post Office	309639	624434	1250
29	Tweedview Farmhouse Oliver	309782	624892	1319
30	The Insch	310111	624518	1682
31	Tallaside	310148	624530	1716
* property within 2km of a turbine, but not within the 130 degrees either side of north limitation				

Receptors Brought Forward for Assessment

17.2.33 All properties within the Study Area and identified in Table 17.2 have been brought forward for assessment.

Potential Effects

Construction and Decommissioning

17.2.34 Shadow flicker is an operational effect and so not considered during the construction or decommissioning phases.

Operation

17.2.35 Figure 17.2 shows the results of the shadow flicker modelling. The results, set out in Table 17.3 below, show both the 'worst-case scenario', which assumes that the sun is always shining during daylight hours, the wind is always blowing, makes no allowance for any screening by vegetation, and includes the potential for micrositing leading to turbines being moved 100 m closer to these properties, and the likely case scenario, whereby the worst-case results are adjusted for likely annual sunshine hours..

17.2.36 Based on the predictive modelling technique outlined above, there is predicted to be the greatest shadow flicker effects of up to 52.9 hours per year at the Hopehead bothy (shown in Table 17.3), assuming the worst-case scenario whereby the sun is always shining during daylight hours, the turbines are always turning, and there is no screening from vegetation. The last two columns of Table 17.3 provide an indication of the likely shadow flicker minutes per day and hours when the 26.2 % average sunshine hours factor is included.

17.2.37 In addition, 28 other properties could also potentially receive shadow flicker effects but of fewer hours. Two properties are not predicted to experience any shadow flicker effects.

Table 17.3 – Receptors within the Study Area

Shadow Flicker Property ID	Receptor Name	Days per Year Where Shadow Flicker Potentially Experienced	Turbine(s) Causing Effect	Max Minutes per Day Where Shadow Flicker Potentially experienced	Total Hours per Year When Shadow Flicker Potentially experienced	Likely Max Minutes per Day Where Shadow Flicker Potentially experienced*	Likely Hours per Year When Shadow Flicker Potentially Experienced*
1	Menzion Farm	139	1, 2, 3, 4	51	77.2	13.4	20.2
2	Oliver Farm	175	1, 2, 4, 5, 6, 7	53.4	97.3	14.0	25.5
3	Oliver Bank West	174	1, 5, 6, 7	46.8	80.6	12.3	21.1
4	The Toll House	177	1, 5, 6, 7	43.2	77.9	11.3	20.4
5	Lilybank	165	1, 5, 6, 7	46.2	72.9	12.1	19.1
6	Oliver House	85	1, 6, 7	31.2	28.8	8.2	7.5
7	The Bield	73	5, 6, 7	28.8	24.1	7.5	6.3
8	Riverview	60	6, 7	27.6	20.6	7.2	5.4
9	Tweedholm Cottage	57	6, 7	27.6	20	7.2	5.2
10	Carngorm	52	6, 7	26.4	17.7	6.9	4.6
11*	Hawkshaw Farmhouse	0	-	0	0	0.0	0.0
12	Hopehead	111	3, 4, 5, 6, 7	118.8	152.9	31.1	40.1
13	Oliver Bank East	174	1, 5, 6, 7	44.4	79.8	11.6	20.9
14	Schoolhouse	170	1, 5, 6, 7	43.8	71.1	11.5	18.6
15	Dorran House Tweedside	177	1, 5, 6, 7	41.4	65.1	10.8	17.1
16	Tweedscape	150	1, 5, 6, 7	39.6	55.6	10.4	14.6
17	Carlowse Cottage	140	1, 5, 6, 7	37.8	51.3	9.9	13.4
18	Glebe House	101	5, 6, 7	33	37.1	8.6	9.7
19	Dykehead Cottage	171	1, 5, 6, 7	43.8	68.4	11.5	17.9
20	Gairlat	173	1, 5, 6, 7	41.4	64.3	10.8	16.8
21	Heatherlea	154	1, 5, 6, 7	40.2	56.8	10.5	14.9
22	Tallahaugh	165	1, 5, 6, 7	43.2	65.7	11.3	17.2
23	Hillhall	164	1, 5, 6, 7	43.8	64.8	11.5	17.0
24	Forest Lodge	160	1, 5, 6, 7	43.8	63.8	11.5	16.7
25	Menzion Farmhouse	137	1, 2, 3, 4	52.8	80.1	13.8	21.0
26	Menzion House	140	1, 2, 4	48	69.3	12.6	18.2
27*	Hawkshaw Cottage	0	-	0	0	0.0	0.0
28	The Old Post Office	178	1, 5, 6, 7	45.6	82.8	11.9	21.7
29	Tweedview Farmhouse Oliver	86	1, 5, 6, 7	31.8	28.1	8.3	7.4
30	The Insch	74	6, 7	25.8	24.4	6.8	6.4
31	Tallaside	73	6, 7	25.8	23.3	6.8	6.1

* based on average sunshine hours being applied to the model as outlined in Limitations to Assessment section of this chapter.

Analysis of Results

17.2.38 The results confirm that 21 of the 31 properties assessed could potentially experience over 30 hours of shadow flicker effect per annum, based on the worst-case assessment criteria. Based on the assessment criteria the effects on these properties would therefore be significant without mitigation.

17.2.39 These figures are an over-estimate of actual effects. Given the conservative nature of this assessment as set out in the limitations of effects section, it is likely that, in practice actual hours of shadow flicker would be considerably less than this due to the wind not always blowing and the sun not always shining, and other assumptions set out earlier.

17.2.40 Expected hours of shadow flicker are provided in the final column of Table 17.3, adjusted for likely sunshine hours. The model does not take into account the proportion of time that the wind is blowing to a sufficient level to rotate turbine blades nor does it take into account screening provided by vegetation and thereby the expected hours of shadow flicker represents a conservative assessment. Therefore, the shadow flicker hours will be even less than predicted. Under these conservative assumptions, the annual hours of shadow flicker anticipated at all properties, with the exception of Hopehead, are under the 30 hours significance threshold. Details of when shadow flicker could be experienced at properties with a potentially significant effect are provided below.

Hopehead

17.2.41 Shadow flicker at this property could be experienced for up to 152.9 hours per year (40.1 hours per year under the average sunshine hours adjustment) from proposed Turbines 3, 4, 5, 6 and 7.

17.2.42 Shadow flicker effects from Turbine 3 would be likely to occur between the hours of 13:49 and 14:32 from mid-November to mid-January, shadow flicker effects from Turbine 4 would be likely to occur between the hours of 13:05 and 13:56 from mid-November to mid-January, shadow flicker effects from Turbine 5 would be likely to occur between the hours of 11:48 and 12:45 from late November to late January, shadow flicker effects from Turbine 6 would be likely to occur between the hours of 09:33 and 10:44 from late October through to mid-February, and shadow flicker effects originating from Turbine 7 would be likely to occur between the hours of 10:42 and 11:16 from early December through to mid-January.

17.2.43 Under the assessment criteria set out earlier in the chapter, the effects on this property would therefore be significant without mitigation.

17.2.44 However, it is noted that the property is used infrequently by groups of people as a temporary overnight stay. It is not a dwelling and is only accessible via a 4 km (2.5 mile) private farm track. . Shadow flicker effects would be limited to the period of late October through to mid-February between 9:33 and 14:32, which, given the property's lack of permanent residents and likely limited use during the day, may also reduce the likelihood of shadow flicker effects actually being experienced.

Mitigation

17.2.45 Based on the significance thresholds outlined previously, significant shadow flicker effects are predicted to occur as a result of the Proposed Development, based on a worst-case scenario, at a single property, Hopehead, which is not permanently inhabited and is infrequently used by groups of people as a temporary overnight stay. Given the property usage, and the time of year and times of day when shadow flicker is predicted to occur at this property, mitigation is not proposed for the property.

17.2.46 Although shadow flicker levels are likely to fall to below the 30-hour per annum significance threshold based on the average sunshine hours expected at the site (with the exception of Hopehead), the Applicant is nonetheless committed to promptly investigating any complaints of shadow flicker and taking appropriate action as required.

17.2.47 The Applicant proposes that prior to the operation of the first turbine, a Wind Farm Shadow Flicker Protocol would be submitted to and approved by SBC. This would set out the protocol to be followed should a shadow flicker complaint be received from a receptor within the study area, and potential mitigation measures. Should a complaint be received these mitigation measures would include using the turbine's shadow flicker control module to be programmed to minimise impacts at the receptor(s). Operation of the Proposed Development would be undertaken in accordance with the Wind Farm Shadow Flicker Protocol.

17.2.48 If a complaint is made regarding shadow flicker, an investigation would take place which considers the weather conditions at the time of the alleged shadow flicker, to determine which turbines were, or were not, creating the effect and the extent of the shadow flicker created. If the investigation confirms a loss of residential amenity at any location, the technical mitigation measures built into these turbines would be activated.

17.2.49 Shadow flicker control modules, consisting of light sensors and specialised software, will be installed on the turbines that can prevent operation during periods when shadow flicker can be experienced at nearby properties. The installation of a programmable shadow flicker module will allow the control of turbines in order to eliminate shadow flicker. The correct operation of the installed shadow flicker control measures will ensure that there will be no impact from shadow flicker. The operation and performance of the shadow flicker control measures will be monitored on an ongoing basis.

17.2.50 The shadow flicker control module consists of bespoke software, a clock, a timer, a switch, a wind direction sensor and a light sensor. The module can control a specific turbine (or turbines) which would be programmed to shut down on specific dates at specific times when the sun is bright enough, there is sufficient wind to rotate the blades and the wind direction is such that nuisance shadow flicker could occur. There is no specific UK guidance regarding what level of light is sufficient to cause a shadow flicker event. However, the actual light level that would trigger a turbine shut down can be manually configured on-site, following installation, to reflect local conditions.

17.2.51 It is proposed that a planning condition would provide an appropriate form of mitigation to ensure that any complaints would be investigated within a reasonable timescale and that the rectification of any substantiated shadow flicker issue would be implemented promptly and effectively. As noted in the DECC guidance (2011) states that *"Mitigation measures which have been employed to operational wind farms such as turbine shut down strategies, have proved very successful, to the extent that shadow flicker cannot be considered to be a major issue in the UK".*

Residual Effects

<u>Operation</u>

17.2.52 Following implementation of mitigation following a complaint, it is considered that there will be no significant effects in relation to shadow flicker as a result of the Proposed Development.

Cumulative Assessment

17.2.53 The results confirm that of the 31 properties assessed, only one (Hopehead) has the potential to experience cumulative shadow flicker effects. In line with the assessment criteria, a 2 km study area has been applied to Glenkerie Wind Farm (see Figure 17.1).

17.2.54 A cumulative shadow flicker model has been run, which shows that Hopehead is not expected to experience any shadow flicker effects from Glenkerie Wind Farm.

17.2.55 Therefore, no cumulative effects from shadow flicker are anticipated as a result of the Proposed Development.

Summary

17.2.56 Under conservative assumptions, the Proposed Development is predicted to potentially cause shadow flicker for a number of properties within the 2,100 m assessment area, with one property (Hopehead, used as a bothy and not permanently inhabited) predicted to experience shadow flicker levels in excess of 30 hours per year under the likely sunshine hours assessment.

17.2.57 A cumulative assessment has also been undertaken which shows that no cumulative effects would be experienced at any properties as a result of the Proposed Development.

17.2.58 Should a shadow flicker complaint be raised, mitigation can be provided, including shutting down individual wind turbines during periods when shadow flicker is modelled to occur and the climactic conditions are such that shadow flicker can be experienced.

17.2.59 A planning condition would provide an appropriate form of mitigation to ensure that any complaints would be investigated within a reasonable timescale and that the rectification of any substantiated shadow flicker issue would be implemented promptly and effectively**.**

17.3 Climate and Carbon Balance

17.3.1 This section of the chapter details the calculations to work out carbon dioxide (CO_2) emissions from the Proposed Development and is supported by Technical Appendix 17.1. In addition to generating electricity, the Scottish Government sees wind farms as an important mechanism for reducing the UK's CO_2 emissions. This section estimates the CO_2 emissions associated with the manufacture and construction of the Proposed Development as well as estimating the contribution the Proposed Development would make to reducing CO_2 emissions, to give an estimate of the whole life carbon balance of the Proposed Development. The assessment is based on a detailed baseline description of the Proposed Development and its location. All calculations are based on site specific data, where available. Where site specific data is not available, approved national/regional information has been used.

17.3.2 An assessment of the vulnerability of the Proposed Development to climate change has not been included, as it is considered that none of the identified climate change trends would affect the Proposed Development, with the exception of increased windstorms. Mitigation with regard to extreme weather events, including windstorms, is detailed in Section 17.4.

17.3.3 Each unit of wind generated electricity would displace a unit of conventionally generated electricity, therefore, contributing to the UK net zero targets by reducing CO_2 emissions associated with power generation. Table 17.4 provides a breakdown of the estimated emissions displaced per annum and over the assumed lifespan of 50 years for the Proposed Development.

Carbon and Peatland

17.3.4 Renewable energy developments in upland areas may often be sited on peatlands which hold stocks of poorly protected carbon, and so have the potential to release carbon to the atmosphere in the form of CO_2 if disturbed. Scotland has the majority of peat soils in the UK and, therefore, has a responsibility to ensure stability of this carbon and to ensure that developments do not cause a significant loss of this carbon reservoir.

17.3.5 The Proposed Development is located in an area where peaty soils and peat have been impacted by commercial land use management by establishment of commercial plantation forestry across the site, which will have reduced the underlying 'peat resource' as a source of carbon. This peatland cannot be considered as pristine due to the disturbance from forestry planting and drainage activity resulting in release of CO_2 to the atmosphere and long-term degradation as a 'carbon sink'. The deeper peat (below the water table) will still be a carbon sink as long as the water table is maintained and the peat is not artificially drained.

17.3.6 The carbon balance assessment considers the implications of any parts of the Proposed Development which could lead to the additional release of CO_2 resulting from the disturbance of peat.

17.3.7 In order to minimise the requirement for the extraction of peat, the layout design process has avoided areas of deeper peat where practicable. The layout design process is described in Chapter 2. Specific details on the peat depth and probing surveys undertaken are included in Technical Appendix 10.1 and Technical Appendix 10.2.

Characteristics of Peatland

17.3.8 The loss of carbon from the carbon fixing potential from plants and vegetation on peat land is small but is calculated for the area from which peat is removed and the area affected by drainage. The carbon stored in the peat itself represents a much larger potential source of carbon loss.

17.3.9 When flooded, peat soils emit less carbon dioxide but more methane than when they are drained. In flooded soils, carbon emissions are usually exceeded by plant fixation, so the net exchange of carbon with the atmosphere is negative and soil stocks increase. When soils are aerated, carbon emissions usually exceed plant fixation, so the net exchange of carbon with the atmosphere is positive.

17.3.10 To calculate the carbon emissions attributable to the removal or drainage of the peat, emissions occurring if the soil had remained in situ and undrained are subtracted from the emissions occurring after removal or drainage.

17.3.11 The indirect loss of CO_2 uptake (fixation) by plants originally on the surface of the site but eliminated by construction activity including the destruction of active bog plants on wet sites and felling, is calculated on site specific data collected as part of the EIA process and based on blanket bog.

17.3.12 Emissions due to the indirect, long-term liberation of CO_2 from carbon stored in peat due to drying and oxidation processes caused by construction of the site, can also be calculated from site specific data for the Proposed Development. This figure is a worst-case scenario, as the peat would be reused on-site to minimise carbon losses.

Carbon Payback Methodology

17.3.13 The assessment of the carbon payback is based on a detailed baseline description of the Proposed Development and its location. All calculations are based on site specific data, where available. Where site specific data is not available approved national/regional information has been used.

17.3.14 The methodology to calculate carbon emissions is based on 'Calculating carbon savings from windfarms on Scottish peat lands - A New Approach' (Nayak et al, 2008), prepared for the Scottish Government Science, Policy and Co-ordination Division. This was superseded in 2011 by the document 'Calculating Carbon Savings from Wind Farms on Scottish Peatlands - A New Approach', (Nayak et al, 2008 and 2010) and (Smith et al, 2007). In terms of carbon footprint, the 'carbon calculator' is the Scottish Government's tool provided to support the process of determining the carbon impact of wind farm developments in Scotland. It is noted that this methodology is specifically designed for wind farms and not for multi-technology renewable energy developments like the Proposed Development. Therefore, the assessment only considers the wind turbine element of the Proposed Development.

Effects of Carbon Emissions from Construction

17.3.15 Emissions arising from the fabrication of the wind turbines and the associated components are based on a full life analysis of a typical wind turbine and include CO_2 emissions resulting from transportation, erection, operation, dismantling and removal of wind turbines and foundations and transmission grid connection equipment from the existing electricity grid system.

17.3.16 With respect to wind turbines, emissions from material production are the dominant source of CO_2. Emissions arising from construction (including transportation of components, quarrying, building foundations, access tracks and hardstands) and commissioning are also included in the calculations. The assessment has used Nayak et al (2008) default values for 'turbine life' emissions, calculated with respect to installed capacity.

17.3.17 The Proposed Development is seeking consent with an operational lifespan of 50 years.

Input Parameters

17.3.18 To undertake this assessment, the following parameters were considered, which encompass a full life cycle analysis of the Proposed Development. These parameters include:

- emissions arising from the fabrication of the wind turbines and all the associated components;
- emissions arising from construction, (including transportation of components; quarrying; building foundations, access tracks and hardstands; and commissioning);
- the indirect loss of CO_2 uptake (fixation) by plants originally on the surface of the site but eliminated by construction activity (including the destruction of active bog plants on wet sites);
- emissions due to the indirect, long-term liberation of CO_2 from carbon stored in peat due to drying and oxidation processes caused by construction; and
- loss of carbon due to drainage.

17.3.19 As part of their methodology, Nayak et al have provided a spreadsheet called 'Scottish Government Windfarm Carbon Assessment Tool' to calculate whole life carbon balance assessments for wind farms on peatlands. The calculation spreadsheet (online calculator version 1.8.1 and reference number (NP06-BZ2F-C2J5 v2) allows a range of data to be input in order to address expected, minimum and maximum values. However, if several parameters are varied together, this can have the effect of 'cancelling out' a single parameter change. For this reason, the approach for this assessment has been to include 'maximum values' as those values which would result in the longest (maximum) payback period; and 'minimum values' as those values which would result in the shortest (minimum) payback period.

17.3.20 This spreadsheet tool provides generic values for CO_2 emissions associated with some components (such as wind turbine manufacture) and requires site specific information for other components (such as habitat type, extent of peat disturbance and ground water levels).

17.3.21 This assessment draws on information detailed in Chapters 8 and 10 of the EIA Report. For the purpose of this assessment, it is assumed that all the embedded good practice measures outlined in the aforementioned chapters would be employed.

17.3.22 The final wind turbine choice is not yet known but would likely be around 7.2 MW and the greenhouse gas savings and carbon payback are based on the input parameters of the proposed seven wind turbines. Figures are based on currently available wind turbines and assume a consistent supplier for all wind turbine locations (i.e. wind turbine types are chosen by manufacturer). Note that, within the calculation spreadsheet, the expected, maximum and minimum values have been adjusted to suit the input parameter.

17.3.23 The capacity factor used within the calculation spreadsheet is based on measured on-site wind data giving a capacity factor of 37.3 %.

17.3.24 The input parameters for the Scottish Government calculation spreadsheet are detailed in Technical Appendix 17.1: Carbon Calculator. The choice of methodology for calculating the emission factors uses the 'site specific methodology' defined within the calculation spreadsheet.

Results

17.3.25 This section presents a summary of the carbon assessment which has been undertaken in respect of the Proposed Development. The purpose of the 'carbon calculator' is to assess, in a comprehensive and consistent way, the carbon impact of wind energy developments. This is undertaken by comparing the carbon costs of manufacture and construction with the carbon savings attributable to a development through operation. An assessment has been undertaken to calculate the carbon emissions which would be generated in the construction and operation of the Proposed Development after an illustrative 50 years.

17.3.26 The carbon calculations spreadsheet is provided in Technical Appendix 17.1. A summary of the anticipated carbon emissions and carbon payback of the Proposed Development relative to the current Department for Business, Energy & Industrial Strategy published figures is provided in Table 17.4.

Table 17.4 CO_2 Emissions and Payback Time

Results	Exp.	Min.	Max.
Net emissions of carbon dioxide (t $CO_{2\ eq}$) (carbon losses minus carbon gains) per annum.	98,304	12,800	136,468
Carbon Payback Time			
…coal-fired electricity generation (years)	0.6	0.1	0.9
…grid-mix of electricity generation (years)	2.9	0.4	4.0
…fossil fuel – mix of electricity generation (years)	1.4	0.2	2.0
Ratio of CO_2 eq. emissions to power generation (g/kWh) (Target ratio by 2030 (electricity generation) <50 g/kWh)	11.94	1.53	16.71

Interpretation of results

17.3.27 The calculations of total carbon dioxide emission savings and payback time for the Proposed Development indicates the overall payback period of a development with seven wind turbines with an average (expected) installed capacity of around 7.2 MW each would be approximately 1.4 years (17 months), when compared to the fossil fuel mix of electricity generation.

17.3.28 This means that the Proposed Development is expected to take around 17 months to repay the carbon exchange to the atmosphere (the CO_2 debt) through construction of the wind turbines; the Proposed Development would in effect be in a net gain situation following this time period and would contribute to national CO_2 reduction targets.

17.3.29 The potential savings in CO_2 emissions due to the Proposed Development replacing other electricity sources over the lifetime of the wind turbines (assumed to be 50 years for the purpose of the carbon calculator) are approximately:

- 115,624 tonnes of CO_2 per year over coal-fired electricity;
- 34,089 tonnes of CO_2 per year over grid-mix of electricity; and
- 69,825 tonnes of CO_2 per year over a fossil fuel mix of electricity.

17.4 Major Accidents and Disasters

17.4.1 The vulnerability of the Proposed Development to major accidents and natural disasters, such as flooding, sea level rise, or earthquakes, is considered to be low due to its geographical location.

17.4.2 In addition, the nature of the proposals and location of the site means there would be negligible risks on the factors identified by the EIA Regulations. For example:

- population and human health – the site is away from major population centres with low population density and the required safety clearances around turbines has been a key consideration throughout the design process;
- biodiversity – receptors and resources would be unaffected as there would be little risk of polluting substances released or loss of habitat in a turbine failure scenario (highly unlikely);
- land, soil, water, air and climate – there would be little risk of polluting substances released or loss of habitat in a turbine failure scenario (highly unlikely); and
- material assets, cultural heritage and the landscape – there would be no adverse effects on these features in a turbine failure scenario (highly unlikely).

Battery Storage Fire Safety

17.4.3 Safety measures would be incorporated within the proposed Battery Energy Storage System (BESS) facility in order to minimise the risk of fire and the risk of contamination to surface water receptors. The BESS compound would be constructed with an impermeable lining and with stormwater storage provided above this. This will include an automatic fire suppression system with a control point or shut off valve so that in the unlikely event of a leak or pollution event occurring it can be retained within this area. Contained pollution or firewater would be pumped to a tanker and removed from the site for treatment and disposal at a suitable licenced facility.

17.4.4 The Applicant will comply with all relevant laws and regulations concerning fire safety. In their decision notice dated 21 February 2024 under application reference ECU00004881[2], the Scottish Ministers stated that *"Fire precautions and matters relating to health and safety are covered by other legislation, are regulated by the Health and Safety Executive (HSE), and such considerations are not material to the application."*

[2] https://www.energyconsents.scot/ApplicationDetails.aspx?cr=ECU00004881&T=6. Accessed on 30 April 2024.

Public Safety and Access

17.4.5 The Renewable UK Onshore Wind Health and Safety Guidelines (2015) note that wind farm development and operation can give rise to a range of risks to public safety including:

- traffic (especially lorries during construction, and abnormal loads for the transport of wind turbine components; including beyond the site boundary);
- construction site hazards (particularly to any people entering the site without the knowledge or consent of the site management);
- effects of catastrophic wind turbine failures, which may on rare occasions result in blade throw, tower topple or fire; and
- ice throw, if the wind turbine is operated with ice build-up on the blades.

17.4.6 The RenewableUK guidance (2015) states that "*Developers should ensure that risks to public safety are considered and managed effectively over the project lifecycle, and should be prepared to share their plans for managing these risks with stakeholders and regulators; effective engagement can both build trust, and help to reduce the level of public safety risk by taking account of local knowledge".*

17.4.7 Site security and access during the construction period would be governed under Health and Safety at Work Act 1974 and associated legislation. Public access to the site including the existing forestry tracks would remain in place as far as possible during construction (subject to temporary health and safety restrictions during certain construction activities) and would re-open to the public fully once construction of the Proposed Development is complete promoted via the recreational heritage trail (Figure 3.13).

17.4.8 The provision of the recreational heritage trail within the Proposed Development would enhance access provision within the site. Interpretation boards would be positioned along the trail outlining background information to cultural and ecological features of interest within the area. Appropriate warning signs would be installed concerning restricted areas of the site such as the substation compound, BESS, switchgear and metering systems. All on-site electrical cables would be buried underground with relevant signage. Further information on the trail is included in the Preliminary Access Management Plan (PAMP) contained in Technical Appendix 14.1

Traffic

17.4.9 Accident data for the roads local to the site (A701 from the site access junction to the A74(M)) has been reviewed and is presented in Chapter 12. An assessment of the potential effects on road safety has been undertaken. In summary, the Proposed Development would create an increase to HGV traffic levels within the study area during construction, but these levels would remain well within the design capacity of the local road network.

Construction

17.4.10 With regard to risks and accidents during the construction phase, the construction works for the Proposed Development would be undertaken in accordance with primary health and safety legislation, including the Health and Safety at Work Act 1974 and the Construction (Design and Management) (CDM) Regulations 2015 which will include a requirement to produce emergency procedures in a Construction Phase (Health & Safety) Plan in accordance with the Regulations.

17.4.11 Nonetheless, the risk of accidents is covered where relevant in individual topic chapters, for instance, the potential for environmental incidents and accidents such as spillages and flood risk are considered in Chapter 10**.** Good practice measures to prevent incidents and spillages are set out in the outline CEMP.

Extreme Weather

17.4.12 As far as the risk of turbine failure during high winds is concerned, the turbines would cut-out and automatically stop as a safety precaution in wind speeds over 25 m/s.

17.4.13 Wind turbines can be susceptible to lightning strike due to their height and appropriate measures are taken into account in the design of turbines to conduct lightning strikes down to earth and minimise the risk of damage to turbines. Occasionally however, lightning can strike and damage a wind turbine blade. Modern wind turbine blades are manufactured from a glass-fibre or wood-epoxy composite in a mould, such that the reinforcement runs predominantly along the length of the blade. This means that blades will usually stay attached to the turbine if damaged by lightning and in all cases, turbines will automatically shut down if damaged by lightning.

17.4.14 Ice build-up on blade surfaces occurs in cold weather conditions. Wind turbines can continue to operate with a very thin accumulation of snow or ice but will shut down automatically as soon as there is a sufficient build up to cause aerodynamic or physical imbalance of the rotor assembly. Potential icing conditions affecting turbines can be expected two to seven days per year (light icing) in Scotland (WECO, 1999). In the event that a turbine is shut down during conditions suitable for ice formation, there is potential for ice throw to occur after start-up. There are monitoring systems and protocols in place to ensure that turbines that have been stationary during icing conditions are re-started in a controlled manner to ensure public safety. The risk to public safety is considered to be very low due to the few likely occurrences of these conditions along with the particular circumstances that can cause ice throw.

Seismic Activity

17.4.15 No geological fault lines are present on or in the immediate vicinity of the site, and there are no records of any earthquakes occurring in the vicinity of the site within the last 15 years (Earthquake Track[3]). Earthquakes in Scotland are typically no greater than 3 on the Richter Scale and, therefore, minor and unlikely to cause significant damage to buildings and infrastructure.

17.4.16 It is very unlikely that an earthquake would occur on the vicinity of the site resulting in any damage to the Proposed Development. Should a wind turbine be damaged, the risk to public safety is considered to be negligible due to the remote location and careful design layout of the infrastructure.

17.5 Population and Human Health

17.5.1 Chapters 7, 10, 12, 13 and 14 contain assessments which relate to the health and wellbeing of the local population. These chapters assess the effects of the Proposed Development, both beneficial and adverse, provide an analysis of the significance of these effects and also put forward measures to mitigate against adverse effects on people and their health.

17.5.2 Chapter 18 provides an overview of the mitigation put forward as part of these assessments in order to reduce any adverse effects of the Proposed Development to an acceptable level.

17.5.3 Further to the topics covered in Chapters 7 to 17, including this chapter, it is not expected that tthe Proposed Development would have significant effects on population and human health.

17.6 Eskdalemuir Seismic Array

17.6.1 The Proposed Development is located within the statutory consultation zone of the seismological recording station at Eskdalemuir, an asset that contributes to the Nuclear Test Ban Treaty. Wind turbines can interfere with seismic monitoring and according to the Ministry of Defence's (MOD) response to the Oliver Forest EIA Scoping Report "*in order to ensure the United Kingdom can continue to implement its obligations in maintaining the Comprehensive Nuclear Test Ban Treaty, a noise budget, based on the findings of research for the 50km radius surrounding the array, is managed by the MOD.*"

17.6.2 The Eskdalemuir Working Group which includes the Scottish Government, the MOD, Scottish Renewables and a number of developers are working together to agree a solution through which the "re-calculated noise budget" is fairly allocated to wind farms in planning and future developments.

17.6.3 The Applicant is supportive of the Eskdalemuir Working Group and will abide by the allocation process and required mitigation once fully agreed.

17.7 Air Quality

17.7.1 Construction activities can result in temporary effects from dust if un-managed. This can result in nuisance effects such as soiling of buildings and, if present over a long period of time, can affect human health. As the nearest property is over 500 m away from any substantial construction works (substation compound), effects associated with dust or vehicle emissions are considered to be unlikely, therefore the effects of dust and vehicle emissions from the construction, operation and decommissioning of the Proposed Development was scoped out of this assessment.

17.7.2 A Dust Management Plan is included within the outline CEMP which sets out mitigation measures to be implemented on-site including for site activities and the movement of construction traffic along with regular monitoring activities to ensure that dust as a result of construction of the Proposed Development is adequately controlled.

17.8 Television and Telecommunications

Introduction

17.8.1 This section of the chapter summarises the potential television and telecommunications effects associated with the Proposed Development.

[3] https://earthquaketrack.com/gb-sct-biggar/recent

Guidance

17.8.2 Tall structures such as wind turbines may cause interference of nearby television signal or telecommunications links. As such, any links in the vicinity of the Proposed Development must be identified and operators must be consulted.

17.8.3 The Ofcom Spectrum Information Portal was used in the first instance to identify fixed telecommunications crossing or adjacent to the site.

17.8.4 A number of other telecommunications services in addition to fixed links may be present, however most of these services are generally only affected if wind turbines are located in the immediate vicinity. Furthermore, where other services are present, there is usually a supporting fixed link to allow onward signal transmission, which would be identified in this assessment. It is therefore considered that the search for fixed microwave links, and discussion with identified operators, also covers all other services.

Scope of Assessment

Effects Scoped Out

17.8.5 Effects on television and radio signal have been scoped out of detailed assessment for the following reasons:

- Operational effects on television: digital television is less likely to be affected by the atmospheric conditions that rendered analogue television unwatchable and does not suffer from reflection effects or ghosted image generation.
- Operational effects on radio broadcasting signals: radio broadcasting will not be affected by the Proposed Development once operational as the length of radio broadcast signal wavelengths are such that interference from wind turbines is unlikely andany interference to the radio signal is unlikely to noticeably affect the audio signal.

Microwave Fixed Links and Scanning Telemetry

17.8.6 Fixed links are direct line-of-sight communication links between transmitting and receiving dishes placed on masts generally located on hilltops that vary in length from a few kilometres to over 70 km. They are used for the transmission of information to broadcasting masts for television and radio and for the mobile telephone networks and other use-cases.

17.8.7 Vodafone were identified as having a fixed link in the area on the Ofcom Spectrum Information Portal which was used in the first instance to identify fixed telecommunications links crossing or adjacent to the site.

17.8.8 A range of other major operators, including scanning telemetry operators, were still contacted as a matter of best practice.

17.8.9 Telecommunications and broadcasting network operators were consulted during the scoping exercise. Table 17.5 summarises the responses from link operators contacted.

Table 17.5 – Link Operators Responses

Link Operator	Response/Issue Raised	Actions
Airwave	No response received	Ofcom Spectrum Information Portal confirms that there are no Airwave links in the vicinity of the site.
Arqiva	Confirmed no impact on Arqiva network on 14/12/22	No actions required
Atkins	No concerns raised	No actions required
BT	Confirmed no impact on BT network on 15/12/22 and 20/12/22 (Scoping Response)	No actions required
JRC	Confirmed no impact on JRC network on 08/12/22 (Scoping Response)	No actions required
MBNL	No response received	Ofcom Spectrum Information Portal confirms that there are no MBNL links in the vicinity of the site.
Vodafone	Confirmed no impact on Vodafone network on 06/01/23, and reconfirmed on 26/01/24	No actions required

17.8.10 With the information available to the Applicant, the Proposed Development does not directly affect fixed or scanning telemetry links.

17.8.11 The Proposed Development does not directly affect fixed or scanning telemetry links.

17.8.12 No significant effects are anticipated on television and communication links, therefore no mitigation is required.

17.9 Conclusion

17.9.1 This chapter has assessed the potential impacts of the Proposed Development on a number of other consideration topics.

17.9.2 A shadow flicker assessment has been conducted which concluded that the annual hours of shadow flicker anticipated at all properties, with the exception of Hopehead, are under the significance threshold of 30 hours. Significant shadow flicker effects are predicted to occur as a result of the Proposed Development, based on a likely-case scenario, at a single property, Hopehead, which is not permanently inhabited and is infrequently used by groups of people as a temporary overnight stay.

17.9.3 Although shadow flicker levels are likely to fall to below the 30-hour per annum significance threshold based on the average sunshine hours expected at the site (with the exception of Hopehead), the Applicant is nonetheless committed to promptly investigating any complaints of shadow flicker and taking appropriate action as required. The Applicant proposes that prior to the operation of the first turbine, a Wind Farm Shadow Flicker Protocol will be developed which will set out the protocol to be followed should a shadow flicker complaint be received from a receptor within the study area.

17.9.4 A carbon assessment for the Proposed Development has also been undertaken. The calculations of total carbon dioxide emission savings and payback time for the Proposed Development indicates the overall payback period of a development with seven wind turbines with an average (expected) installed capacity of around 7.2 MW each would be approximately 1.4 years (17 months), when compared to the fossil fuel mix of electricity generation.

17.9.5 This means that the Proposed Development is expected to take around 17 months to repay the carbon exchange to the atmosphere (the CO_2 debt) through construction of the wind turbines; the Proposed Development would in effect be in a net gain situation following this time period and would contribute to national CO_2 reduction targets.

17.9.6 Assessment of the effects of the Proposed Development on television and telecommunications effects concludes no significant effects as a result of the Proposed Development.

17.10 References

Department of Energy and Climate Change. (2011). *Update of UK Shadow Flicker Evidence Base.* Available at https://www.gov.uk/government/news/update-of-uk-shadow-flicker-evidence-base Accessed on: 19 March 2024.

Northern Ireland Department of the Environment. (2009). *Best Practice Guidance to Planning Policy Statement 18 (PPS 18) Renewable Energy*. Available at: https://www.infrastructure-ni.gov.uk/publications/best-practice-guidance-pps-18-renewable-energy Accessed on: 19 March 2024.

Ofcom. (2024). *Spectrum Information Portal*. Available at: https://www.ofcom.org.uk/spectrum/frequencies/spectrum-information-portal/ Accessed on: 12 June 2024.

Scottish Borders Council. (2018). *Supplementary Guidance, Renewable Energy*. Available at https://www.scotborders.gov.uk/plans-guidance/renewable-energy-supplementary-guidance Accessed on: 19 March 2024.

Scottish Government. (2022). *Onshore Wind Policy Statement*. Available at https://www.gov.scot/publications/onshore-wind-policy-statement-2022/ Accessed on: 19 March 2024.