Chapter 12: Other Issues

Chapter 12
Other Issues

Introduction

12.1 This chapter presents the findings of the assessment of likely effects of the Proposed Development on the following topics:

- Climate Change Mitigation (including carbon balance) and Adaptation;
- Shadow Flicker; and
- Population and Human Health.

12.2 These assessments have been undertaken by LUC, supported by East Point Geo (Carbon Balance). Further details on expertise are provided in **Appendix 1.2: Statement of Competence**.

12.3 The assessment of effects is based on the proposed layout as outlined in **Chapter 3: Development Description** and **Figure 3.1**. Unless otherwise stated, potential effects identified are considered to be negative.

12.4 A number of additional potential effects have been scoped out of the assessment: socio-economics and major accidents and disasters, as explained in **Chapter 1: Introduction**.

12.5 The following figure and appendices are also referred to in this chapter:

- **Figure 12.1: Shadow Flicker; and**
- **Appendix 12.1: Carbon Balance Assessment**.

Climate change mitigation and adaptation

Introduction

12.6 This assessment considers the potential effects of the Proposed Development on climate change mitigation (including carbon balance) and adaptation and has been undertaken in accordance with the latest good practice guidance.

12.7 The impacts of climate change are widely recognised as being one of the greatest global economic, environmental and social challenges facing the world today. Consequently, climate change is also seen to be an important consideration in relation to project level assessment and decision-making. A major cause of climate change is a rise in the concentration and volume of Greenhouse Gases (GHGs) in the atmosphere, a significant contributor to which is the use of fossil fuels to generate electricity. The purpose of the Proposed Development is to generate electricity from a renewable source of energy, offsetting the need for electrical generation from the combustion of fossil fuels. Consequently, the electricity that will be generated and distributed by the Proposed Development will result in a saving in emissions of Carbon Dioxide (CO_2) with associated environmental benefit. The climate change assessment therefore draws largely on this premise. However, no form of electricity generation is completely carbon free; there will be emissions resulting from the manufacture of components, as well as emissions from both construction and decommissioning activities and transport.

12.8 This assessment is informed by **Appendix 12.1**. This provides an estimate of the benefit of displacing conventionally generated electricity in the grid compared to the predicted direct and indirect emissions of carbon resulting from the construction and operation of the Proposed Development over its 35-year lifetime, including losses of stored carbon from affected peatland. The carbon calculator provides an estimate of the carbon payback time for the Proposed Development over its lifetime.

Scope of the Assessment

Effects Assessed in Full

12.9 The following effects have been considered in this assessment:

- Direct Carbon Dioxide (CO_2) and Nitrogen Oxide (NO_X) emissions during construction;
- Other carbon emissions in the materials and systems which form temporary and permanent structures, arising as a result of the extraction and manufacture of materials, fabrication, transportation to Site, waste and the future demolition and potential re-use;
- The positive contribution that the Proposed Development will make to offsetting CO_2 emissions arising from construction and decommissioning (including peat) once operational (climate mitigation); and
- The ability of receptors, such as species and habitats, to adapt to climate change (climate adaptation) during operation of the Proposed Development, and whether the effects of the Proposed Development on those receptors assessed under the current climate baseline will change with a future climate, i.e. 'in-combination climate effects'.

Effects Scoped Out

12.10 On the basis of the desk-based work undertaken, the professional judgement of the Environmental Impact Assessment (EIA) team, experience from other relevant projects and policy guidance or standards, the following topic areas have been 'scoped out' of detailed assessment:

- Direct CO_2 and NO_X emissions from vehicles during operation as movements associated with turbine maintenance are considered to be minimal;
- The ability of receptors to adapt to climate change during construction of the Proposed Development as these effects are assessed long term, i.e. over the 35-year operational period;
- The ability of receptors to adapt to climate change during operation of the Proposed Development in-combination with other nearby wind farms as this is largely a project specific consideration, namely the resilience of the project in question to climate change and the extent to which projected climate change could alter the predicted effect judgements;
- Project resilience (or vulnerability) to climate change. The latest Institute of Environmental Management and Assessment (IEMA) guidance[1] states that *"The resilience of something is a measure of its ability to respond to changes it experiences. If a receptor or a project has good climate change resilience, it is able to respond to the changes in climate in a way that ensures it retains much of its original function and form. A receptor or project that has poor climate change resilience will lose much of its original function or form as the climate changes"* (page 49). The Proposed Development is designed to cope with changes in temperature and rainfall. Turbines will shut down if winds are too strong or if overheating occurs, and appropriate infrastructure design including maintaining up to a 50 metres (m) buffer around watercourses where possible[2] and the incorporation of standard good practice measures for site drainage (including Sustainable Drainage System (SuDS) principles and designing all watercourse crossings and infrastructure to withstand a 1:200 year flood event where appropriate[3]) will be achieved; and
- Indirect emissions arising from the demand for energy produced using fossil fuels (e.g., electricity for heating, cooling and lighting).

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[1] IEMA (2020) The Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation
[2] Locations where a 50m buffer cannot be achieved are described in the assessment and **Appendix 7.1**.
[3] Consultation with the flood risk and drainage office at ABC concluded that sizing crossings to pass the 1 in 200 year flow plus climate change allowance could potentially lead to large culverts/crossings, which are not necessarily applicable for peatland watercourses in rural upland areas and could potentially cause damage to morphology of channels and peatlands (e.g. due to increased scour by oversized culverts). In addition, flood risk in the rural upland area is not an issue, so crossings designed for smaller return period flows may be more applicable in this environment.

Assessment Methodology

Legislation and Guidance

Legislation and Policy

12.11 The climate change assessment has been undertaken in the context of the current key climate change legislation and policy and the targets and aspirations set out within these, including:

- The Climate Change (Scotland) Act 2009[4] as amended by The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019[5];
- Update to the Climate Change Plan 2018-2032: Securing a Green Recovery on a Path to Net Zero 2020[6];
- Onshore Wind Policy Statement 2022[7];
- National Planning Framework 4[8];
- Scotland's Energy Strategy Position Statement 2021[9]; and
- Draft Energy Strategy and Just Transition Plan 2023[10].

12.12 Further details of these key legislation and policy documents are set out in the Planning and Energy Policy Statement which accompanies the application.

Guidance

12.13 This assessment is carried out in accordance with the principles contained within the following documents:

- IEMA (2022) Assessing Greenhouse Gas Emissions and Evaluating their Significance (2nd Edition)[11];
- IEMA (2020) The Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation[1];
- SNH[12] (2016) Technical Guidance Note on Calculating Carbon Losses and Savings on Scottish Peatlands – Version 2.10.0[13]; and
- Scottish Renewables and Scottish Environment Protection Agency (SEPA) (2012) Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and the Minimisation of Waste[14].

Consultation

12.14 Table 12.1 below provides details of consultation that has been used to inform the assessment related to Climate Change Mitigation and Adaptation within this chapter.

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[4] UK Government (2009) Climate Change (Scotland) Act 2009 [online]. Available at: https://www.legislation.gov.uk/asp/2009/12/contents
[5] UK Government (2019) Climate Change (Emissions Reduction Targets) (Scotland) Act 2019. Available at: https://www.legislation.gov.uk/asp/2019/15/enacted
[6] Scottish Government (2020) Securing a green recovery on a path to net zero: climate change plan 2018-2032 – update [online]. Available at: https://www.gov.scot/publications/securing-green-recovery-path-net-zero-update-climate-change-plan-20182032/documents/
[7] Scottish Government (2020) Onshore wind: policy statement 2022 [online]. Available at: https://www.gov.scot/publications/onshore-wind-policy-statement-2022/
[8] Scottish Government (2023) National Planning Framework 4. Available [online] at: https://www.gov.scot/publications/national-planning-framework-4/
[9] Scottish Government (2021) Energy strategy: position statement [online]. Available at: https://www.gov.scot/publications/scotlands-energy-strategy-position-statement/
[10] Scottish Government (2023) Draft Energy Strategy and Just Transition Plan [online]. Available at: https://www.gov.scot/publications/draft-energy-strategy-transition-plan/
[11] IEMA (2022) Assessing Greenhouse Gas Emissions and Evaluating their Significance (2nd Edition)
[12] Scottish Natural Heritage is now called NatureScot as of 24th August 2020.
[13] Scottish Natural Heritage (2016) Calculating Potential Carbon Losses and Savings from Wind Farms on Scottish Peatlands (Version 2.10.0)
[14] Scottish Renewables and SEPA (2012) Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and the Minimisation of Waste

Table 12.1: Consultation responses

Consultee and Date	Scoping/Other Consultation	Issue Raised	Response/Action Taken
East Lothian Council 8/4/2022	Scoping	Windfarms may have effect on microclimate, as they can change the speed of the wind, turbulence and mixing, as well as evapotranspiration. This in turn could affect plant growth, carbon cycling and soil. The EIAR should consider the potential for microclimatic effects and any significant effects consequent on that.	There is currently no evidence to justify inclusion of an assessment of effects on micro-climate within the EIA and no guidance available to inform an assessment of the effects associated with changes to microclimate at operational wind farms. The Site, similar to much of the Lammermuir Hills is managed for grouse shooting which directly influences the flora and fauna present within the Site and this land management will likely outweigh the effect of potential alterations to wind characteristics at ground level on plant assemblages. An OREP (**Appendix 6.6: Outline Restoration and Enhancement Plan**) has been proposed that will aim to introduce more diversity and connectivity to the habitats present within the Site through moorland re-wetting, replacing muirburn with cutting and substantial riparian tree planting.
		The Council agrees that future baseline effects cannot be entirely predicted, however reasonable assumptions can be made, and an assessment of likely effects made. It is not considered appropriate to scope out decommissioning. While the proposal is not in East Lothian and the direct impacts of decommissioning are unlikely to impact East Lothian, there may be indirect impacts from noise, climate emissions and landscape impacts if decommissioning is not achieved. Sufficient information should be given to show that the project is capable of being decommissioned and what the main impacts are.	As noted above, the assessment of effects on climate change considers the positive contribution that the Proposed Development will make to offsetting CO2 emissions arising from construction and decommissioning once operational. Further details on decommissioning are provided in **Chapter 3** and assessed within this chapter.
		The Council supports the Applicants proposal to carry out a carbon balance assessment for the proposal using Scottish Government guidance.	Noted. The carbon balance assessment is provided as **Appendix 12.1**
		The potential of the land for carbon sequestration through restoration of peatland (as well as what is there just now) should also be considered, as the benefits of this can be considerable. Peatland Condition Assessment should be prepared in line with NatureScot	A peatland condition assessment has been carried out and is detailed in **Appendix 6.8: Peatland Condition Assessment**

Consultee and Date	Scoping/Other Consultation	Issue Raised	Response/Action Taken
		guidance to evaluate the condition of peat as a precursor to restoration.	
		The EIA Report should consider the project in relation to the Scottish Government updated climate change plan Securing a Green Recovery on a Path to Net Zero: Climate Change Plan 2018–2032 Update, which aims to increase renewable energy generation as well as restore 250,000 hectares of degraded peat by 2030. Impacts on circular economy aspirations should also be considered, including through consideration of decommissioning and how it will contribute.	This has been considered in the Planning and Energy Policy Statement which accompanies the application.

Study Area

12.15 The assessment considers the effects of the Proposed Development on the global climate, with specific reference to the climate changes expected in the UK. These have been defined using the UK's climate change projections (UKCP18), which allow climate changes to be projected at the regional level; in this case, the East of Scotland. The effects of a changing climate on the Proposed Development have largely been assessed in relation to the Site and its immediate surroundings.

12.16 The study area for calculating stored soil carbon in **Appendix 12.1** has been the Site under existing conditions. For the carbon payback assessment, since greenhouse gas emissions and savings are both ultimately a global 'pool', this assessment is not restricted solely to those emissions or savings that occur within the Site. Land-based emissions from peat and habitat losses are based on the Proposed Development footprint, but other activities, for example, emissions resulting from the extraction and production of steel for turbines, are still attributable to the Proposed Development even though they are likely to occur in other parts of the world.

Desk Based Research and Data Sources

12.17 The following data sources have informed the assessment:

- UK Climate Projections (UKCP18)[15];
- Department for Business, Energy and Industrial Strategy (BEIS): National Statistics publication Energy Trends. Table 6.1. Renewable Electricity Capacity and Generation[16];
- Scottish Government Carbon Calculator Tool[17]; and
- RenewableUK Wind Energy Statistics[18].

Field Survey

12.18 The assessment has been desk based, drawing largely from published guidance and data. Peat depth probing was undertaken to inform the layout of the Proposed Development, and this data was also used to inform the carbon balance assessment (see **Appendix 8.2: Peat Survey Report**).

[15] Met Office (2018) UK Climate Projections (UKCP18) [online]. Available at: http://ukclimateprojections.metoffice.gov.uk/
[16] Department for Business, Energy and Industrial Strategy (2021) Energy Trends (Table 6.1. Renewable electricity capacity and generation)
[17] Smith et al. (2011) Carbon Implications of Windfarms Located on Peatlands – Update of the Scottish Government Carbon Calculator Tool (Version 2) (as updated)
[18] Renewable UK (undated) Wind Energy Statistics [online]. Available at: https://www.renewableuk.com/page/UKWEDhome

Assessing Significance

Climate Change Mitigation

12.19 All emissions contribute to climate change. However, specifically in the EIA context, the IEMA guidance provides relative significance descriptions to assist with assessments. A number of distinct levels of significance have been defined, which are not solely based on whether a project emits GHG emissions alone, but how the project makes a relative contribution towards achieving a science-based 1.5°C aligned transition towards net zero.

12.20 The UK has set a legally binding GHG emission reduction target for 2050 (2045 in Scotland) with interim five-yearly carbon budgets which define a trajectory towards net zero. The IEMA guidance states (in Section 6) *"The 2050 target (and interim budgets set to date) are… compatible with the required magnitude and rate of GHG emissions reductions required in the UK to meet the goals of the Paris Agreement, thereby limiting severe adverse effects… To meet the 2050 target and interim budgets, action is required to reduce GHG emissions from all sectors, including projects in the built and natural environment. EIA for any proposed project must therefore give proportionate consideration to whether and how that project will contribute or jeopardise the achievement of these targets"* (page 23).

12.21 Furthermore, the guidance also states the following *"The crux of significance therefore is not whether a project emits GHG emissions, nor even the magnitude of GHG emissions alone, but whether it contributes to reducing GHG emissions relative to a comparable baseline consistent with a trajectory towards net zero by 2050"* (page 24).

12.22 For the purposes of this assessment, this guidance has been interpreted as outlined in **Table 12.2** and has been used to determine significance of effects.

Table 12.2: Significance criteria

Significance of Effect	Description Based on IEMA Guidance[11]
Adverse (Major or Moderate)	A project that follows a 'business-as-usual' or 'do minimum' approach and is not compatible with the UK's net zero trajectory or accepted aligned practice or area-based transition targets, results in a significant adverse effect. It is down to the practitioner to differentiate between the 'level' of significant adverse effects e.g., 'moderate' or 'major' adverse effects. For example, a major adverse effect may indicate that a project does not comply with existing local and national policy for the project in question, whilst a moderate adverse effect may indicate that that the project partially meets applicable existing and emerging policy requirements. .
Adverse (Minor)	A project that is compatible with the budgeted, science-based 1.5°C trajectory (in terms of rate of emissions reduction) and which complies with up-to-date policy and 'good practice' reduction measures to achieve that has a minor adverse effect that is not significant. It may have residual emissions but is doing enough to align with and contribute to the relevant transition scenario, keeping the UK on track towards net zero by 2050 with at least a 78% reduction by 2035 and thereby potentially avoiding significant adverse effects.
Negligible – Minor Positive	A project that achieves emissions mitigation that goes substantially beyond the reduction trajectory, or substantially beyond existing and emerging policy compatible with that trajectory, and has minimal residual emissions, is assessed as having a negligible or minor effect that is not significant. This project is playing a part in achieving the rate of transition required by nationally set policy commitments.
Positive (Significance)	A project that causes GHG emissions to be avoided or removed from the atmosphere has a beneficial effect that is significant. Only projects that actively reverse (rather than only reduce) the risk of severe climate change can be judged as having a significant beneficial effect.

Climate Change Adaptation

12.23 The purpose of the 'in-combination climate assessment' is to determine whether the significance of effects of the Proposed Development on a given receptor (under the existing climate baseline) are likely to be changed by future climatic conditions and whether the Proposed Development is likely to affect a receptor's ability to adapt. Significance of effects are determined through the following steps:

- Receptors identified and assessed in the topic chapters of the EIA Report under the current climate baseline are evaluated to determine whether the susceptibility and vulnerability as well as their value/importance will change with the future climatic conditions defined. A high value receptor that has very little resilience to changes in climatic conditions should be considered more likely to be significantly affected than a high value receptor that is very resilient to changes in climatic conditions.
- The magnitude of the effects on the receptors under the existing climate baseline is evaluated to determine whether the probability and/or consequence of the effect changes with the future climatic conditions.

12.24 Building on the evaluation of sensitivity and magnitude of the effect, an assessment is undertaken to identify whether the additional effects of future climate impacts alter the sensitivity and/or magnitude of the effect so that the level of significance of the effects within other topics identified against baseline conditions changes. The assessment uses the significance criteria used by other topics assessed in the EIA Report i.e., if a Minor (adverse) effect on direct habitat loss is not likely to change under a future climatic scenario, then the in-combination effect (effect of the Proposed Development with future climate change) remains as Minor (adverse).

Assessment Assumptions and Limitations

Assumptions

12.25 In considering future climate change scenarios, IEMA guidance[1] recommends the use of the UK Climate Projections UKCP18 website[15]. 'Probabilistic' projections are provided for a range of variables including temperature, precipitation and sea level rise. Wind speed and storm frequency/intensity are considered separately as global modelling information is currently more limited.

12.26 The UKCP18 projections, first released in November 2018 and updated in August 2022, are now the most up to date climate change projections available. The climate projections website states that UKCP18 provides a valid assessment of the UK's future climate over land, but that when considering decisions that are sensitive to projected future changes in summer rainfall, additional information should also be used.

12.27 The UKCP18 projections for temperature and precipitation are presented for the UK as a whole and also on a regional basis. The UK projections consider three variables:

- Timeframe: The projections are presented for four overlapping time periods (2020s, 2040s, 2060s and 2080s).
- Probability: The projections are provided as probability distributions rather than single values, with figures provided for 5, 10, 50, 90 and 95% probability.
- Representative Concentration Pathways (RCP): Four pathways have been adopted; RCP2.6, RCP4.5, RCP6.0 and RCP8.5. These pathways describe different greenhouse gas (GHG) and air pollutant emissions as well as their atmospheric concentrations and land use with each one resulting in a different range of global mean temperature increases over the 21st Century. RCP2.6 represents a scenario which aims to keep global warming likely below 2°C compared to pre-industrial temperatures. RCP4.5 and RCP6.0 represent intermediate scenarios while RCP8.5 is the highest impact emission scenario. All scenarios are considered to be equally plausible.

12.28 Table 12.3 below explains the assumptions made in applying the UKCP18 projections to the assessment of the Proposed Development. The IEMA guidance[1] states *"Recommended best practice is to use the higher emissions scenario (RCP 8.5 in the latest UKCP18 projections) at the 50th percentile, for the 2080s timelines, unless a substantiated case can be made for not doing this (e.g. anticipated lifespan of the project is shorter than 2080s)"* (page 44).

Table 12.3: Climate change assessment assumptions

Variable	Assumptions	Rationale
Timeframe	2050-2069	This is considered a realistic timeframe given the design life of the Proposed Development (35 years of operation).
Probability	50th percentile used to establish what is projected as the central estimate with consideration given to lowest (5th) and highest (95th) percentiles to determine the lowest and highest projections that could happen within the timeframe.	By providing a range of results rather than single best estimate values, a clearer picture can be provided regarding the level of confidence in different outcomes.
RCP	RCP 8.5	RCP 8.5 is selected as recommended in the IEMA guidance[Error! Bookmark not defined.] and allows for a worst-case scenario future climate to be defined resulting in a conservative assessment.

12.29 All key assumptions made with input data for the carbon calculator are set out in **Appendix 12.1**.

Limitations

12.30 The key limitations to the assessment of effects in this chapter are as follows:

- Estimated carbon losses in the calculator are conservative, and it is assumed that all the carbon in excavated peat is lost, although it will all be used for restoration onsite as set out in **Appendix 8.3: Peat Management Plan**;
- The carbon calculator does not account for carbon emissions and direct CO_2 and NO_X emissions from Heavy Goods Vehicles (HGV) transporting components, materials and their production (including stone, concrete, solar panels and batteries) and staff to Site during construction, but rather only emissions associated with turbine life and emissions associated with their production, and so a qualitative approach has been used in regards to transport emissions in the assessment. This effect can therefore only be assessed qualitatively in the absence of a whole life cycle carbon assessment.
- The carbon calculator does not account for emissions associated with the working of machinery onsite such as excavators, and generators; and
- It is beyond the scope of this assessment to quantitively assess the cumulative offsetting effects of other schemes, and so any other positive effects identified are qualitative and based on professional judgement.

Existing Conditions

Current Climate

12.31 The current baseline is that of the current climate. Between the years of 1981 and 2020 at the Kew Gardens climate station, the average maximum summer temperature was 18.72ºC and the average minimum summer temperature was 9.79ºC. For the same location and over the same time period, the average maximum winter temperature was 6.49ºC and the average minimum winter temperature was 0.95ºC.

12.32 The average rainfall during the same time period and same location noted above was 68.95mm and 58.94mm for summer and winter respectively. An average wind speed of 8.57 knots has been recorded at this climate station.

Extreme Weather Events

12.33 A heatwave and extreme drought conditions became established over most of the UK during the late winter and early spring of 2002/2003. The spring period saw a record-breaking lack of rainfall and gave way to a long, warm summer in 2003[19].

[19] Marsh (2004) The Drought of 2003: A Hydrological Review. Available at: https://historicdroughts.ceh.ac.uk/content/hot-summer-2003

In July 2022, the UK also experienced an intense heatwave. On the 19th of July, temperatures in southern England widely reached 40.2 degrees. The all-time temperature record for Scotland was set at the Borders, with the Charterhall climate station recording 34.8˚C, surpassing the previous record of 32.9˚C recorded in 2003.

12.34 In 2010/2012, most of the UK experienced exceptional departures from normal rainfall, runoff and aquifer recharge patterns. Generalising broadly, drought conditions developed through 2010, intensified during 2011 and were severe across much of England and Wales by the early spring of 2012. Record late spring and summer rainfall then triggered a hydrological transformation, with seasonally extreme river flows common through the summer and extensive flooding during the autumn and early winter[20].

12.35 In November 2021, the UK experienced one of the most powerful and damaging winter storms of the last decade in the form of Storm Arwen. The storm, tracking south to the north-east of the UK, brought northerly winds gusting widely over 69mph[21].

Future Baseline in the Absence of the Proposed Development

12.36 The UKCP18 projections show a general trend towards warmer, wetter winters and drier, hotter summers. However, it should be noted that both temperature and rainfall patterns across the UK are not consistent and will vary dependent on seasonal and regional scales and will continue to vary in the future.

12.37 Table 12.4 below outlines the projected changes in temperature, precipitation and wind speed and storms by 2050-2069, assuming a 50th percentile probability.

Table 12.4: Projected climate change

Climate Variable	Projected Change
Temperature	Temperatures across East Scotland are projected to increase, with projected increases in summer temperatures greatest. The central estimate of increase in winter mean temperature is 1.6ºC; it is very unlikely to be less than -0.1ºC and also unlikely to be greater than 3.4ºC. The central estimate of increase in summer mean temperature is 2.1ºC; it is unlikely to drop below 0.2ºC and more than 4.1ºC.
Probability	Winter rainfall is projected to increase, and summer rainfall is most likely to decrease. The central estimate of change in winter mean precipitation is 12%; it is very unlikely to be less than -7% and is very unlikely to be more than 35%. The central estimate of change in summer mean precipitation is -14%; it is very unlikely to be less than -35% and is very unlikely to be more than 8%.
Wind Speed and Storms	Changes in wind speeds are not currently available at the regional level and there remains considerable uncertainty in the projections with respect to wind speed. However, there are small changes in projected wind speed, for example, across the UK, near surface wind speeds are expected to increase in the second half of the 21st century with winter months experiencing more significant impacts of winds[22]. This is accompanied by an increase in frequency of winter storms over the UK. However, the increase in wind speeds is projected to be modest.

12.38 With respect to climate change adaptation, all specialist topic area authors were provided with a summary of the climate change projections above and were asked to consider the relevance of this for their baseline descriptions to determine those receptors which are susceptible to a changing climate.

[20] Marsh et al. The 2010-12 Drought and Subsequent Extensive Flooding: A Remarkable Hydrological Transformation. Available at: https://historicdroughts.ceh.ac.uk/content/drought-flood-2010-2012
[21] Metoffice.gov.uk. (2022) [online] Available at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/weather/learn-about/uk-past-events/interesting/2021/2021_07_storm_arwen.pdf
[22] Met Office (2019) UKCP18 Factsheet: Wind. Available [online] at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-fact-sheet-wind_march21.pdf

12.39 For the following topics, it is not considered that baseline conditions, and therefore the susceptibility and vulnerability of receptors as well as their value/importance will change with the future climatic conditions defined, such that in-combination climate change adaptation effects are unlikely, and these topics are not considered further in the assessment:

- **Chapter 9: Noise and Vibration** – The consequences of the projected climate change scenario are unlikely to substantially affect baseline noise conditions for the purpose of the assessment in this EIA Report, given that periods of rainfall are excluded and the variation with wind speed was taken into account, in line with requirements of ETSU-R-97 and current good practice.
- **Chapter 10: Access, Traffic and Transport** – It is considered that climate change projections will not have a discernible impact on the baseline conditions for road traffic within the timescales of the Proposed Development. It is assumed that, at a regional level, appropriate measures will be put in place to ensure flood risk is managed and does not have long term effects on transport infrastructure.
- **Chapter 11: Aviation** - It is considered that climate change projections will not have a discernible impact on the baseline aviation receptors considered and their operation. It is assumed that appropriate measures will be put in place to ensure that aviation radar installations will be able to withstand and adapt to changes in climate given the importance of maintaining civil and military air safety and defence.

12.40 The following assessments provided more detailed consideration on baseline conditions that will be influenced by projected climate change:

- **Chapter 4: Landscape and Visual Impact Assessment**;
- **Chapter 5: Cultural Heritage**
- **Chapter 6: Ecology**;
- **Chapter 7: Ornithology**; and
- **Chapter 8: Hydrology, Hydrogeology, Geology and Peat**.

Design Considerations

12.41 The purpose of the Proposed Development is to generate electricity from a renewable source of energy, reducing the need for electricity generation from the combustion of fossil fuels. Consequently, the electricity that will be produced by the Proposed Development will result in a saving in emissions of CO_2 with associated environmental benefits. The overall design has sought to maximise the renewable energy production to ensure that it will remain a commercially viable project, whilst striking a balance with environmental sensitivities including landscape and visual effects.

12.42 The following modifications and design considerations have also been made during the iterative EIA process and relate to the issues considered in this assessment:

- Impacts upon deep peat (physical damage, excavation and transportation) have been minimised as far as possible;
- The use of up to three borrow pits for the extraction of stone from which it is anticipated that the majority of stone aggregate will be sourced for construction including stone for tracks (new and upgraded), hardstandings and the construction compounds. This is likely to reduce the theoretical volume of construction traffic calculated in **Chapter 10** and associated emissions, which has assumed that 50% of stone aggregate will be imported to the Site as a worst case scenario.
- Concrete batching is proposed to be undertaken onsite thereby reducing the peak traffic volumes associated with foundation pours and associated vehicle emissions; and
- Modern turbines are designed and constructed to withstand the forces likely to be exerted on them, often in remote environments which are regularly subject to high wind speeds. Adherence to relevant design and safety standards ensures that there is extremely limited risk of structural failure of turbines or foundations from wind or high temperatures.

Micrositing

12.43 A general micro siting allowance of 100 m is being sought for the Proposed Development to allow a degree of flexibility in the layout of site components during construction should unfavourable ground conditions be encountered. It is anticipated that any turbine micrositing of more than 50 m would require agreement with the Ecological Clerk of Works (ECoW) and written approval of the Scottish Borders Council (SBC) planning officer. The magnitude and resulting significance of effects identified in this chapter will not be affected by this allowance.

Assessment of Effects

12.44 The assessment of effects is based on the project description as outlined in **Chapter 3**. Unless otherwise stated, potential effects identified are considered to be negative.

Potential Construction Effects

Carbon Emissions Including Direct CO_2 and NO_X Emissions from HGV Vehicles

12.45 Carbon dioxide emissions during the life of a wind turbine include those that occur during production, transportation, erection, concrete production, operation, dismantling and removal of turbines and foundations.

12.46 As stated in **Chapter 10**, the highest levels of vehicle movements associated with the Proposed Development will occur during construction, with the peak construction estimated in month 11 with a total of 110 daily journeys (42 car/light vehicles and 68 HGV journeys). It is considered that the opportunity to use onsite borrow pits for the majority of stone requirements is likely to significantly reduce HGV traffic movements and the associated emissions. In addition, concrete batching will be undertaken onsite which will reduce concrete delivery requirements.

12.47 Overall, the Proposed Development will be a net generator of GHG emissions during construction. Based on qualitative consideration of the likely scale of emissions, and in accordance with the assessment methodology, a Minor (negative) effect is predicted which will be Not Significant under the Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017 - the EIA Regulations.

Proposed Mitigation

12.48 No specific mitigation measures are proposed in relation to climate change, although a Construction Traffic Management Plan (CTMP), as referenced in **Chapter 10**, will be implemented as good practice, with the intention that measures will be implemented to ensure traffic movements are undertaken efficiently during construction, and unnecessary journeys avoided.

Residual Construction Effects

12.49 All residual effects are considered to be Not Significant following the implementation of the mitigation measures identified above.

Potential Operational Effects

Carbon Losses and Savings

12.50 As outlined in **Chapter 1**, the purpose of the Proposed Development is to generate electricity from a renewable source of energy, avoiding the need for power generation from the combustion of fossil fuels and to add capacity to the electrical generating potential to facilitate a decarbonisation of heat and transport networks. Consequently, the electricity that will be produced by the Proposed Development will result in an overall saving in emissions of CO_2 during its operational life. At this stage based on the candidate turbine, the wind farm will have a maximum installed capacity of up to 108 megawatts (MW). It is estimated that the number of households that can be potentially powered by the Proposed Development is 62,000 per annum[23].

[23] Load factors based on the five year rolling averages on unchanged configuration basis using Table 6.5 of 'Digest of UK Energy Statistics' - latest figures as per July 2022 release. Digest of UK Energy Statistics (DUKES): renewable sources of energy - GOV.UK (www.gov.uk).

12.51 One of the key aims of **Appendix 12.1** was to calculate the 'payback time' of CO_2 emissions for the Proposed Development. The payback time is defined as the length of time (in years) required for the Proposed Development to be considered a net avoider of emissions rather than a net emitter and is calculated by dividing the net emissions of carbon (total of carbon losses and gains) by the annual estimated carbon savings.

The expected carbon payback period, assuming that the Proposed Development will offset the emissions associated with a grid mix of electricity generation, is calculated to be in the region of 1.8 years (or approximately **22 months**).

12.52 Assuming a 35-year operational life and based on an overall expected annual carbon saving of around 50,000 tCO_2e and a total carbon loss (during both construction and operation) of just around 90,000 tCO_2e, this equates to a total saving of approximately 1.7 million tCO_2e[24] (50,000 x 35 minus the emissions emitted) over the Proposed Development's operational lifetime as well as over 5,700 tonnes of CO_2e gains estimated Site is estimated to produce significant gains over the lifetime of the windfarm through the re-wetting of degraded peat bog.

12.53 Whilst it has not been possible to calculate construction traffic emissions for HGVs and personnel, overall, it is considered that these will be offset at an early stage of the Proposed Development's operational life along with any backup generation if required, and that a **Positive (significant)** effect is likely on balance. The Proposed Development's carbon saving potential will contribute to meeting Scotland's net zero greenhouse gas emissions targets.

Adaptation

12.54 Taking account of receptors within the EIA topics identified above, under 'existing conditions', as potentially susceptible to a changing climate, this section gives further consideration as to whether or not the introduction of the Proposed Development is likely to affect judgements of effects and/or the ability of the receptors within or close to the Site to adapt to climate change. Topics considered are:

- Landscape and Visual Amenity;
- Cultural Heritage;
- Ecology;
- Ornithology; and
- Hydrology, Hydrogeology, Geology and Peat;

12.55 Chapter 4 – For East Scotland, the UK Climate Change Projections 2018 (UKCP18) projects that temperatures are projected to increase, particularly in summer, and winter rainfall is projected to increase whilst summer rainfall is most likely to decrease. The Landscape Institute's *"Landscape for 2030"*[25] acknowledges that changes in average temperatures, precipitation and extreme weather events will have an effect on the landscape. However, whilst a change in rainfall and rising temperatures are anticipated, it is unlikely that the susceptibility/vulnerability and value/importance of the receptors will materially change, neither will the magnitude of the predicted effects of the Proposed Development under the existing baseline, such that no significant in-combination climate effects are considered likely for Landscape and Visual Amenity.

12.56 Chapter 5 – Increased rainfall as a result of climate change will change groundwater and soil conditions, potentially affecting the preservation of buried archaeological remains and eroding / flooding above ground heritage assets. Evidence of historic land use of the moorland and hilltops within the Site comprises grazing and later sporting activities. This in-combination with the exposed and unproductive environment suggests there is a low potential for previously unrecorded heritage assets, including buried archaeological remains, within the Site above 350 m AOD. There is greater potential for previously unrecorded buried archaeological remains below this level, particularly adjacent to watercourses and along the lower slopes of the Dye Water and Watch Water. No significant effects resulting from direct physical effects on heritage assets during construction have been identified. Given these conclusions, it is not considered likely that an in-combination climate change effect will occur.

[24] The results of the Carbon Calculator for the Proposed Development show that the Proposed Development is estimated to produce annual carbon savings of approximately 40,000 tCO_2 per year, through the displacement of grid electricity, based on the current average grid mix.
[25] Landscape Institute (2021) Landscape for 2030 – How landscape practice can respond to the climate crisis [pdf]. Available at: https://landscapewpstorage01.blob.core.windows.net/www-landscapeinstitute-org/2021/04/12510-LANDSCAPE-2030_v6.pdf

12.57 Chapter 6 – The projected effects of climate change are likely to have a bearing on the future ecological status of the Site. The UK Climate Projections generally suggest hotter, drier summers and milder, wetter winters, with an increase in the number of heavy rain days and in the frequency of winter storms. These predicted changes in climate may result in changes to vegetation assemblages; however, it is unlikely that climate change will have a significant bearing on the structure and function of the upland habitats present within the Proposed Development and surrounding area. However, individual species may be adversely affected by the predicted changes in climate if conditions affect the survival rate of the animals at a critical life stage (such as at hibernation or during breeding). The distribution of species in the uplands may therefore be altered as a result of projected climate change. Although the exact nature of the effects are difficult to predict due to the complex nature of interactions between species and their resources, potential effects on ecology are not predicted to change markedly from the effects set out in **Chapter 6** as a consequence of climate change over the lifespan of the Proposed Development.

12.58 Chapter 7 – The projected climate change may result in changes in bird distribution and behaviour, including delayed breeding, and reduced or increased breeding success depending on the species range. However, on balance, there is no reason to consider that the bird assemblage using the Site will change substantially. Potential effects on ornithology receptors detailed in **Chapter 7** are therefore not predicted to substantively change as a consequence of climate change over the lifespan of the Proposed Development.

12.59 Chapter 8 – In April 2023, SEPA published new guidance[26] on climate change in Scotland which provides a regional based approach to estimate uplift in future river flows in Scotland. For large river catchments (over 50 km^2), the peak (200-year) design flow should be increased by 59% in the Tweed River Basin to account for projected climate change increases to the year 2100. In addition, the peak rainfall intensity allowance for the Tweed region of Scotland is 35% to the year 2100. Thus, this part of Scotland, which includes the Site, is likely to get wetter with higher peak flows in the watercourses in the future. Site drainage and watercourse crossing designs will consider future estimates of increased precipitation and flows and will follow an adaptive approach, as per relevant guidance documents from SEPA and SBC.

Proposed Mitigation

12.60 No additional mitigation measures are proposed to address in-combination effects of the Proposed Development in respect to climate change adaptation for the receptors assessed.

12.61 Whilst not specifically a measure to manage the effects of climate change, the Outline OREP includes proposals for ditch-blocking to retain water within upland moorland areas of the Site to improve habitat diversity. These interventions are likely to make its habitats more resilient to periods of low and high rainfall.

Residual Operational Effects

12.62 All effects remain as discussed above.

Cumulative Effects During Construction

Carbon Emissions Including Direct CO_2 and NO_X Emissions from HGV Vehicles

12.63 Climate change is, in essence, a cumulative effect due to emissions from multiple sources including new development. All wind farms will involve the generation of direct and embodied greenhouse gas emissions during construction. It is assumed, however, that any other wind farm applications that are consented and built will include reasonable measures to avoid, reduce and/or avoid the generation of greenhouse gas emissions, particularly from construction traffic. Overall, a Minor (negative) cumulative construction effect is therefore predicted which will be Not Significant.

Proposed Mitigation

12.64 No mitigation measures are proposed in relation to cumulative climate change effects during construction of the Proposed Development.

[26] SEPA (2023) Climate change allowances for flood risk assessment in land use planning, Version 3, 4 April 2023

Residual Cumulative Effects During Construction

12.65 As no mitigation is proposed, the effect remains as Minor (negative) and Not Significant.

Cumulative Effects During Operation

Carbon Losses and Offsetting

12.66 The Proposed Development, in combination with other onshore wind developments, will have a positive effect on offsetting emissions released from the burning of fossil fuels and will play an integral part in helping Scotland meet its climate change and energy targets. A **Positive** and **Significant** effect is therefore identified, given the importance of this collective role of onshore wind generation to addressing the global climate emergency.

Adaptation

12.67 With respect to in-combination climate effects, this is largely a project specific consideration, namely the ability of assessed receptors to adapt to future climatic conditions, and the extent to which projected climate change could alter the predicted effect judgements. Effects are considered to be **Not Significant**.

Proposed Mitigation

12.68 No mitigation is proposed in relation to cumulative effects on climate change during the operation of the Proposed Development.

Residual Cumulative Effects During Operation

12.69 As no mitigation is proposed, the effects remain as noted above, i.e. **Positive (Significant)** for carbon reductions, and **Not Significant** in relation to climate change adaptation.

Summary of Significant Effects

12.70 Table 12.5 below summarises the predicted significant effects of the of the Proposed Development on climate change mitigation and adaptation.

Table 12.5: Summary of significant effects

Predicted Effect	Significance	Mitigation	Significance of Residual Effect
Operation			
Carbon Losses and Carbon Offsetting (climate change mitigation)	Positive (significant)	None	Positive (significant)
Cumulative Operation			
Carbon Losses and Carbon Offsetting (climate change mitigation)	Positive (significant)	None	Positive (significant)

Shadow Flicker

Introduction

12.71 This section presents the findings of the assessment of potential shadow flicker effects from the Proposed Development on residential receptors.

12.72 Shadow flicker occurs when the sun shines onto a window of a building from behind a moving wind turbine causing a shadow to flick on and off as the wind turbine blades rotate and break the line of sight between the sun and the window. Shadow flicker occurs when a certain combination of conditions prevail at a certain location, time of day and year, and may have a negative effect on residents and occupants of affected properties.

12.73 The shadow flicker assessment identifies which properties close to the Proposed Development could theoretically experience shadow flicker.

Effects Scoped in to the Assessment

- Operational effects from shadow flicker.

Effects Scoped Out of the Assessment

- Construction effects, as shadow flicker only occurs from operational turbines,
- Operational effects on residential properties outside the shadow flicker study area where shadow flicker occurrence is unlikely to happen (see the description of the study area below);
- Operational effects on properties that are not considered to be habitable, for example derelict buildings and agricultural sheds;
- Potential effects relating to epilepsy. Over 600,000 people in the UK have epilepsy; this equates to approximately 1 in every 100 people[27]. Up to 3% of people with epilepsy are affected by flashing lights (this is called 'photosensitive epilepsy'). The Epilepsy Society states that *"turbine blades would need to rotate at speeds faster than 3 hertz (flashes per second)"*[28] in order to trigger epileptic seizures in people with photosensitive epilepsy. The National Policy Statement (NPS) for Renewable Energy Infrastructure (EN-3) (2011)[29] states that *"the maximum frequency of the shadowing effect from commercial scale wind turbines is less than 1 hertz…Therefore, shadow flicker frequencies are not in the region known to induce seizures in sufferers of epilepsy"* (page 72). Therefore, any potential shadow flicker effects arising from the Proposed Development are effects on residential amenity only, rather than having the potential to affect the health or well-being of residents; and
- Although the currently operational Fallago Rig farm is in close proximity to the Proposed Development, it falls outside the potential zone of influence for shadow flicker effects on properties and therefore no cumulative assessment has been carried out.

Legislation, Policy and Guidance

12.74 This assessment is carried out in accordance with the principles contained in the following documents:

- Department of Energy and Climate Change (DECC) (2011) Update of UK Shadow Flicker Evidence Base[30];

[27] Epilepsy Society (no date) Epilepsy Facts and Myths. Available at: https://epilepsysociety.org.uk/about-epilepsy/what-epilepsy/epilepsy-facts-and-myths
[28] Epilepsy Society (no date) Wind Turbines and Photosensitive Epilepsy. Available at: https://epilepsysociety.org.uk/about-epilepsy/epileptic-seizures/seizure-triggers/photosensitive-epilepsy/wind-turbines-and
[29] Department of Energy and Climate (2011) National Policy Statement for Renewable Energy Infrastructure (EN-3). Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/47856/1940-nps-renewable-energy-en3.pdf
[30] Department of Energy and Climate Change (DECC) (2011) Update of UK Shadow Flicker Evidence Base. Available [online] at: https://www.gov.uk/government/publications/update-of-uk-shadow-flicker-evidence-base

- Scottish Government (2014) Onshore Wind Turbines Planning Advice[31];
- Department of Northern Ireland (2009) Practice Guidance for Planning Policy Statement 18 (PPS18)[32]; and
- NPF4[33].

Consultation

12.75 In undertaking the shadow flicker assessment, consideration has been given to the relevant Scoping responses received, as detailed in **Table 12.6**.

Table 12.6: Consultation Responses

Consultee / Date	Consultation Stage	Issue Raised	Response/Action Taken
East Lothian Council 8/4/2022	Scoping	The Scoping Report does not appear to give a maximum rotor diameter. Assuming this would be at most 230 m (260 m to tip, 30 ground clearance), multiplying this by 10 would give a distance of 2.3 kilometres (km) where shadow flicker should be considered. The only residential property within this distance is at Kilpallet, which is around 1 km from the Site boundary. Shadow flicker should be considered for this property if it is within a distance of 10x the proposed rotor diameter.	The candidate turbine has evolved since the Scoping stage and now includes consideration for a turbine with a maximum rotor diameter of 180 m. All properties within 1.8 km of the proposed turbines have been assessed for potential shadow flicker events (see **Table 12.8**).
Scottish Borders Council 1/5/2022	Scoping	The development's compatibility with current guidance, which normally refers to a 10x rotor diameter range should be considered. The Council SG also requests assessment for residential properties within 2 km of each turbine. Any residential properties within this distance should still be assessed for shadow flicker.	Properties within 1.8 km have been assessed as stated above, and no additional properties within 2 km of the turbines were identified.

Study Area

12.76 In the UK, shadow flicker is only likely to occur in a building located within a distance of 10 times the rotor diameter of a wind turbine[34]. The maximum rotor diameter of the Proposed Development's turbines has been assumed for the purposes of this assessment to be 180 m; therefore, the potential area in which shadow flicker could occur will be around 1.8 km from the wind turbines. Properties which are beyond 130 degrees either side of north relative to the turbine were excluded, following the UK Government's Planning Practice Guidance for Renewable and Low Carbon Energy (2013)[35]. This is because turbines in the UK do not cast long shadows on their southern side due to the angle of the sun.

[31] Scottish Government (2014) Onshore Wind Turbines: Planning Advice. Available [online] at: https://www.gov.scot/publications/onshore-wind-turbines-planning-advice
[32] No formal guidance is available (at the time of writing) as to what levels of shadow flicker are considered to be acceptable in Scotland. Therefore, in the absence of any specific guidance for Scotland, the PPS18 is considered to be a valid reference for determining the significance of shadow flicker effects.
Department of Northern Ireland (2009) Practice Guidance for Planning Policy Statement 18 (PPS18). Available [online] at: https://www.infrastructure-ni.gov.uk/sites/default/files/publications/infrastructure/Best%20Practice%20Guidance%20to%20PPS%2018%20-%20Renewable%20Energy_0.pdf
[33] Scottish Government (2023) National Planning Framework 4. Available [online] at: https://www.gov.scot/publications/national-planning-framework-4/
[34] 10 times the rotor diameter is used as a general rule in the UK as shadow flicker should have no effect on properties located further than this distance (Scottish Government (2014) Onshore Wind Turbines: Planning Advice).
[35] UK Government (2013) Planning Practice Guidance for Renewable and Low Carbon Energy. Available at: https://www.gov.uk/guidance/renewable-and-low-carbon-energy

Desk Study

12.77 The following data sources have informed the assessment:

- OS AddressBase data;
- Google Maps aerial imagery;
- Met Office Data: Sunshine at Charterhall Climate Station[36]; and
- National Oceanic and Atmospheric Administration (NOAA) Data: Global Monitoring Laboratory Sunrise and Sunset at the Proposed Development[37].

Assessing Significance

12.78 The Scottish Government Onshore Wind Turbines Planning Advice (2014) 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*." (page 6)

12.79 Although the effect of shadow flicker has been quantified as part of the shadow flicker assessment for the Proposed Development, there is no formal guidance available (at the time of writing) regarding the occurrence of shadow flicker that is considered acceptable or not acceptable within Scotland. In the absence of this, the Department of Environment Northern Ireland (2009) Best Practice Guidance for Planning Policy Statement 18 (PPS18): Renewable Energy 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 dwellings…should not exceed 30 hours per year or 30 minutes per day*" (page 29).

12.80 This limit is widely accepted as a suitable metric in shadow flicker analysis for wind farms and is considered to be an appropriate threshold in which to make a professional judgement on the significance of the Proposed Development's effects on shadow flicker. In this way, predicted effects are judged as being **significant** and require mitigation whereby shadow flicker occurrence is estimated to exceed the aforementioned thresholds. Any values below these thresholds represent effects that are **not significant**. Where a significant effect is identified, this is considered to be significant in the context of the EIA Regulations. It should be noted, however, that as there is no formal guidance available on this topic within the UK or Scotland, the conclusions drawn are relative to these thresholds and are based on professional judgement and common practice.

Assessment Assumptions and Limitations

12.81 The shadow flicker assessment has been undertaken using ReSoft Windfarm Shadow Flicker module ('ReSoft model' or 'ReSoft modelling'). As explained above, it is assumed that effects will not be experienced by properties which are at a greater distance than 10 rotor diameters (1.8 km in the case of the Proposed Development) and outside 130 degrees either side of north, relative to the proposed wind turbines.

12.82 This chapter provides a maximum theoretical scenario and a realistic scenario of shadow flicker occurrence. In both scenarios, worst-case assumptions have been applied in accordance with EIA best practice, however this does also mean that the final assessment findings are worst-case as explained below.

[36] Met Office UK Climate Averages. Available [online] at: https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/gcykcv8b2
[37] NOAA (no date) Global Monitoring Laboratory, Sunrise Table for 2023, Location: Latitude 55.312741 Longitude -3.555932. Available [online] at: https://gml.noaa.gov/grad/solcalc/table.php?lat=55.312741&lon=-3.555932&year=2023

Theoretical 'Maximum-Case' Scenario

12.83 In the ReSoft modelling, the following worst-case assumptions have been used to determine a maximum theoretical level of shadow flicker occurrence:

- All properties within the 1.8 km study area are assumed to have a specified window size (in this case 1.5 m x 2 m) facing directly on to each turbine that has the potential to cause an effect;
- The wind turbine blades are assumed to be rotating for 365 days per year;
- The wind turbine blades are assumed to always be positioned so that their full face will be between the sun and each property;
- The sun always shines in a clear sky on every day of the year, i.e., there are no periods of cloud cover or low visibility due to fog, mist and haze etc;
- A human receptor is deemed to be present in all affected rooms at all times;
- No account is taken of the potential screening by trees or vegetation; and
- Curtains or blinds are assumed not to be fitted to windows.

12.84 The ReSoft modelling is therefore based on a theoretical 'maximum-case' or 'worst-case' scenario based on conservative (i.e. high) estimates, and this is what is shown in **Figure 12.1**. However, the occurrence of shadow flicker is only possible during the operation of the wind turbines (i.e., when the rotor blades are turning), when the sun is shining and when the sky is clear enough to cast shadows, therefore, the real-life instances of shadow flicker will always be less than that predicted by the ReSoft model.

Realistic Scenario

12.85 To quantify a more 'realistic' occurrence of shadow flicker which could be experienced by residential receptors within the study area, the modelled Hours per Year results can be adjusted to take account of the average percentage of time the sun shines during the daytime in this part of Scotland. The high estimates identified during the theoretical maximum-case scenario have therefore been translated into a more realistic estimate, particularly in respect to when the sunshine will be bright enough to cast a shadow.

12.86 The more realistic scenario is therefore based on the assumption that the sun is not always shining (e.g., due to cloud cover) and does not shine every day of the year. Therefore, it is only necessary to calculate shadow flicker for the average percentage of time when the sun is likely to be shining throughout a typical year (see **Table 12.7** below[36]).

Table 12.7: Monthly Percentage of Sunny Daylight Hours

Month	Total Daylight Hours (per month)	Typical Sunshine Hours (per month)	Monthly % of Sunny Hours
January	240.05	58.84	24.51
February	269.133	80.24	29.81
March	367.58	124.26	33.80
April	425.8	167.01	39.22
May	505.17	187.98	37.21
June	523.88	193.01	36.84
July	523.66	177.02	33.80
August	465.38	169.1	36.34

Month	Total Daylight Hours (per month)	Typical Sunshine Hours (per month)	Monthly % of Sunny Hours
September	395.21	139.79	35.37
October	323.28	99.81	30.87
November	249.45	78.82	31.60
December	220.55	50.72	22.30
Annual	4491.83	1526.6	**33.99%**

12.87 It should be noted that the more 'realistic' scenario, like the theoretical maximum scenario, does not reflect the fact that the turbines will not be continually rotating 365 days a year, for example, due to changes in wind speed and maintenance/shut-down periods, nor will potential receptors be present in all affected rooms at all times, for example, people may be sleeping, occupied in another unaffected room or absent from the property entirely (for example, at work or on holiday) during times where shadow flicker effects may be experienced. Moreover, the 'realistic' scenario does not reflect potential shielding/screening effects of buildings, trees, vegetation or other obstacles. The effects of shadow flicker which occur under the 'realistic' scenario may, therefore, be potentially reduced further, however, it is not practicable or proportionate to model every scenario and therefore the realistic scenario is considered a reasonable approach.

12.88 Whilst a few limitations have been identified, it is considered that there is sufficient information to enable an informed decision to be taken in relation to the identification and assessment of likely significant environmental effects on shadow flicker.

Existing Conditions

12.89 There are four properties located within 1.8 km (10x the rotor diameter distance) and within 130 degrees either side of north, relative to the proposed wind turbines, which could be potentially affected by the occurrence of shadow flicker (shown in **Figure 12.1**).

12.90 Annual average sunlight hours were calculated using Met Office Data from the Charterhall Climate Station (for typical sunshine hours) and NOAA Data at the Proposed Development Site (for typical daylight hours). Charterhall Climate Station is the closest climate station to the Proposed Development, located approximately 17 km south-east of the nearest proposed turbine (T15). Sunny daylight hours are only expected to occur approximately 33.99% of the time on average over the course of a year, as detailed within **Table 12.7.**

Implications of Climate Change

12.91 The Climate Change Mitigation and Adaptation assessment within this chapter provides details of the climate change projections in the East of Scotland for the 2050s, when the operational period of the Proposed Development is likely to end. In summary, the projections highlight that in the 2050s, summer and winter temperatures are likely to be greater than the current baseline, with winter rainfall increasing and summer rainfall decreasing. As shadow flicker effects are intrinsically linked to weather, there is the potential that the current baseline sunny daylight hours could be affected in the future due to climate change. The baseline percentage of sunny daylight hours per year is, however, not expected to change over the 35-year operational life of the Proposed Development to such a degree that the assessment of effects under the realistic scenario will be materially affected.

Future Baseline in Absence of the Proposed Development

12.92 In the absence of the Proposed Development, it is likely that the land will continue under the same land use, with no shadow flicker effects being generated as a consequence. However, the effects of shadow flicker could be influenced by further wind energy development. There are an increasing number of operational, consented and proposed domestic wind turbines of varying heights and rotor diameters, located within the surrounding landscape. As farmers diversify income and seek opportunities to generate energy for domestic and commercial use, interest in this type of development may continue.

Design Considerations

12.93 As part of the design of the Proposed Development, proximity of turbines to properties was considered in relation to reducing effects on residential visual amenity and operational noise and a minimum buffer of 1.2 km was adopted. This in turn has helped to minimise the potential for shadow flicker occurrence at certain properties – see **Chapter 2: Site Selection and Design Strategy.**

Assessment of Effects

12.94 The assessment of operational effects is based on the turbine layout provided in **Chapter 3**. Potential effects identified are considered to be adverse unless otherwise stated.

Operational Effects

12.95 Based on the applied assumptions above, the maximum theoretical shadow flicker occurrence (i.e., the 'Theoretical Maximum Hours per Year' and 'Theoretical Maximum Minutes per Day') for each property within the study area has been calculated. The results are summarised within **Table 12.8** below and the Theoretical Hours Per Year shown in **Figure 12.1**.

12.96 Table 12.8 also presents a more 'realistic' scenario which is the theoretical maximum hours per year and minutes per day factored down by the percentage of time the sun is expected to realistically be shining (33.99%). This percentage has been calculated using data from the Met Office and NOAA as explained above. As mentioned previously, the theoretical maximum shadow flicker analysis assumes the sun is always shining. Therefore, the more realistic scenario was calculated to take into account more typical daylight and sunlight hours (when sunshine will be bright enough to cause the effects of shadow flicker). In addition, the theoretical maximum scenario assumes that turbines will be constantly operating during the daytime and facing in the correct orientation which will not be the case in reality.

Table 12.8: Shadow Flicker Occurrence (minutes per day and hours per year)

Receptor (ID)	Theoretical Maximum Days per Year	Theoretical Maximum Hours per Day	Theoretical Maximum Hours Per Year	Realistic Scenario (minutes per day)	Realistic Scenario (hours per year)
(ID1) Keepers house	84	0.48	**30**	9.8	10.2
(ID2) 2 Byrecleugh Farm Cottage	123	0.5	**46.6**	10.2	15.8
(ID3) 4 Byrecleugh Farm Cottage	152	0.5	**58.2**	10.2	19.8
(ID4) Kilpallet	34	0.59	14.8	12.0	5.0

12.97 The assessment of shadow flicker effects on potential receptors identified in **Table 12.8** above indicates that the maximum theoretical occurrence of shadow flicker amounts to 58.2 hours per year at the most affected property (ID3: 4 Byrecleugh Farm Cottage). Two other properties (ID1: Keepers house and ID2: 2 Byrecleuch Farm Cottage) also have a theoretical shadow flicker occurrence at/above the thresholds of 30 hours per year or 30 minutes per day, with 30 and 46.6 hours per year respectively. The last property (ID4: Kilpallet) will experience theoretical shadow flicker of 14.8 hours per year.

12.98 As the theoretical maximum case occurrence at some properties exceeds significance thresholds, it is considered that these properties could experience significant effects due to shadow flicker under the theoretical maximum scenario. However, following the calculation of the more 'Realistic Scenario', which takes into consideration average sunny daylight hours when the sun will be bright enough to cause the effects of shadow flicker, the shadow flicker predictions fall below the significance threshold at all properties (**Table 12.8**). The realistic scenario assessment shows that the highest occurrence of shadow flicker amounts to 19.8 hours per year at the most affected property (ID3: 4 Byrecleugh Farm Cottage), with the other properties also falling below the realistic scenarios Hours per Year threshold for significance. All properties are below the 30 'Minutes per Day' threshold.

12.99 As explained above, in reality, the occurrence of shadow flicker is likely to be reduced even further due to the following, and so even with weather data considered, the results presented in the realistic scenario are still considered to be conservative (high):

- The wind turbine blades are not always rotating for 365 days per year; for example, the wind turbine blades will not be rotating during low wind conditions or where maintenance is required;
- The wind turbines blades will not always be positioned so that their full face will be between the sun and each property; and
- Receptors may not always be present in all affected rooms.

12.100 Trees, vegetation and local topography in the vicinity of the residential receptors may have a screening effect which could either reduce the effects of shadow flicker or eliminate shadow flicker completely.

12.101 Based on the results above (realistic scenario), all properties are predicted to experience shadow flicker effects which are considered to be below the thresholds in accordance with guidance, and therefore, **not significant.**

Proposed Mitigation

12.102 It is not considered that additional mitigation for shadow flicker effects is required based on the above assessment. Should EDF Energy Renewables Ltd (the Applicant) receive any complaints from nearby properties regarding shadow flicker effects, these will be fully investigated, and suitable mitigation will be implemented in agreement with SBC.

Residual Operational Effects

12.103 Residual operational effects will remain as **not significant.**

Interrelationship between Effects

12.104 The issue of shadow flicker is one which relates to residential amenity. The potential effects of the Proposed Development are considered above in terms of effects on shadow flicker as a discrete environmental topic. Interrelated effects with other topic areas are also possible. The other topics with potential to also have an adverse effect on residential amenity include landscape and visual amenity, traffic and noise. There are no significant effects predicted in relation to shadow flicker for the properties assessed, and there are also no significant effects predicted in relation to residential visual amenity (see **Appendix 4.2: Residential Visual Amenity Assessment (RVAA))**, operational noise (see **Chapter 9**), or traffic and transport (see **Chapter 10**) for the properties assessed for shadow flicker. It is therefore considered that there will be no significant interrelated effects with shadow flicker.

Summary of Significant Effects

12.105 The potential shadow flicker effects from the Proposed Development on residential receptors is considered to be **not significant** in the context of the EIA Regulations.

Population and Human Health, including Dust

12.106 In considering potential human health effects, it has been important to take into account the significance of primary effects identified throughout the EIA Report to determine if there could be 'secondary effects' on human health. Where primary effects are not predicted to be significant i.e., operational and cumulative noise, then there is not considered to be a potential health effect. Where potential human health impacts have been identified, these are assessed in the relevant topic chapters.

12.107 Health effects that could be a result of construction and operational noise and construction traffic accidents are considered in the respective chapters (**Chapter 9** and **Chapter 10**).

12.108 Health effects as a result of deterioration of water quantity and quality of public and private water supplies are considered further in **Chapter 8**. The Site is within a source zone for public water supply and is in proximity to a Drinking Water Protection Area (Dye Water) and private water supplies. Water quality and pollution prevention measures are proposed to account for the sensitive receptor as detailed in **Chapter 8.**

12.109 Health effects associated with shadow flicker (specifically in relation to epilepsy) are considered above.

Dust

12.110 With respect to dust effects during construction and operation of the Proposed Development, the Institute for Air Quality Management (IAQM) states that potential effects associated with dust should be considered where there is:

- *"A 'human receptor'*[38] *within:*
  - *350m of the boundary of the site*[39]*; or*
  - *50m of the route(s) used by construction vehicles on the public highway, up to 500m from the site entrance(s)."*

12.111 There are ten residential properties within 350 m of the construction works (there are no additional properties within 500m of the Site entrance located along the public highway):

- Crawlaw is approximately 70 m from the nearest construction activity along the existing Fallago Rig access track;
- Wedderlie Farm Cottages (Cluster of six properties), about 20 m – 70 m from construction activities along the existing access track; and
- Byrecleugh Keepers House and two Byrecleugh Cottages are also about 20 – 100 m from the proposed access track leading up to T5.

12.112 The Applicant is committed to adopting good practice measures for dust management during construction and will implement these through the Construction Environmental Management Plan (CEMP), thereby controlling and reducing any potential effects that dust generation may have on health (see **Appendix 3.1: Outline Construction Environmental Management Plan**). Dust management measures include:

- Where possible all machinery and dust-causing activities will be located away from the sensitive receptors mentioned above;
- Operatives of all construction vehicles must switch off engines when not moving or working onsite;
- All road-going vehicles will comply with current emissions standards;
- Movement of construction traffic around the Site will be minimised, where possible;
- Appropriate speed limits will be set around the Site;
- Loads will be covered if the load has the potential to generate dust;

[38] The IAQM guidance states that human receptors *"will most commonly relate to dwellings, but may also refer to other premises such as buildings housing cultural heritage collections (e.g. museums and galleries), vehicle showrooms, food manufacturers, electronics manufacturers, amenity areas and horticultural operations (e.g. salad or soft-fruit production)".*
[39] The number of properties has been calculated within 350m of infrastructure rather than the Site boundary as there are extensive areas within the Site boundary where no works will be taking place.

- Dust and road cleanliness on the public road at the main Site access will be monitored;
- A wheel wash facility will be installed at the Site compound and should it be deemed necessary a road sweeper will be deployed;
- Material deliveries and vehicle access will be timed to avoid the need for traffic to queue;
- Water will be used as a dust suppressant, where required and particularly in dry conditions, including at borrow pits and at the concrete batching area;
- Prolonged storage of material and debris on the Site will be kept to a minimum;
- Completed earthworks and exposed areas will be covered or re-vegetated as soon as is practicable;
- Slopes of any stockpiles and mounds will not be greater than the natural angle of repose of the material. The stockpiles/mounds must not have sharp changes in shape. Should a problem be identified with a stockpile then appropriate measures would be taken such as suppressants or sheeting.
- Appropriate wetting of soil surfaces will be carried out during earth moving activities to minimise contamination through airborne dust. This may be done using a water bowser or static sprinklers.
- Hard surfacing of internal roads will be completed as soon as practical to aid in minimising dust re-suspension; and
- The existing Fallago Rig access track passes through Wedderlie Farm (near to the Site entrance). The section through the farm will be re-surfaced with tarmac to minimise dust disturbance caused by construction and operational vehicles accessing Dunside and Fallago Rig Wind Farms.

12.113 On the basis that the above good practice measures will be in place for the duration of the construction period, no significant health effects relating to dust are predicted. During operation of the Proposed Development there will be limited dust-raising maintenance activities and vehicular movements to and from the Site will also be limited.

12.114 Decommissioning effects are likely to be of a similar nature to construction effects and therefore assumed to be not significant.

Health and Safety

12.115 The Construction (Design and Management) Regulations 2015 (the CDM Regulations) have formed an integral part of the conceptual design of the Proposed Development. Health and safety risks have been taken account of and their consideration reflected in the design. Surveys and investigations have been undertaken throughout the pre-consent phase to, as far as reasonably practicable, identify, manage and if possible, avoid any potential risks during construction and operation.

12.116 All construction activities will be managed within the requirements of the CDM Regulations and will also comply with the requirements of the Health and Safety at Work etc. Act 1974. To further reduce possible health and safety risks, a Health and Safety Plan for the project will be strictly adhered to throughout its construction, operation and decommissioning. All staff and contractors working on the construction will be required to comply with the safety procedures and work instructions outlined in the Plan.

12.117 To ensure that hazards are appropriately managed, risk assessments will be undertaken for all major construction, operational (e.g. maintenance) and decommissioning activities, with measures put in place to manage any hazards identified.

Turbine Icing

12.118 With respect to turbine icing, the Scottish Government has previously stated in the ‘Onshore wind turbines: planning advice note’ that the build-up of ice on turbine blades is unlikely to present problems on the majority of sites. Even where icing occurs, the turbines’ own vibration sensors are likely to detect the imbalance and inhibit the operation of the machines. Nevertheless, the Applicant will implement measures to ensure the safety of workers and the general public in relation to ice throw and ice fall, including notices alerting members of the public of the possible risk of ice throw and ice fall under certain conditions.

Glossary/Abbreviations

Table 12.9: Glossary and abbreviations

Term in Full	Abbreviation
Construction Traffic Management Plan	CTMP
Ecological Clerk of Works	ECoW
Environmental Impact Assessment	EIA
Greenhouse Gas Emission	GHG
Heavy Goods Vehicle	HGV
Institute of Environmental Management and Assessment	IEMA
Peat Management Plan	PMP
Scottish Borders Council	SBC
Scottish Environment Protection Agency	SEPA
Sustainable Drainage System	SuDS
UK Climate Change Projections 2018	UKCP18