16 CLIMATE CHANGE AND CARBON BALANCE

16.1 Introduction

This Chapter of the Environmental Impact Assessment Report ('EIA Report') evaluates the effects of the Ladyfield Wind Farm ('the Development') on the climate change and carbon balance resource and presents a Climate Change Impact Assessment (CCIA). This assessment was undertaken by ERM.

This Chapter of the EIA Report is supported by the following Technical Appendix documents provided in Volume 3 Technical Appendices:

- A16.1: Carbon Balance Calculations.

This chapter includes the following elements:

- Legislation, Policy and Guidance;
- Assessment Methodology and Significance Criteria;
- Baseline Conditions;
- Assessment of Potential Effects;
- Cumulative Effect Assessment;
- Mitigation and Residual Effects;
- Summary of Effects; and
- Statement of Significance.

16.2 Legislation, Policy and Guidance

The following guidance, legislation and information sources have been considered in carrying out this assessment:

- Institute of Environmental Management and Assessment (IEMA) Environmental Impact Assessment Guide to Climate Change Resilience and Adaption 2020
- [477] and Environmental Impact Assessment Guide to Assessing Greenhouse Gas Emissions and Evaluating their Significance – 2nd Edition (2022)[478];
- Electricity Act 1989[479]
- National Planning Framework 4 (2023)[480];
- Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017, as amended[481];
- The 2020 Routemap for Renewable Energy in Scotland (2011)[482] and as updated in 2013[483] and 2015[484];

[477] Institute of Environmental Management (2020). Environmental Impact Assessment Guide to: Climate Change Resilience and Adaption [Online]. Available at https://www.iema.net/resources/reading-room/2020/06/26/iema-eia-guide-to-climate-change-resilience-and-adaptation-2020 (Accessed 29/03/2023)
[478] IEMA (2022) IEMA Environmental Impact Assessment Guide to Assessing Greenhouse Gas Emissions and Evaluating their Significance 2nd Edition [Online] Available at: https://www.iema.net/resources/blog/2022/02/28/launch-of-the-updated-eia-guidance-on-assessing-ghg-emissions (Accessed 29/03/2023)
[479] UK Government (1989) Electricity Act 1989 [Online] Available at: Electricity Act 1989 (legislation.gov.uk) (Accessed 29/03/2023)
[480] Scottish Government (2023) National Planning Framework 4 [Online] Available at: https://www.gov.scot/publications/national-planning-framework-4/pages/1/ (Accessed 29/03/2023)
[481] UK Government (2017) Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017 [Online] Available at: The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017 (legislation.gov.uk) (Accessed 29/03/2023)
[482] Scottish Government (2011). 2020 Routemap for Renewable Energy in Scotland [Online]. Available at: 2020 Routemap for Renewable Energy in Scotland (webarchive.org.uk) (Accessed 29/03/2023)
[483] Scottish Government (2013). 2020 Routemap for Renewable Energy in Scotland – Update 2013 [Online]. Available at: https://www.gov.scot/Resource/0044/00441628.pdf (webarchive.org.uk) (Accessed 29/03/2023)
[484] Scottish Government (2015). 2020 Routemap for Renewable Energy in Scotland – Update 2015 [Online]. Available at https://www.gov.scot/Resource/0048/00485407.pdf (webarchive.org.uk) (Accessed 29/03/2023)

- The Electricity Generation Policy Statement (2013)[485];
- Scottish Energy Strategy (SES) (December 2017)[486] and SES Position Statement (2021)[487];
- Onshore Wind Policy Statement (December 2022)[488];
- European Commission Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment (2013)[489];
- Achieving Net Zero (2020)[490];
- The Committee on Climate Change (CCC) Reducing UK emissions: 2023 Progress Report (2023)[491];
- Energy White Paper: Powering our net zero future (2020)[492];
- Scottish Government: Securing a green recovery on a path to net zero: climate change plan 2018–2032 – update (2020)[493];
- HM Government UK Climate Change Risk Assessment Government Report (2022)[494];
- Scottish Government's Scottish Climate Change Adaption Programme (2014)[495];
- The Scottish Climate Change Plan (2018)[496];
- Scottish Government Open Government Action Plan 2021 to 2025 – Commitment 4: Climate Change (2023)[497];
- The Scottish Government's declaration of a Climate Emergency (April 2019)[498]; and
- The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019[499] and the legally binding net zero target for 2045 and interim targets for 2020, 2030 and 2040.

Notable information sources containing baseline and projected climate data include:

---

485 Scottish Government (2013) Electricity Generation Policy Statement 2013 [Online] Available at: Electricity generation policy statement 2013 - gov.scot (www.gov.scot) (Accessed 29/03/2023)
486 Scottish Government (2017) The Future of Energy in Scotland: Scottish Energy Strategy [Online] Available at: The future of energy in Scotland: Scottish energy strategy - gov.scot (www.gov.scot) (Accessed 29/03/2023)
487 Scottish Government (2021). Energy Strategy: Position Statement. [Online] Available at: https://www.gov.scot/publications/scotlands-energy-strategy-position-statement/ (Accessed 29/03/2023)
488 Scottish Government (2022) Onshore Wind: Policy Statement [Online] Available at: Onshore wind: policy statement 2022 - gov.scot (www.gov.scot) (Accessed 29/03/2023)
489 European Commission (2013). Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment (2013) [Online]. Available at: EIA Guidance.pdf (europa.eu) (Accessed 29/03/2023)
490 National Audit Office (2020) Achieving Net Zero [Online] Available at: https://www.nao.org.uk/wp-content/uploads/2020/12/Achieving-net-zero.pdf (Accessed 29/03/2023)
491 The CCC (2023) Reducing UK emissions: 2023 Progress Report to Parliament [Online] Available at: 2023 Progress Report to Parliament - Climate Change Committee (theccc.org.uk) (Accessed 29/03/2023)
492 HM Government (2020) The Energy White Paper - Powering our Net Zero Future [Online] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/945899/201216_BEIS_EWP_Command_Paper_Accessible.pdf (Accessed 29/03/2023)
493 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/pages/0/ (Accessed 29/03/2023)
494 HM Government (2022). UK Climate Change Risk Assessment: Government Report [Online]. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1047003/climate-change-risk-assessment-2022.pdf (Accessed 29/03/2023)
495 Scottish Government (2014). Scottish Climate Change Adaption Programme (SCCAP) [online]. Available at: Scottish Climate Change Adaptation Programme (SCCAP) - gov.scot (www.gov.scot) (Accessed 29/03/2023)
496 Scottish Government (2018) Climate Change Plan: Third Report on Proposals and Policies 2018 – 2031 (RPP3) [Online[Available at: Climate Change Plan: third report on proposals and policies 2018-2032 (RPP3) - summary - gov.scot (www.gov.scot) (Accessed 29/03/2023)
497 Scottish Government (2023) Open Government Action Plan 2021 to 2025 – Commitment 4: Climate Change. [Online] Available at: Open Government action plan 2021 to 2025 - commitment 4: climate change - gov.scot (www.gov.scot) (Accessed 28/08/2023)
498 Scottish Government (2019) Action to Address Climate Emergency [Online] Available at: Action to address climate emergency - gov.scot (www.gov.scot) (Accessed 29/03/2023)
499 Scottish Government (2019) Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 [Online] Available at: Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 (legislation.gov.uk) (Accessed 29/03/2023)

- Digest of United Kingdom Energy Statistics (DUKES) 2023[500];
- State of the UK Climate 2022[501];
- Met Office UK Climate Projections 2018 (UKCP18) (updated August 2022)[502]; and
- The Met Office UKCP18 Science Overview Report[503].

Other information sources are referenced throughout the Chapter.

The COP26 Climate Change Conference which was held in Glasgow in November 2021 reaffirmed the aim of limiting the temperature rise to 1.5°C. All countries agreed to revisit and strengthen their current emissions targets to 2030, known as Nationally Determined Contributions (NDCs). For the first time, heeding calls from the majority of world nations, the COP26 agreed action on phasing down fossil fuels.

Similarly, countries reaffirmed their commitment to limit global temperature rise to 1.5°C above pre-industrial levels at the COP27 Climate Change Conference, held in Sharm el-Sheikh in November 2022. Governments were also requested to revisit and strengthen their 2030 targets by the end of 2023, as well as increase efforts in phasing down coal generated power[504].

16.3 Assessment Methodology and Significance Criteria

16.3.1 Scoping Responses and Consultations

Consultation for this EIA Report topic was undertaken with the organisations shown in Table 16.1.

Table 16.1 Consultation Responses

Consultee	Type and Date	Summary of Consultation Response	Response to Consultee
Argyll and Bute Council	Scoping Response (15/02/2022)	The Council agrees with the proposed methodology to assess carbon balance using the Windfarm Carbon Calculator Tool, and agrees that the Development's vulnerabilities and resilience to climate change will result in no significant impacts and therefore can be scoped out of the EIA.	As detailed in the Scoping Report, the Windfarm Carbon Calculator has been used in Section 16.5 to complete the carbon balance assessment for the Development. The details on expected carbon savings predicted as a result of the operation of the Development have also been provided in Table 16.6.
SEPA	Scoping Response	Should the development disturb peat, Carbon dioxide emissions should be assessed and minimised.	A carbon balance assessment has been carried out using the Scottish Government's Carbon Calculator, as seen in Section 16.5.
RSPB	Scoping Response	Turbines 6, 7, 8, 19, and 22 are located in areas that would be situated on Class 2 Peat. A full assessment of the carbon implications should be undertaken using the	The layout and infrastructure has been designed to avoid and minimise disturbance to peat where possible.

[500] UK Government (2023) Digest of United Kingdom Energy Statistics 2023 [Online] Available at: Digest of UK Energy Statistics (DUKES) 2023 - GOV.UK (www.gov.uk) (Accessed 28/08/2023)
[501] Kendon, M., McCarthy, M., Jevrejeva, S., Matthews, A., Williams J., Sparks, T., & West F. (2022). State of the UK Climate 2022. *International Journal of Climatology*, 43 (Issue S1), 1– 83. [Online] Available at: State of the UK Climate 2022 - Kendon - 2023 - International Journal of Climatology - Wiley Online Library. (Accessed 28/08/2023)
[502] Met Office (2022) UK Climate Projections [Online] Available at: https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/about/project-news (Accessed 19/01/2023)
[503] Lowe, J.A. *et al*. (2018) UKCP18 Science Overview Report [Online] Available at: https://www.metoffice.gov.uk/pub/data/weather/uk/ukcp18/science-reports/UKCP18-Overview-report.pdf (Accessed 29/03/2023)
[504] UNFCCC (2022) Maintaining a clear intention to keep 1.5°C within reach - Key takeaways from COP27 [Online] Available at: https://unfccc.int/maintaining-a-clear-intention-to-keep-15degc-within-reach (Accessed 29/03/2023)

Consultee	Type and Date	Summary of Consultation Response	Response to Consultee
		Scottish Government's Carbon Calculator.	A carbon balance assessment has been carried out as seen in Section 16.5

16.3.2 Scope of Assessment

The following assessments are considered in terms of the Development:

- The influence of the Development on climate change; and
- A summary of effects on environmental receptors sensitive to climate change.

These assessments consider effects on environmental receptors as a result of the Development.

The assessment of the influence of the Development on climate change focusses on the overall balance of greenhouse gas (GHG) emissions as climate change is directly linked to these emissions. No further analysis is undertaken of how climate parameters change in direct response to the emissions balance of the Development. The summary of effects on environmental receptors sensitive to climate change is drawn together through a literature review of the predicted effects of climate change, and how these may impact environmental receptors throughout the lifetime of the Development.

16.3.3 Elements Scoped Out of Assessment

An assessment of the vulnerability of the Development to climate change has been scoped out, on the basis that none of the identified climate change trends could affect the Development, with the exception of increased windstorms. Windstorms are defined as wind that is strong enough to cause at least light damage to trees and buildings, can be accompanied by precipitation, and typically have windspeeds in exceedance of 34 miles per hour[505]. Any risk to the turbines from windstorms would be mitigated by installing braking mechanisms on the turbines, which would allow them to be operated only under specific wind speeds. Should severe windstorms be experienced, the turbines would be shut down. Additionally, flooding is not expected to pose a significant risk to the operation of the Development.

In relation to the effects on other environmental receptors, a qualitative review is undertaken in this Chapter of whether projected climate change will modify the future baseline without the Development sufficiently to change the results of the assessments undertaken in other chapters. The assessments are not repeated in this Chapter, as it should be read in conjunction with the other technical chapters.

Of the technical assessments included within this EIA Report, receptors within ecology, ornithology and hydrology have been identified as having a potential for the baseline to be modified as a result of climate change. Effects of climate change on ecology, ornithology and hydrology are included in this Chapter, with all other technical areas scoped out of further consideration as baseline receptors are unlikely to be affected by the climate changes forecast during the operational phase of the Development.

16.3.4 Study Area / Survey Area

The assessment of the influence of the Development on climate change considers GHG emissions (current levels and targets) within the Scottish and UK spatial scale. Reference is made to the global context as appropriate.

For the environmental receptors sensitive to the Development, the Study Area for the assessment on the future baseline for these receptors is outlined in individual technical chapters, specifically ecology, ornithology and hydrology.

---

505 Britannica (2023). https://www.britannica.com/science/windstorm (Accessed 24/08/2023)

16.3.5 Design Parameters

The design of the Development is a balance of technical, resource and environmental considerations. Those of relevance for the assessments in this Chapter include:

- Installed capacity and capacity factor - for calculation of carbon balance;
- Turbine spacing in relation to prevailing wind direction - for effects on generation, turbulence and vulnerability to damage with potential changes to wind speed direction and storminess;
- Inclusion of a Battery Energy Storage System (BESS) – although this is not included in the Carbon Calculator, high-level calculations can be used to assess how it impacts the carbon balance of the Development, and storage systems are important to allow renewable energy to be used effectively through balancing supply and demand;
- Amount and layout of new track and infrastructure in relation to peat – for calculation of carbon balance;
- Permanent felling associated with the Development – for calculation of carbon balance;
- Buffers to watercourses – for assessing vulnerability to flooding due to changes in precipitation events; and
- Construction management commitments particularly in relation to minimisation of disturbance and re-use of peat, and potential for flooding (as embedded in a Construction Environmental Management Plan (CEMP), and Outline Peat Management Plan (oPMP), etc.) – for assessing potential emissions and vulnerability to flooding.

The Development considers the use of 180 m tip height wind turbines, having been reduced from 200 m as described in Chapter 3: Site Selection and Design. This balances the risks of having larger turbines (a higher magnitude of landscape and visual impacts for example) with most effectively utilising the wind resource at the Site. The 180 m tip height allows electricity generation to remain high, utilise the potential increases in wind speeds associated with climate change (as discussed in Section 16.4.1), and maximise generation on the Site while mitigating potential adverse impacts.

16.3.6 Baseline Survey Methodology

Climate trends and projections are published by the Met Office through the UK Climate Projections website. The UKCP18 became available in November 2018, and was most recently updated in August 2022[506]. The UKCP18 provide the most up to date assessment of how the climate of the UK may change over this century.

UKCP18 uses scenarios for future GHG emissions called Representative Concentration Pathways (RCPs). The four RCPs attempt to capture a range of potential alternative futures and outcomes linked to global temperature increases and include a wide variety of assumptions on socio-economic development and commitment to emissions reductions. The sensitivity of the scenario responses is much more pronounced in the second half of the 21st Century, where the responses diverge more rapidly than in the first half of the century. The four RCPs are as follows:

- RCP2.6: assumes an increase in global mean surface temperature of 1.6°C (-0.9-2.3) by 2081-2100 (no change scenario)[507];
- RCP4.5: assumes an increase in global mean surface temperature of 2.4°C (1.7-3.2) by 2081-2100 (low emissions scenario)[29];
- RCP6.0: assumes an increase in global mean surface temperature of 2.8°C (2.0-3.7) by 2081-2100 (medium emissions scenario)[29]; and
- RCP8.5: assumes an increase in global mean surface temperature of 4.3°C (3.2-5.4) by 2081-2100 (high emissions scenario)[29].

[506] Met Office (2022) UK Climate Projections [Online] Available at: https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/about/project-news (Accessed 29/03/2023)
[507] Met Office (2018) UCKP18 Guidance: Representative Concentration Pathways [Online] Available at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-guidance---representative-concentration-pathways.pdf (Accessed 29/03/2023)

Over the 40-year anticipated operational phase of the Development, the choice of scenario is therefore not fundamental to the assessment but, where appropriate, the medium emissions scenario RCP6.0 is utilised as the future baseline. Reflecting the Paris Climate Agreement[508], in which most countries including the UK pledged to reduce emissions by 2030, this scenario assumes no further emissions reductions after 2030 and allows for some increase in emissions.

Projections are reported for 20-year time periods through to 2100. The 2021 – 2040 and 2041 - 2060 periods provide the closest projections to the operational phase of the Development. For the purpose of this CCIA, where appropriate the 2040 - 2059 time period is used as the impacts of climate change are anticipated to be more evident with time.

Projected climatic changes at the 50% probability level (central estimate) are utilised, unless otherwise indicated. This is the level where there is as much evidence pointing to a lower outcome as a higher one. There is substantial evidence that the actual climatic change outcome will be in the 10th to 90th percentile range (the range in which 80% of the data sits, with the range excluding the extreme highs and lows of the data. The 10th percentile marks the point where 10% of the data falls below that number, and likewise the 90th percentile marks the point where 90% of the data falls below that point), and this is also utilised for limited assessment parameters[509].

16.3.6.1 Influence of the Development on Climate Change

This section of the CCIA seeks to quantify the effect of the Development on climate change.

National Planning Framework 4 (NPF4), adopted in February 2023[510], does not make specific reference to using the carbon calculator tool. It is therefore assumed that the Scottish Government Carbon Calculator tool is still the most appropriate tool for calculating carbon balance. This has been completed for the Development using the latest version of the calculator (C-CalcWebV1.7.0)[511]. The Development's carbon calculator reference number is **MV20-EO4E-BHQ1**, as detailed within Technical Appendix A16.1.

The carbon assessment methodology used is consistent with that published by the Rural and Environment Research and Analysis Directorate of the Scottish Government entitled 'Calculating carbon savings from wind farms on Scottish peat lands – a new approach'[512]. This publication sets out the approach and assumptions that should be used to estimate potential carbon losses[513] and savings from wind farms on Scottish peatlands.

The calculation evaluates the balance of total carbon savings and carbon losses over the lifetime of the Development. It should be noted that the calculator does not include the option to account for battery storage systems in the Development, and therefore only assesses the wind turbine generation of electricity and excludes the storage of energy. This is a limitation to the carbon calculator, as including BESS with renewable energy generation benefits the grid through capturing

---

[508] United Nations (2016) Framework Convention on Climate Change. Adoption of the Paris Agreement, 21st Conference of the Parties, Paris [Online] Available at: https://unfccc.int/resource/docs/2015/cop21/eng/10a01.pdf (Accessed 29/03/2023)
[509] Lowe et al (2018) UKCP18 Science Overview Report (Page 13)
[510] Scottish Government (2023) National Planning Framework 4 [Online] Available at: https://www.gov.scot/publications/national-planning-framework-4/pages/1/ (Accessed 29/03/2023)
[511] Scottish Government & SEPA. Carbon Calculator Tool v1.7.0 [Online]. Available at: https://informatics.sepa.org.uk/CarbonCalculator/index.jsp (Accessed 29/03/2023)
[512] Nayak et al (2008) Calculating carbon savings from wind farms on Scottish peat lands: a new approach (Scottish Government) [Online] Available at: https://www.gov.scot/publications/calculating-carbon-savings-wind-farms-scottish-peat-lands-new-approach/pages/13/ (Accessed 29/03/2023)
[513] Carbon losses are defined within the Scottish Governments Technical Note Version 2.10.0 on Calculating potential carbon losses and savings from wind farms on Scottish peatlands. Available at: https://www.gov.scot/binaries/content/documents/govscot/publications/advice-and-guidance/2018/12/carbon-calculator-technical-guidance/documents/calculating-potential-carbon-losses-and-savings-from-wind-farms-on-scottish-peatlands-technical-guidance/calculating-potential-carbon-losses-and-savings-from-wind-farms-on-scottish-peatlands-technical-guidance/govscot%3Adocument/Calculating%2Bpotential%2Bcarbon%2Blosses%2Band%2Bsavings%2Bfrom%2Bwind%2Bfarms%2Bon%2BScottish%2Bpeatlands%2B-%2Btechnical%2Bguidance.pdf (Accessed 29/03/2023)

excess energy from the wind farm and the grid and releasing it when there is demand. This therefore smooths the flow and reduces the overall back up energy generation demand.

The potential carbon savings and carbon costs associated with wind farms are as follows:

- Carbon emission savings due to generation (based on displacing emissions from different power sources);
- Lifetime costs associated with manufacture of turbines and construction;
- Loss of carbon from backup power generation;
- Loss of carbon-fixing potential of peatland;
- Loss and/or saving of carbon stored in peatland (by peat removal or changes in drainage);
- Loss and/or saving of carbon-fixing potential as a result of forestry clearance; and
- Carbon gains due to proposed habitat improvements such as bog restoration.

The calculation of the carbon balance of a proposed wind farm provides a mechanism by which the carbon costs of a wind farm development can be weighed against the carbon savings attributable to the wind farm during its lifetime. This calculation is summarised as the length of time (in years) it will take the carbon savings to amount to the carbon costs and is referred to as the 'payback period'. This information can then inform decision makers of the viability of a wind farm development in terms of overall carbon savings.

Calculations are provided for expected, minimum and maximum scenarios of the Development. The expected scenario is based on the layout of 13 turbines and candidate turbine (Vestas V136, 4.5 Megawatts (MW)) described in Chapter 2 - Development Description and has an estimated installed capacity in excess of 50 MW. This does not include the additional 41.4 MW Battery Energy Storage System (BESS) due to the carbon calculator not allowing for BESS systems to be included. A high-level calculation regarding the BESS storage capacity and carbon losses has been completed in Section 16.5.1.4 to assess the effect of the BESS on the predicted payback periods. The other scenarios are generated by the carbon calculator and are based on varying assumptions regarding wind energy capacity factor, characteristics of peatland and Development land-take. The 'minimum' scenario uses the 'minimum' values inputted into the Carbon Calculator, giving the lowest energy output of the wind farm, with the lowest carbon losses, and the 'maximum' scenario uses the 'maximum' values inputted into the Carbon Calculator, giving the highest energy output of the wind farm, and the highest carbon losses due to the wind farm.

The data sources and assumptions used in the carbon balance calculation are detailed in Technical Appendix 16.1. The assessment was informed by an iterative peat probing process, as described in Chapter 11 - Geology and Peat.

16.3.6.2 Effects on Environmental Receptors Sensitive to Climate Change

This section of the CCIA identifies where climate change has the potential to significantly impact the findings of assessments undertaken and reported elsewhere in this EIA Report. Reference is made to the specific assessment chapters, where the baseline conditions and sensitivity of receptors are discussed, and assessments are not repeated.

16.3.7 Methodology for the Assessment of Effects

The significance of the potential effects of the Development has been classified by professional consideration of the sensitivity of the receptor and the magnitude of the potential effect.

To determine whether effects are significant under the EIA Regulations, it is appropriate to consider the sensitivity (vulnerability and susceptibility) of the receptor and the magnitude of the impact, taking into account uncertainty. This is based on the professional judgement of the assessor.

16.3.7.1 Sensitivity of Receptors

The sensitivity of the baseline conditions, including the importance of environmental features on or near to the Site or the sensitivity of potentially affected receptors, will be assessed in line with best practice guidance, legislation, statutory designations and / or professional judgement.

Table 16.2 details the framework for determining the sensitivity of receptors.

Table 16.2 Framework for Determining Sensitivity of Receptors

Sensitivity of Receptor	Definition
Very High	The receptor has little or no ability to absorb change without fundamentally altering its present character, is of very high environmental value, or of international importance.
High	The receptor has low ability to absorb change without fundamentally altering its present character, is of high environmental value, or of national importance.
Medium	The receptor has moderate capacity to absorb change without significantly altering its present character, has some environmental value, or is of regional importance.
Low	The receptor is tolerant of change without detriment to its character, is low environmental value, or local importance.
Negligible	The receptor is resistant to change and is of little environmental value.

16.3.7.2 Magnitude of Effect

The magnitude of potential effects will be identified through consideration of the Development, the degree of change to baseline conditions predicted as a result of the Development, the duration and reversibility of an effect and professional judgement, best practice guidance and legislation.

The criteria for assessing the magnitude of an effect are presented in Table 16.3.

Table 16.3 Framework for Determining Magnitude of Effects

Magnitude of Effects	Definition
High	A fundamental change to the baseline condition of the asset, leading to total loss or major alteration of character.
Medium	A material, partial loss or alteration of character.
Low	A slight, detectable, alteration of the baseline condition of the asset.
Negligible	A barely distinguishable change from baseline conditions.

16.3.7.3 Significance of Effect

The sensitivity of the asset and the magnitude of the predicted effects will be used as a guide, in addition to professional judgement, to predict the significance of the likely effects.

The IEMA guidelines for CCIA state the following with regards to the assessment of significance:

"This guidance is not proposing changes to the significance criteria used in the EIA process. However, the susceptibility or resilience of the receptor to climate change must be considered as well as the value of the receptor.

Therefore, 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 uncertainty of the combined effect needs to be taken into account. If uncertainty about how a receptor will adapt to a changing climate is high, then it is recommended that a conservative threshold of significance is adopted within the evaluation".

Table 16.4 summarises guideline criteria for assessing the significance of effects.

Table 16.4 Framework for Assessment of the Significance of Effects

Magnitude of Effect	Sensitivity of Resource or Receptor				
	Very High	High	Medium	Low	Negligible
High	Major	Major	Moderate	Moderate	Minor
Medium	Major	Moderate	Moderate	Minor	Negligible
Low	Moderate	Moderate	Minor	Negligible	Negligible
Negligible	Minor	Minor	Negligible	Negligible	Negligible

Those predicated to be of major or moderate significance are considered to be 'significant' in the context of the EIA Regulations and are shaded in light grey in Tables 16.4 and 16.5.

The categories of significance are described in Table 16.5.

Table 16.5: Categories of Significance of Effect

Significance	Definition
Major	A fundamental change to location, environment, species, or sensitive receptor.
Moderate	A material, but non-fundamental change to a location, environment, species, or sensitive receptor.
Minor	A detectable but non-material change to a location, environment, species, or sensitive receptor.
Negligible	No detectable or material change to a location, environment, species or sensitive receptor.

Effects assessed can be both negative and neutral. Whilst receptors may be considered "high-value", a non-material magnitude of the impact would result in any effect being considered not significant.

16.3.8 Assessment Limitations

The climate change projections are based on global models for a range of GHG emissions scenarios and generally consider regional responses to climate change rather than local responses. This is based on best scientific knowledge at this time and judgements on datasets and future socioeconomic drivers.

Downscaling adds another level of uncertainty. There may be more detail, but the uncertainty of the science may be higher. As understanding of the climate system and the ability to model it improves, it is likely that future projections will be refined.

The probabilities presented and the estimated ranges are based on a set of modelling, statistical and dataset choices with expert judgement playing an important role. However, as some potential influences on future climate are not yet known some choices may change as the science develops[514].

Specifically, in relation to wind, the UKCP18 Wind Fact sheet[515] states that local variations due to the land surface are hard to model, particularly in very exposed or sheltered locations. This can be particularly relevant in high wind speed situations where local gusts can result from small scale weather events such as thunderstorms.

[514] Lowe *et al* (2018) UKCP18 Science Overview Report
[515] UKCP18 (2019) Factsheet: Wind [Online] Available at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-fact-sheet-wind_march21.pdf (Accessed 29/03/2023)

16.3.9 Embedded Mitigation

As detailed in Chapter 3 - Site Selection and Design, the Development design has been driven by the key objective of capturing the maximum energy possible, while balancing environmental and technical constraints. The design choices made as a consequence of the key constraints are considered to be mitigation which is 'embedded' in the design; the following are most relevant for the CCIA:

- Development infrastructure is built to withstand strong windspeeds and to harness energy;
- Turbine spacing is sufficient to reduce turbulence effects on turbines downwind;
- The turbines are located to maximise energy generation while minimising environmental impacts;
- The proposed turbine height is 180 m, decreased from 200 m, to maximise electricity generation while also reducing visual impacts;
- The Development design aims to minimise environmental impacts e.g., through use of existing tracks as far as possible;
- Turbines, and associated infrastructure, have generally been sited in areas of peat with depths less than 1 metre (m) to minimise peat disturbance;
- The area of felling required was reduced as much as practicable, although any felled forestry will be restored through equivalent habitat enhancements, for example peatland restoration and compensatory forestry planting, elsewhere in the vicinity of the Site or the surrounding area;
- Implementation of a CEMP and PMP during construction to minimise environmental impacts and peat disturbance; and
- Buffers from watercourses incorporated in layout design, protecting water quality and also protecting Development infrastructure from flooding.

16.4 Baseline Conditions

The State of the UK Climate 2022[516] provides the latest report on observed climate data for UK. Key findings are as follows:

- Recent decades in the UK have been warmer, wetter, and sunnier than in the 20th century, with UK temperature extremes changing much faster than the average temperature.
- 2022 was the warmest year in the UK series from 1884 – 0.9°C above the 1991-2020 average and was also the first year to record a UK annual mean temperature above 10°C and record a temperature of 40°C in the UK.
- All the top-10 warmest years for the UK in the series from 1884 have occurred in the 21st century.
- The most recent decade (2013-2022) has been on average 0.3°C warmer than the 1991-2020 average, and 1.1°C warmer than the 1961-1990 average. This is the warmest 10-year period in the UK series from 1884 and the Central England Temperature (CET) series from 1659.
- 2022 rainfall was 94% of the 1991-2020 average.
- Five of the 10 wettest years for the UK in a series from 1836 have occurred in the 21st century.
- The most recent decade (2013-2022) has been on average as wet as 1991-2020, and 8% wetter than 1961-1990 for the UK overall.
  - For the most recent decade, UK winters have been 10% wetter than 1991-2020 and 25% wetter than 1961-1990.
  - There are much smaller changes overall for spring, summer, and autumn.
- 2022 was comparable in storminess with other years in recent decades, although unusually, all five named storms occurred in January and February.
- There have been fewer occurrences of max gust speeds exceeding 40/50/60 Kt in the last two decades compared to the 1980s and 1990s.

[516] Kendon *et al*. (2023) State of the UK Climate 2022. International Journal of Climatology, 43 pp.1-83. [Online] Available at: State of the UK Climate 2022 - Kendon - 2023 - International Journal of Climatology - Wiley Online Library (Accessed 28/08/2023).

- The UK annual mean wind speed from 1969 to 2022 shows a downward trend, consistent with that observed globally, although it is highlighted that this series must be interpreted with some caution.

Climate Projections show that the trends over the 21st Century in the UK are towards warmer and wetter winters and hotter, drier summers, with an increase in frequency and intensity of extremes.

The climate parameters considered most relevant to the assessments referenced within this Chapter are wind speed, temperature and precipitation.

16.4.1 Wind Speed

The HADUK-Grid dataset of UK annual mean wind speed from 1969 to 2022 shows a downward trend, with 2022 being close to the 1991-2020 average. In comparison, 2021 was the second least windy year in the series (behind 2010). The UK was often influenced by high pressure in January, March, April, August, September, and December and so these months were less windy than average, but in contrast February was the UK's windiest month since February 2020. This series should however be interpreted with some caution as it has not been rigorously assessed for long-term uniformity of the series, and observations may be significantly affected by changes in the observing network and to the exposure of sites over time.

The 2020 Bulletin of the American Meteorological Society (BAMS) State of the Global Climate Report (Dunn *et al.*, 2021[517]) shows that on a continental and global scale prior to around 2010 there was widespread and general slowdown of near-surface winds (termed 'global-stilling'). More recently, the 2021 BAMS State of the Global Climate Report[518], stated that the stilling observed before the 2010s ceased in the last decade, with a weak reversal or stabilization of surface winds globally, although it also highlights that this may be due to internal variability. The UK mean wind speed series broadly reflects the globally documented behaviours, although for the UK the decline has only stopped, not reversed.

In terms of storminess, the most recent two decades have seen fewer occurrences of max gust speeds (a measure of storminess) above the threshold levels of 40/50/60 Kt (46/58/60 mph), particularly when comparing the periods before and after 2000. However, there is a large amount of yearly and decadal variation, and the series is relatively short, and so conclusions should be drawn with caution.

16.4.2 Temperature

The UK mean temperature for 2022 was 10.0°C, which is 0.9°C above the 1991-2020 long-term average and was ranked the warmest year in the Central England Temperature series from 1659 (0.1°C warmer than the next warmest year, 2014). The most recent decade (2013-2022) has been the warmest 10-year period in the CET series. For the UK, all four seasons were in the top ten warmest in the series from 1884, with anomalies of +1.1°C for winter, +0.8°C for spring, +1.1°C for summer, and +1.3°C for autumn.

In the future, at a UK level, annual change in temperature from 1981-2000 to 2041-2060 under the RCP8.5 scenario (unmitigated scenario) is projected at +1.8°C (50% probability)[519]. Results for the 10th to 90th percentile range are between +0.9°C to +2.7°C[520]. Key observations are that:

- Both winters and summers will be warmer, with more warming in the summer; and

[517] BAMS (2021). State of the Climate in 2020. [Online] Available at: State of the Climate in 2020 in: Bulletin of the American Meteorological Society Volume 102 Issue 8 (2021) (ametsoc.org) (Accessed: 28/08/2023)
[518] BAMS (2022). State of the Climate in 2021. [Online] Available at: StateoftheClimate2021_lowres.pdf (ametsoc.net) (Accessed: 28/08/2023)
[519] Met Office (2018). UKCP18 Science Overview Report. [Online] Available at: UKCP18-Overview-report.pdf (researchgate.net) (Accessed: 28/08/2023)
[520] Lowe *et al* (2018) UKCP18 Science Overview Report November 2018 (Updated March 2019) (Table 2.2, Page 16)

- In summer there is a pronounced north/south divide with greater increases in maximum summer temperatures over the southern UK compared to Scotland.

16.4.3 Precipitation

Rainfall patterns over the UK are not uniform and vary on regional (e.g. Highland-wide, or from coast to coast) and seasonal scales, which will continue in the future.

The UK rainfall total for 2022 was 94% of the 1991-2020 average, with rainfall totals being below average across most of the UK except for parts of Scotland and the west of Northern Ireland. Rainfall data shows large interannual variability, but the most recent decade (2013-2022) has been on average 8% wetter than 1961-1990 and exactly as wet as 1991-2020 for the UK. Monthly and seasonal rainfall patterns showed some large variations over the course of the year, but the most notable features for 2022 were the persistent dryness for January to August, and the wetter than average autumn. Typically, for the most recent decade, winters have been wetter, while summers have been drier, than the 1991-2020 average.

Future changes are uncertain but point to wetter winters and drier summers in general. Drying in summer will be strongest in the south of England, whilst Scotland is generally associated with increased precipitation in winter[521].

In general (without reference to regional or seasonal variations), across the UK, the changes to precipitation projected for 2041-2060 (compared to 1981-2000) for RCP8.5 (unmitigated scenario) are:

- Winter precipitation – increase of 7% (50% probability). Results for the 10th to 90th percentile range are between -5% and +21%.
- Summer precipitation – decrease of 15% (50% probability). Results for the 10th to 90th percentile range are between -31% and +0%.

16.4.4 Greenhouse Gas Emissions and Renewable Energy

The central aim of the Paris Agreement is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C[522]. This goal was highlighted at COP26 in Glasgow, where the Glasgow Climate Pact was adopted by nations to mitigate and adapt to climate change, including asking nations to re-evaluate current emission reduction plans in order to limit temperature increase to 1.5°C[523]. All countries agreed to revisit and strengthen their current emissions targets to 2030, known as NDCs, in 2022. This will be combined with a yearly political roundtable to consider a global progress report and a Leaders summit in 2023[524].

Other outcomes from COP26 include:

- The Global Methane Pledge, which aims to cut methane emissions by at least 30% by 2030, and currently has 110 countries participating[525] ;
- The Glasgow Leaders Declaration on Forests and Land Use, which aims to reverse deforestation by 2030, and currently has 141 endorsers[526]; and

---

521 Lowe *et al* (2018) UKCP18 Science Overview Report
522 UN Climate Change (2015) the Paris Agreement [Online] Available at: https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement (Accessed 29/03/2023)
523 UN Climate Change Conference UK 2021 (2021). COP26 keeps 1.5ºC alive and finalises Paris Agreement. [Online] https://ukcop26.org/cop26-keeps-1-5c-alive-and-finalises-paris-agreement/ (Accessed 29/03/2023)
524 UNFCCC (2021) Glasgow Climate Pact [Online] Available at: https://unfccc.int/sites/default/files/resource/cop26_auv_2f_cover_decision.pdf (Accessed 29/03/2023)
525 Global Methane Pledge (2021) About the Global Methane Pledge [Online] Available at: https://www.globalmethanepledge.org/ (Accessed 29/03/2023)
526 UKCOP26 (2021) Glasgow Leaders' Declaration on Forests and Land Use [Online] Available at: https://ukcop26.org/glasgow-leaders-declaration-on-forests-and-land-use/ (Accessed 29/03/2023)

- Glasgow Financial Alliance for Net-Zero with USD $130 trillion in funds under management pledging to assist achievement of Paris temperature goals[527].

COP27 was held in Sharm el-Sheikh in November 2022. The highlight of COP27 was the agreement to establish the loss and damage fund. This fund establishes a dedicated fund to assist developing countries in responding to loss and damage caused as a result of climate disasters[528]. The Paris Agreement goal was also reaffirmed through the Sharm el-Sheikh Implementation Plan, which also states there is a clear emissions gap between current national climate plans and what is needed to meet the target.

The 2018 Intergovernmental Panel on Climate Change (IPCC) Special Report[529] highlighted that to limit global warming to below 1.5ºC by the end of the century, emissions would need to decline by approximately 45% by 2030 and reach net zero around 2050. This is the temperature rise when a variety of increasingly severe effects are considered to occur and the IPCC identifies that rapid and far-reaching transitions are required in all sectors including energy.

The IPCC AR6 Synthesis Report[530], published in 2023, states that pathways which limit warming to 1.5°C with no or limited overshoot reach net zero CO_2 in the early 2050s, followed by net negative CO_2 emissions. Despite this, figures from the 2022 Global Carbon Budget[531] state that 2021 global fossil CO_2 emissions were 9.9 ± 0.5 GtC yr^{-1}, the same as the 2019 emissions level. Preliminary estimates suggest fossil CO_2 emissions continued to increase by 1.0% in 2022 relative to 2021, resulting in emissions of 10.0 GtC yr^{-1}, and emissions from coal, oil and gas in 2022 are expected to be above their 2021 levels. The remaining carbon budget for a 50% likelihood to limit global warming to 1.5°C has reduced to 105 GtC from the beginning of 2023, equivalent to approximately 9 years of emissions assuming 2022 emission levels.

In June 2023, the Climate Change Committee published the 2023 Progress Report to Parliament[532], assessing progress in reducing UK emissions over the past year. Although the UK is one of the few countries with emissions targets in line with the long-term temperature goal of the Paris Agreement, and has a solid Net Zero strategy in place, important policy gaps remain and emphasis must be placed on delivery. The report highlights that the UK has lost its clear global leadership position on climate actions, and it has backtracked on fossil fuel commitments despite the release of new details on the Government's plan for Net Zero in the Carbon Budget Policy Plan Report. Continued delays in policy development and implementation also mean that the achievement of NDCs in 2030 is increasingly challenging. Greenhouse Gas emissions were 46% below 1990 levels in 2022, although the emissions were still affected by the impacts of the COVID-19 pandemic (2022 emissions were 0.8% higher than in 2021, but 9% below pre-pandemic levels in 2019). Electricity supply accounted for 11% of UK emissions in 2022, and reducing emissions from electricity generation and using low-carbon electricity is a central part of reaching Net Zero. Sector emissions have fallen rapidly over the last decade, and the Government has made a commitment to fully decarbonise the sector by 2035, subject to security of supply.

---

[527] GFANZ (2021) Our progress and plan towards a net-zero global economy [Online] Available at: https://assets.bbhub.io/company/sites/63/2021/11/GFANZ-Progress-Report.pdf (Accessed 29/03/2023)
[528] United Nations (2022) COP27 Reaches Breakthrough Agreement on New "Loss and Damage" Fund for Vulnerable Countries [Online] Available at: https://unfccc.int/news/cop27-reaches-breakthrough-agreement-on-new-loss-and-damage-fund-for-vulnerable-countries?gclid=EAIaIQobChMIr5fC1ezT_AIVT9PtCh2-jgsBEAAYAiAAEgIbPvD_BwE (Accessed 29/03/2023)
[529] IPCC (2018) Global Warming of 1.5ºC: Summary for Policymakers [Online] Available at: https://www.ipcc.ch/sr15/ (Accessed 29/03/2023)
[530] IPCC (2023). AR6 Synthesis Report: Climate Change 2023. [Online] Available at: AR6 Synthesis Report: Climate Change 2023 — IPCC (Accessed: 28/08/2023)
[531] Fredlingstein *et al.* (2022). Global Carbon Budget 2022. [Online] Available at: ESSD - Global Carbon Budget 2022 (copernicus.org) (Accessed: 28/08/2023)
[532] Climate Change Committee (2023). 2023 Progress Report to Parliament. [Online] Available at: 2023 Progress Report to Parliament - Climate Change Committee (theccc.org.uk) (Accessed: 28/08/2023)

On 14 December 2020, Alok Sharma MO, then Secretary of State for Business, Energy and Industrial Strategy announced the launch of the Energy White Paper[533]. The White Paper set out the UK Governments strategy to put net zero into practice and for fighting climate change, following the Prime Ministers Ten Point Plan for a Green Industrial Revolution. The White Paper reiterates the compelling case to urgently address climate change and avert the dangerous consequences that will arise if global temperature increase is not kept at well below 2°C as per the Paris Agreement, and if possible, not above 1.5°C. The White Paper sets out the measures that need to be put in place to achieve the carbon emission targets for the UK. These entail a major shift in energy use from fossil fuels to electricity and hydrogen. Clean electricity is to become the predominant form of energy, with a consequent doubling of demand. This transition must be secured whilst retaining reliability, resilience and affordability. Delivering this will require billions of pounds of investment in clean energy infrastructure, including offshore wind farms and new nuclear plants. The White Paper is clear that onshore wind will be a key building block in the energy mix, and aimed to deploy around 12 GW of new low-cost renewable generation capacity in the next Contracts for Difference auction in late 2021, of which onshore wind and solar would be important, along with offshore wind.

The Scottish Government has introduced a number of policies aimed at reducing GHG emissions and meeting renewable energy targets set at a UK, European and International level with ambitious targets for reductions in greenhouse gas emissions. The Climate Change Act (Emissions Reduction Targets) (Scotland) Act 2019 which amends the Climate Change (Scotland) Act 2009, was introduced to Parliament in May 2018. The Bill was passed in September 2019 and received Royal Assent in October 2019. Following the Committee on Climate Change recommendation, the Act was amended to set a new target to cut Scottish greenhouse gas emissions to net zero by 2045, five years ahead of the target date set for the whole of the UK, with interim targets now set to cut emissions by 75% and 90% by 2030 and 2040 respectively (in relation to 1990 levels). GHG emissions from the electricity sector decreased by 83% between 1990 and 2016, with the 2018 Climate Change Plan (CCP) setting out policies and proposals to reduce emissions from this sector by a further 28% between 2018 and 2032, taking the overall reduction within the sector to 87% compared to 1990[534].

The Climate Change Adaptation Programme: Progress Report 2023[535], is the fourth annual progress report on the Climate Ready Scotland: Scotland's Climate Change Adaptation Programme 2019 to 2024 (SCCAP2), and states that Scotland's climate has already changed and whilst progress continues to be made in implementing SCCAP2, it is clear more needs to be done to build resilience in Scotland. It also highlighted that the IPCC's 2023 Synthesis Report shows that progress on global adaptation action is not yet keeping pace with the worsening impacts, and this is a shared global challenge. Progress in Scotland has been made through the Scottish 3-day Flood Forecast, the Scottish Biodiversity Strategy, NatureScot's investment in peatland restoration, and other projects, and going forwards the Scottish Government is now developing Scotland's next statutory climate change adaptation programme.

Overall, the Scottish economy has decarbonised more rapidly than the remainder of the UK with emissions falling while the economy has grown[536]. To date much of the emissions savings have

---

533 Secretary of State for Business, Energy and Industrial Strategy (2020). The Energy White Paper. Powering out New Zero Future. [Online]. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/945899/201216_BEIS_EWP_Command_Paper_Accessible.pdf (Accessed 29/03/2023)

534 Scottish Government (2018) Climate Change Plan: third report on proposals and policies 2018-2031 (RPP3) – summary. [Online] Available at: Climate Change Plan: third report on proposals and policies 2018-2032 (RPP3) - summary - gov.scot (www.gov.scot) (Accessed 29/03/2023)

535 Scottish Government (2023). Climate Change Adaptation Programme: Progress Report 2023. [Online]. Available at: Climate change adaptation programme: progress report 2023 - gov.scot (www.gov.scot) (Accessed: 28/08/2023)

536 Climate Change Committee (December 2020) Reducing Emissions in Scotland: 2020 Progress Report to Parliament [Online]. Available at: https://www.theccc.org.uk/publication/reducing-emissions-in-scotland-2020-progress-report-to-parliament/ (Accessed 29/03/2023)

come from action in the electricity sector, with the closure of Scotland's last remaining coal-fired power station in 2016 and rapid growth in renewable generation to fill the energy gap. In December 2022, the CCC published the 'Scottish Emission Targets – first five-yearly review & Progress in reducing emissions in Scotland' Reports[537], which state that Scotland's emissions reductions are amongst the most stretching in the world, but while key milestones are ambitious, there is no clear delivery plan on how they will be achieved. Scotland missed its annual emissions target in 2019[538], and prior to the COVID-19 pandemic was not on track to meet legislated emission reduction targets in 2020. The 2020 interim target was ultimately achieved, with emissions in 2020 falling by 12% from 2019 and 51% from 1990, although this is likely due to the COVID-19 pandemic, and it is unlikely the target would have been met without it. The annual targets in the 2020s are likely to be harder to achieve as emissions rebound, and the 75% reduction from 1990 levels interim target for 2030 is suggested to be extremely challenging, with current predictions projecting a 65-67% reduction in Scotland's emissions by 2030. Despite this challenge, between 1990 and 2020 there has been a 51% reduction in estimated emissions[539], with the most significant contributions coming from reductions in energy supply emissions (75.2% reduction), land use emissions, business emissions, waste management emissions, and domestic transport emissions. The Scottish Climate Change Plan aims to reduce emissions from electricity supply to zero by 2032, which although being a reserved policy area, is substantially influenced by devolved policies over planning and consenting key infrastructure and leasing offshore sites for renewable generation.

Scotland had 14.5 GW of installed renewable electricity generation capacity operational in March 2023[540], an 8.1% increase from March 2022 due to increases in onshore and offshore wind capacity. Most of the operational capacity comes from onshore wind, and half of the renewable capacity in Scotland comes from large installations of over 50 MW. It is anticipated that 87.8% of electricity generated in Scotland in 2021 was from low carbon sources, compared to 10.9% generated from fossil fuels. This has been caused by the growth of renewables, rising from 19.0% of all generation in 2010 to 57.0% in 2021. Comparatively, England and Wales use a significantly smaller proportion of low carbon (48.7%) and renewable (36.2%) sources for electricity generation and fossil fuels comprise 48.1% of their electricity generation.

Despite improvements in Scotland's renewable generation, further progress still needs to be made to reach Scotland's targets of a 75% reduction in greenhouse gas emissions by 2030, and to reaching net zero by 2045, as detailed in the 2021 Climate Change Plan. Although changes are required across the whole range of sectors, the electricity sector targets are on track, including the installed capacity of renewable generation[541]. In addition, due to the electrification of other sectors, including transport and heating, energy demand is increasing and ideally this energy should come from renewable sources. The Scottish Government is seeking to achieve the renewable, all energy consumption target of 50% by 2030, covering electricity, heat, and transport through expanding onshore and offshore wind, solar, bioenergy and hydro power. In addition, the Scottish Government is also committed to reviewing its energy consenting processes, and there was a total renewable capacity in the pipeline for Scotland of approximately 21.9 GW in March 2023. This was split between 433 projects, with 11.9 GW currently in planning and the rest under construction or awaiting construction. Were all capacity in the pipeline to be delivered, it would

---

537 Climate Change Committee (2022). Scottish Emission Targets – first five-yearly review & Progress in reducing emissions in Scotland – 2022 Report to Parliament. [Online]. Available at: Scottish Emission Targets & Progress in reducing emissions in Scotland – 2022 Report to Parliament - Climate Change Committee (theccc.org.uk) (Accessed: 28/08/2023)

538 Scottish Government (2021). Scottish Greenhouse Gas Statistics: 1990-2019. [Online]. Available at: https://www.gov.scot/publications/scottish-greenhouse-gas-statistics-1990-2019/ (Accessed 29/03/2023)

539 Scottish Government (2022). Scottish Greenhouse Gas Statistics 2020. [Online] Available at: Scottish Greenhouse Gas Statistics 2020 - Scottish Greenhouse Gas Statistics 2020 - gov.scot (www.gov.scot) (Accessed: 28/08/2023)

540 Scottish Government. (2023). Scottish Energy Statistics Hub. [Online] Available at: Scottish Energy Statistics Hub (shinyapps.io) (Accessed: 28/08/2023)

541 Scottish Government (2022). Climate Change Plan: Monitoring Reports 2022. [Online] Available at: Chapter 1: Electricity - Climate Change Plan: monitoring reports 2022 - gov.scot (www.gov.scot) (Accessed: 09/05/2023)

more than double the level currently deployed, and could generate approximately 53.8 TWh of renewable electricity per year, but there are a number of factors that influence whether projects get consented and constructed.

16.5 Assessment of Potential Effects

As a large energy generating asset with a capacity in excess of 50 MW, the Development can be classed as an asset of 'regional' importance and therefore, as 'medium' sensitivity for the following assessments.

16.5.1 Influences of the Development on Climate Change

16.5.1.1 Carbon Savings

Every unit of electricity produced by a wind farm development displaces a unit of electricity which would otherwise have been produced by a conventional power station, and therefore presents carbon savings. The Scottish Government Carbon Calculator was used to assess the carbon balance of the Development, and the full results can be seen on the tool's website (https://informatics.sepa.org.uk/CarbonCalculator/) using the Reference Number **MV20-EO4E-BHQ1**.

The electricity produced by a wind farm is assumed to substitute energy production by a mix of fossil fuels, or the national grid mix of energy generation. A renewable energy development would have a maximum potential to save carbon emissions when substituting a fossil fuel mix of electricity generation.

However, it is not appropriate to define the electricity source for which this renewable electricity project would substitute, due to uncertainty in future grid mix. For this reason, carbon emission savings are calculated for each scenario in the Carbon Balance Assessment using the carbon calculator (Technical Appendix 16.1). The results provided by the Carbon Calculator determining carbon savings from coal-fired electricity generation have been excluded from the assessment, as presently very little of the UK's electricity generation comes from coal-fired power stations and therefore the results are not relevant to the assessment.

The potential annual carbon emission savings for the Development are provided in Table 16.6. Based on the latest DUKES Statistics[542] and an average capacity factor of 32.4% (calculated as a rolling average of the past five years for wind using data from the DUKES 2023 Report, using stats 2018-2022), it is expected the Development would result in the production of approximately 166,037.05 megawatt hours (MWh) annually, equating to approximately 6,641,482 MWh over the operational life of the Development (40 years). This equates to displacing approximately 2,869,120 tonnes of fossil fuel mix generation equivalent CO_2 emissions, over the operational life which is a positive environmental effect. The projected change in wind speeds as a result of climate change over the operational phase of the Development is considered to be non-material for the purposes of this assessment.

Table 16.6: Carbon Savings for the Development (Expected Scenario)

Type of Generation	**Expected CO_2 Saving (t $C0_2yr^{-1}$)**
Grid mix electricity generation	32,108
Fossil fuel mix electricity generation	71,728

It should be noted that the average capacity factor of 32.4% is likely to represent a considerable underestimation when compared to the actual capacity factor at the Site. Consequently, carbon savings are also likely to be conservative.

542 UK Government (2023) Load factors for renewable electricity generation (DUKES 6.3) [Online] Available at: DUKES_6.3.xlsx (live.com) (Accessed 28/08/2023)

16.5.1.2 Carbon Losses

As detailed within the Scottish Government's Technical Note Version 2.10.0 on Calculating potential carbon losses and savings from wind farms on Scottish peatlands[513], the manufacturing, construction and installation of the wind turbines on Site has an associated carbon cost, and carbon losses are also generated by the requirement for extra capacity to back up wind power generation (although in reality this is influenced by the inclusion of BESS with the Development, which isn't accounted for in the Carbon Calculator results). Carbon losses associated with reduced carbon fixing potential and loss of soil organic matter occurs through drainage effects and excavation of peat for construction. Carbon losses at this Site are also associated with felling of existing forestry.

Organic soils (peatlands) in Scotland act as carbon sinks, whereby they absorb carbon dioxide and store it as carbon. This carbon can be released as carbon dioxide due to land use change, such as drainage for agriculture or the establishment of forestry. Wind farm developments on peatlands may result in a negative impact on these habitats if not appropriately considered during scheme design and development. Changes to the peatland habitat through development could result in a significant effect on its ability to store carbon, potentially resulting in reduced net carbon benefits of the Development.

Carbon losses for the expected scenario are summarised in Table 16.7.

Table 16.7: Carbon Losses for the Development (Expected Scenario)

Losses	t $C0_2$ Equivalent (total for wind farm lifetime)
Losses due to turbine life (e.g., manufacture, construction, decommissioning)	51,662
Losses due to back-up	44,277
Losses due to reduced carbon fixing potential	1,549
Losses from soil organic matter	14,782
Losses due to Dissolved Organic Carbon (DOC) and Particulate Organic Carbon (POC) leaching	18
Losses due to felling forestry	41,871
TOTAL LOSSES OF CO_2	154,159

16.5.1.3 Payback Period

The carbon payback period is a measurement/indicator to help assess a proposal. The shorter the payback the greater benefit the Development will have in displacing emissions associated with electricity generated by burning fossil fuels.

The payback period is calculated taking the total carbon cost (carbon losses) associated with the Development and dividing by the annual carbon gains from displaced fossil fuel power generation and any site improvements.

The estimated payback period for the Development is 4.7 years if it displaces energy generated from grid-mix electricity generation. In comparison to fossil fuel mix, the payback period of the Development reduces to 2.1 years. Table 16.8 below goes into further detail regarding the carbon payback period for the Development.

Table 16.8: Payback in Years for each Scenario (described in Section 16.3.6.1) used in the Carbon Calculator

Compared to…	Expected Scenario	Minimum Scenario	Maximum Scenario
Grid-mix electricity generation	4.7	2.3	7.6
Fossil fuel-mix of electricity generation	2.1	1.0	3.4

On this basis, the CO_2 emission generated from the construction of the Development are forecast to be cancelled out within approximately 5 years. The CO_2 emission savings for the operational lifetime beyond that (currently predicted as 40 years), would be a net benefit of the Development to reducing climate change. This is considered a 'Low' magnitude of effect (i.e., a slight, detectable, alteration of the baseline condition).

16.5.1.4 Battery Energy Storage System

As stated in Section 16.3.6.1, the carbon calculator devised by SEPA does not have the ability to account for BESS associated with wind farm developments. IEMA states, in the 'EIA Guide to Greenhouse Emissions Assessment', that high level, qualitative assessment is acceptable particularly where data is unavailable, or mitigation measures are agreed. This is the approach followed in this section.

There is a national requirement to balance the peaks and troughs associated with electricity supply and demands, to avoid strains on transmission and distribution networks, and to try to keep the electricity system stable. A BESS up to 41.4 MW is therefore proposed as part of the Development to support the flexible operation of the National Grid and decarbonisation of electricity. The BESS also reduces the need to have extra capacity within the electricity generation sector to back-up wind farm generation and reduces the need to have further electricity generation elsewhere as storage allows the complete utilisation of wind energy by minimising losses associated with supply and demand. In this assessment we assume the BESS has a two-hour duration (meaning the energy storage capacity would be 82.8 MWh), although this will be finalised before construction depending on the technology available at the time.

Investigation into the environmental effects of stationary batteries (Vandepaera et al)[543] demonstrates that the manufacturing stage drives the majority of environmental effects. This effect is greatly dependent on the percentage of fossil fuels in the electricity mix of the country of production. Romare and Dahllöf[544] concluded lifecycle greenhouse gas emissions of between 150-200 kg CO_2 eq/kWh installed, following a literature review of life-cycle assessments on lithium-ion batteries. Although focussed on the production of batteries for light duty vehicles, the (limited) data available pointed to a near-linear scale up of greenhouse gas emissions when the battery size increases. Using the higher emissions factor and based on the higher candidate design energy storage capacity of the project of 82.8 MWh, this gives an emissions cost of approximately 16,560 t eq CO_2. This cost would be 'paid back' by a further c. 0.52 years' of operation of the wind turbine generators as set out above compared to grid-mix electricity generation.

This figure does not allow for any savings in CO_2 emissions and is therefore conservative. Energy storage assets provide significant benefits in both decarbonisation and security of supply, and these benefits increase when they are operated as part of a portfolio of renewable generators (e.g., Barnhart, 2018)[545]. Batteries are capable of capturing "free" energy when generation is greater than demand and supplying it when demand is higher than generation. This assists with the operational management of the electricity network, especially when generation of electricity is variable (in addition to demand being variable), as it is with wind and solar power, which constitute the majority of renewable energy generation in the UK.

The battery storage aspect of the Development has the potential to facilitate the use of the electricity generated by the wind turbine generator aspect of the Development during peak times, or when electricity would otherwise be generated by fossil fuel sources. Although it is likely that the integration benefits of battery storage will enable further decarbonisation of the UK electrical grid, such decarbonisation is likely to be claimed by individual renewable energy development

---

[543] Vandepaera, L. *et al*. (2017) Environmental Impacts of Lithium Metal Polymer and Lithium-ion stationary batteries. Renewable and Sustainable Energy Reviews, Vol. 78, October 2017, p 46-60, Elsevier.

[544] Romare and Dahllöf (2017) The Life Cycle Energy Consumption and Greenhouse Gas Emissions from Lithium-Ion Batteries: A Study with Focus on Current Technology and Batteries for light-duty vehicles. IVL Swedish Environmental Research Institute Ltd.

[545] Barnhart, C. (2018). Energy and Carbon Intensities of Stored Solar Photovoltaic Energy. A comprehensive Guide to Solar Energy Systems pages 351-360, Academic press

applications, and any specific, quantified accounting here could be seen as double-counting. Despite the enabling effect, therefore, no direct CO_2 emissions saving has been ascribed, in this assessment, to the operation of the energy storage facility.

As the inclusion of an 82.8 MWh BESS in the Development only adds an additional approximately 0.52 years of operation of the windfarm to payback the carbon losses associated with the Development, the BESS is assessed to have negligible environmental effects which are not significant under the EIA Regulations.

16.5.1.5 Assessment

Given the challenge and international urgency of climate change, as identified in the recent IPCC special report, climate is considered to have 'Very High sensitivity' to changes in GHG emissions. The magnitude of change is considered 'Low' (i.e., a slight, detectable, change to the baseline condition, leading to an alteration of character).

The Development is therefore assessed to have 'Moderate', positive environmental effects, which is **significant** under the EIA Regulations.

16.5.2 Effects of Future Climate Change Scenario on Environmental Receptors Sensitive to Climate Change

The potential for environmental receptors to be impacted by the Development are assessed in Chapters 6 - 17 of this EIA Report. Of these ecological, ornithological and hydrological receptors are the most sensitive to climate change and are discussed further in Table 16.9 below.

Table 16.9: Climate Change Effects on Environmental Receptors

EIA Report Chapter	Receptor	Climate Change Effect by 2081 - 2100	Effect on Receptor
7	Ornithology	Temperature: up to Global mean of 2.8ºC (2.0 ˚C - 3.7 ˚C) Shift to wetter winters and drier summers Negligible change in wind speeds	A rise in temperature has the potential to impact on habitats which in turn may affect the behaviour of bird interests. As noted above uncertainties are high and the type and significance of effects identified from the Development are not anticipated to alter as a result.
8	Ecology	Temperature: up to Global mean of 2.8ºC (2.0 ˚C – 3.7 ˚C) Shift to wetter winters and drier summers Negligible change in wind speeds	While changes in temperature could affect the composition and growth rates of plant communities and invertebrates, and hence protected species and habitats, the uncertainties are high and it is not clear that the effect of the Development on those receptors would alter substantially as a result.
10 and 11	Hydrology and Hydrogeology and Geology and Peat	Shift to wetter winters and drier summers	Limited change to future baseline and to the identified effects of the Development.

Given the relatively limited magnitude of change in climate parameters predicted over the operation of the Development, negligible changes to the baseline for environmental receptors are anticipated during this period. This is incorporated into the assessments undertaken in other chapters of this EIA Report.

No additional significant effects will occur as a result of climate change during the operational phase of the Development.

16.6 Cumulative Effect Assessment

The Scottish and UK Governments have set ambitious targets for reducing GHG emissions by 2045 and 2050 respectively. The Development, in conjunction with other renewable energy developments, will contribute to Scotland and the UK's aims to reduce carbon emissions and achieve its ambitious GHG emissions targets.

DUKES 2023 details that renewable electricity represented 41.5% of total UK generation in 2022, with wind generations overall share of capacity increasing to 24.7% of all generators overall, up 3.8% on 2021. Of the total renewable electricity generation in the UK, onshore wind accounts for 10.8%[546].

Scotland had 14.5 GW of installed renewable electricity generation capacity operational as of March 2023. The bulk of Scottish renewable generation capacity as of 2023 is still onshore wind, at 9.3 GW of operational capacity. Total renewable capacity in Scotland continues to grow steadily with an 8.1% increase between March 2022 and March 2023[547].

The Development will contribute over 50 MW of installed capacity which will contribute to increasing renewable energy generation capacity within Scotland and the UK.

The cumulative effect of the Development with other Scottish renewables generation is considered to be a fundamental change in the climate effects of Scottish / UK energy supply and contribute to the legally binding emission reduction targets.

As a 'Very High' sensitivity receptor (i.e., very high environmental value, and of international importance), with a 'High' magnitude of effect (i.e., a fundamental change to the baseline condition), this represents a major, positive effect that is **significant** under the EIA Regulations.

16.7 Mitigation and Residual Effects

As detailed in Section 16.5.1, the Development will have a positive effect due to the CO_2 emission savings for the operational lifetime and beyond resulting in a net benefit of the Development to reducing climate change. Any adverse, negative effects as a result of the Development are of such limited, and negligible nature, that they are not significant in terms of the EIA Regulations. As such, no mitigation is required under the EIA Regulations other than that already embedded into the Development and recommended as best practice.

An iterative design approach was taken for the layout of the Development to carefully site turbines and hardstanding (e.g., maintain buffers to watercourses, use existing tracks where possible, minimise disturbance of peat soils and associated carbon losses). Further micro-siting will be informed by detailed pre-construction ground investigations.

An oPMP has been produced and is provided in Technical Appendix 11.2. Proposed reuses of the excavated peat are in line with the Scottish Renewables and SEPA Guidance[548]. Methods for handling and storing excavated peat have been described in the oPMP to ensure its reuse potential is maximised and any carbon losses are minimised. Monitoring of the reinstated areas will be carried out to ensure that the environmental objectives are realised.

The oPMP will be updated prior to construction once further site investigation data and detailed engineering designs are available. Temporary peat storage locations will be identified in the updated PMP and will be guided by a geotechnical engineer. The updated PMP will also include

546 UK Government (2023) Digest of United Kingdom Energy Statistics 2023 [Online] Available at: Digest of UK Energy Statistics (DUKES) 2023 - GOV.UK (www.gov.uk) (Accessed 28/08/2023).
547 Scottish Government (2023). Scottish Energy Statistics Hub. [Online] Available at: Scottish Energy Statistics Hub (shinyapps.io) (Accessed: 28/08/2023)
548 Scottish Renewables, SEPA (2012) Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and Minimisation of Waste [Online] Available at: https://www.gov.scot/Topics/Business-Industry/Energy/Energy-sources/19185/17852-1/CSavings/guidancepeatwaste (Accessed 29/03/2023)

detailed method statements and phasing of works and will be agreed with SEPA and the planning authority prior to construction commencing.

Under the Scottish Government's Control of Woodland Removal policy, any tree crops permanently removed as a result of the Development would require to be replanted on a like-for-like area basis either within the Site or at a suitable substitute location. Approximately 79.3 hectares (ha) of productive forestry would be removed to accommodate construction of the Development, and would be replanted on site where possible, with the remaining balance replaced by a compensatory planting scheme on a substitute site. The mitigation work to re-establish the areas of crops removed by both restocking within the Site and supplemental compensatory planting out with the Site will ensure the overall area of forestry crops is maintained. Chapter 14: Forestry provides further detailed assessment of forests and woodland**.**

Other mitigation measures will include the management of wind turbines to maintain operational efficiency during their lifetime. Maintenance plans for wind turbines would be developed to maximise turbine output and efficiency.

16.8 Summary of Effects

Table 16.10 provides a summary of the effects detailed within this chapter.

Table 16.10 Summary of Effects

Receptor	Potential Effect	Significance of Effect	Mitigation Proposed	Residual Effect
Influence of the Development on Climate Change				
Climate – average temperature predictions linked to GHG emissions	Reduction in GHG emissions through offsetting of existing conventional generation.	Moderate Major Cumulatively	None Embedded mitigation has reduced payback period and maximised beneficial impact.	Significant contribution cumulatively to regional emissions and renewable energy generation targets.
Effects on Environmental Receptors				
Environmental Receptors assessed in individual chapters of EIA Report.	Change to future baseline of receptors and assessment results.	Negligible Little change over time period to baseline condition of receptors.	None Mitigation as identified in individual assessment chapters.	None

16.9 Statement of Significance

The Development will have a significant, positive effect on carbon savings and cumulatively with Scottish renewable energy deployment. This is significant in terms of the EIA Regulations.

No additional significant effects to those already identified within the EIA Report will occur as a result of climate change during the operational phase of the Development.