Environmental Impact Assessment Report

Teindland Wind Farm

Volume 1

Chapter 10: Climate Change

Document prepared by Envams Ltd for: Teindland Wind Farm Ltd

April 2025

Envams

Contents

10 CLIMATE CHANGE AND CARBON BALANCE

10.1 INTRODUCTION

This Chapter evaluates the effects of the proposed Teindland Wind Farm (the Development) on land owned by Forestry and Land Scotland approximately 3 km north of Rothes, Moray, (the Site) on climate change, carbon balance, and presents a Climate Change Impact Assessment (CCIA). The Development is described in Chapter 4.

The carbon calculator is an online tool produced by the Scottish Government for use in processing the determination of onshore wind farm developments in Scotland. The purpose of the tool is to comprehensively assess the predicted carbon impact of the Development.

This Chapter is supported by Technical Appendix (TA) A10.1: Carbon Calculator Inputs.

This assessment was carried out by Paul Phillips, one of the directors of Envams Ltd, an environmental and planning consultancy specialising in renewable energy development in the UK. Paul is an IEMA Registered Environmental Impact Assessment Practitioner with over 20 years experience in Environmental Impact Assessment, the large majority of which he has spent working on renewable energy developments.

10.1.1 Scoping Responses and Consultations

Consultation for in relation to climate change and carbon emissions was undertaken as shown in Table 10.1.

Table 10.1: Consultation Responses from Consultees

Consultee	Type and Date	Summary of Response	Response to Consultee
SEPA	Scoping Response, 16th August 2022	Scottish Planning Policy states "Where peat and other carbon rich soils are present, applicants must assess the likely effects of development on carbon dioxide (CO_2) emissions."	Peat surveys and reporting are provided in Technical Appendix A12.1. The results of those surveys have been used to inform an assessment of potential effects of the Development on carbon dioxide emissions in accordance with relevant guidance in Section 10.5.2 of this Chapter.

10.2 LEGISLATION POLICY AND GUIDANCE

The EIA process is undertaken according to the below steps:

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

- The Electricity Act 1989[1];
- The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017 (the EIA Regulations)[2];
- National Planning Framework 4 (NPF4)[3];
- Onshore Wind Policy Statement 2022[4];
- The Draft Energy Strategy and Just Transition Plan[5];

[1] The Electricity Act (1989). Available at: https://www.legislation.gov.uk/ukpga/1989/29/contents [accessed on 13/04/2025].
[2] The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017, SI 2017/101. Available at: https://www.legislation.gov.uk/ssi/2017/101/contents [accessed on 13/04/2025].
[3] Scottish Government (2024). National Planning Framework 4. Available at: https://www.gov.scot/publications/national-planning-framework-4/ [accessed on 13/04/2025].
[4] Scottish Government (2022). Onshore Wind Policy Statement. Available at: https://www.gov.scot/publications/onshore-wind-policy-statement-2022/ [accessed on 13/04/2025].
[5] Scottish Government (2023). Draft Energy Strategy and Just Transition Plan. Available at: https://www.gov.scot/publications/draft-energy-strategy-transition-plan/ [accessed on 13/04/2025].

- Seventh Carbon Budget 2025[6];
- Net Zero Strategy: Build Back Greener[7];
- Update to the Climate Change Plan 2018-2032: Securing a Green Recovery on a Path to Net Zero[8];
- Progress in reducing UK emissions - 2023 Report to Parliament[9];
- UKCP18[10];
- Moray Council (2021). Climate Change Plan and Route Map to Net Zero[11]; and
- IEMA's "Assessing greenhouse gas emissions and evaluating their significance"[12] (the "IEMA Guidelines").

10.3 ASSESSMENT METHODOLOGY AND SIGNIFICANCE CRITERIA

10.3.1 Scope of Assessment

The following assessments are considered in terms of the Development:

- The vulnerability of the Development to climate change; and
- The influence of the Development on 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 results of the assessment are a conservative estimate as the battery energy storage system (BESS) of the Development is not included in the Scottish Government tool for calculating carbon savings. The BESS will store electricity for export to the grid at times of need and will further displace other forms of generation usually drawn on at those times.

10.3.2 Study Area

The study area considered for the assessment of vulnerability of the Development to climate change consists of all infrastructure proposed within the Site. The assessment considers the forecast climate changes over the planned operational phase of the Development, i.e., 40 years from commissioning. Information on climate trends and projections at the Scottish and local scale are utilised.

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.

---

[6] Climate Change Committee (2025). The Seventh Carbon Budget. Available at: https://www.theccc.org.uk/publication/the-seventh-carbon-budget/ [accessed on 13/04/2025].

[7] DESNZ (2022). Net Zero Strategy: Build Back Greener. Available at: https://www.gov.uk/government/publications/net-zero-strategy [accessed on 13/04/2025].

[8] Scottish Government (2020). Securing a green recovery on a path to net zero: climate change plan 2018–2032 – update. Available at: https://www.gov.scot/publications/securing-green-recovery-path-net-zero-update-climate-change-plan-20182032/ [accessed on 13/04/2025].

[9] Climate Change Committee (2023). Progress in reducing UK emissions - 2023 Report to Parliament. Available at: https://www.theccc.org.uk/wp-content/uploads/2023/06/Progress-in-reducing-UK-emissions-2023-Report-to-Parliament-1.pdf [accessed on 13/04/2025].

[10] MetOffice (2025). UK Climate Projections. Available at: https://www.metoffice.gov.uk/research/approach/collaboration/ukcp [accessed on 13/04/2025].

[11] Moray Council (2021). Climate Change Plan and Route Map to Net Zero. Available at: http://www.moray.gov.uk/downloads/file149060.pdf [Accessed 28/03/2025]

[12] Institute of Environmental Management and Assessment (IEMA) (2017). Assessing Greenhouse Gas Emissions and Evaluating their Significance 2nd Edition [Online]. Available at: https://www.iema.net/resources/blogs/2022/02/28/iema-launch-of-the-updated-eia-guidance-on-assessing-ghg-emissions-february-2022/ [accessed on 13/04/2025].

10.3.3 Design Parameters

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

- Installed capacity and capacity factor of the wind turbines - for calculation of carbon balance;
- Turbine spacing in relation to prevailing wind direction - for effects on generation, turbulence, vulnerability to damage with potential changes to wind speed, direction and storminess;
- Amount and layout of new track and infrastructure, including excavations and small areas of felling, in relation to deep peat – 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.

10.3.4 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 September 2019. The UKCP18 provides the most up to date assessment of how the climate of the UK may change over this century.

UKCP18 uses scenarios for future greenhouse gas 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 socioeconomic 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);
- RCP4.5: assumes an increase in global mean surface temperature of 2.4°C (1.7-3.2) by 2081-2100 (low emissions scenario);
- RCP6.0: assumes an increase in global mean surface temperature of 2.8°C (2.0-3.7) by 2081-2100 (medium emissions scenario); 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).

Over the 40-year anticipated lifetime 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[13], 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 and this is also utilised for limited assessment parameters[14].

[13] United Nations (2016) Framework Convention on Climate Change. Adoption of the Paris Agreement, 21st Conference of the Parties, Paris. Available at: https://unfccc.int/resource/docs/2015/cop21/eng/10a01.pdf (Accessed 28/03/2025)
[14] Lowe et al (2018) UKCP18 Science Overview Report (Page 13)

Vulnerability of the Development to Climate Change

This section of the CCIA identifies aspects of the Development which are potentially vulnerable to the effects of climate change. Where identified, these vulnerabilities can then be mitigated through embedded mitigation or the application of other measures.

Taking into account the nature and location of the Development, the following climate related parameters are considered to have the potential to impact upon the operation of the Development:

- Wind (speed, direction and gustiness);
- Temperature; and
- Precipitation.

The construction and decommissioning stages of the Development are not considered to be vulnerable to climate change and have been scoped out of further consideration.

Influence of the Development on Climate Change

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

In Scotland, applications submitted under Section 36 of the Electricity Act 1989 are required to undertake the carbon balance assessment using the Scottish Government's carbon calculator tool. At the time of completing this Carbon Balance assessment, the online calculator was unavailable. When approached, the Energy Consents Unit provided the latest draft of the Carbon Calculator in excel format (Version 2.14.1). 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'[15]. This publication sets out the approach and assumptions that should be used to estimate potential carbon losses and savings from wind farms on Scottish peatlands. The carbon balance assessment inputs are included as TA A10.1. Note that this method does not account for the carbon savings from constructing and operating the BESS (which would displace emissions from gas generation, typically, and hence would lead to further savings), so in this respect the assessment is conservative.

The calculation evaluates the balance of total carbon savings and carbon losses over the life of the Development (excluding the effect of the batteries and other infrastructure in the BESS compound, as these are not covered by the Scottish Government's carbon calculator tool). The potential carbon savings and carbon costs associated with wind farms generally 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 value of a wind farm development in terms of overall carbon savings.

Calculations are provided for expected, best case and worst-case scenarios of Development. All scenarios are based on the layout of 12 turbines and candidate turbine described in Chapter 4: Development Description. The final turbine capacity will be

[15] Nayak et al (2008) Calculating carbon savings from wind farms on Scottish peat lands: a new approach (Scottish Government). Available at: https://www.gov.scot/publications/calculating-carbon-savings-wind- farms-scottish-peat-lands-new-approach/pages/13/ (Accessed 28/03/2025)

confirmed prior to construction, and is likely an estimated installed capacity of approximately 86 MW case, plus the battery energy storage system (BESS).

The other scenarios are based on varying assumptions regarding wind energy capacity factor, characteristics of peatland and Development land-take. The data sources and assumptions used in the carbon balance assessment are detailed in TA A10.1. The assessment was informed by peat probing data and analysis, as described in TA A12.1: Peat Assessment and Peat Management Plan.

10.3.5 Methodology for the Assessment of Effects

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.

10.3.5.1 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, is assessed in line with best practice guidance, legislation, statutory designations and / or professional judgement. Table 10.2 details the criteria for determining the sensitivity of receptors.

Table 10.2: Criteria 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 or benefit to its character, is low environmental value, or is of local importance.
Very Low	The receptor is resistant to change and is of little environmental value.

The two receptors that are the focus of this chapter are the Development itself, and the climate. The Development is assessed as being of High sensitivity to changes to it caused by the weather, on the basis that it is a National Development (as categorised by National Planning Framework 4). Climate change is well established as being one of the major threats to the world, as well as locally, and hence the climate is assessed as being Very High sensitivity.

10.3.5.2 Magnitude of Change

The magnitude of change 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 change are presented in Table 10.3.

Table 10.3: Criteria for Determining Magnitude of Change

Magnitude of Change	Definition
Very High	A national-level change to the baseline condition of a receptor.
High	A fundamental change (positive or negative) to the baseline condition of the receptor, leading to total loss or major alteration of character.
Medium	A material change (positive or negative) leading to partial loss or alteration of character.
Low	A slight, detectable, alteration of the baseline condition which may be positive or negative.
Negligible	A barely distinguishable change from baseline conditions.

10.3.5.3 *Significance of Effect (General)*

The sensitivity of the asset and the magnitude of the predicted change 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:

"Once the sensitivity and magnitude have been determined, these should be combined to reach an overall judgement on the significance of the likely environmental effect. As there is no legislative definition of 'significance', the conclusion of whether an effect is significant/the level of significance is down to the CCAR [Climate Change Adaption and Resilience] Coordinator in conjunction with the EIA Coordinator. An explanation of the outcomes of the assessment should be clearly set out.

Appropriate criteria for sensitivity, magnitude and significance for the climate resilience assessment should be developed on a project-by-project basis by the CCAR Coordinator in conjunction with the EIA Coordinator, and should take into account the aims/purpose of the project."

Table 10.4 outlines the framework for the assessment of significance of effects.

Table 10.4: Framework for Assessment of the Significance of Effects

Magnitude of Change	Sensitivity of Resource or Receptor				
	Very High	**High**	**Medium**	**Low**	**Negligible**
Very High	Major	Major	Major	Moderate	Minor
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 predicted 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 the above table.

The categories of significance are described in Table 10.5.

Table 10.5: 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, environmental, 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 positive, negative or neutral. Whilst receptors may be considered "high-value", a non-material magnitude of the impact would result in any effect being considered not significant.

10.3.5.4 Significance of Effect (Carbon Emissions)

The IEMA Guidelines plot different levels of significance against five levels of net zero compatibility. The significance level for 'business as usual' and 'do minimum' has been decided within this assessment using professional judgement. These are:

- Business as usual – the development is not compatible with the UK's net zero trajectory and GHG impacts are not mitigated. Classed as a major significant adverse effect;
- Do minimum – the development is not compatible with the UK's net zero trajectory and GHG are partially mitigated. Classed as a moderate significant adverse effect;
- Compatible with the budgeted, science base 1.5% trajectory – the development may have residual emissions but is doing enough to align with and contribute to the relevant transition scenario. Classed as a minor non-significant effect;
- Achieves emissions mitigation that goes substantially beyond the reduction trajectory – the development has minimal residual emissions and plays a part in achieving the rate of transition required by nationally set policy commitments. Classed as a negligible non-significant effect; and
- Causes GHG emissions to be avoided – the development actively reverses the risk of severe climate change. Classed as a major beneficial significant effect.

10.3.6 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 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[16].

Specifically, in relation to wind, the UKCP18 Wind Fact sheet[17] 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.

At the time of conducting the assessment, the online version of the carbon calculator tool was not available, and the Scottish Government directed the project team to use an Excel version, version number 2.14.1, dated 27/01/2023. It is noted that this version makes the implicit assumption that the carbon emissions from coal, gas and grid-mix electricity generation, that will be displaced as a result of the Development generating electricity, will remain constant across the 40-year operational life of the Development. Other government sources[18] indicate this is not likely to be the case, with long-run marginal emissions factors

[16] Lowe et al (2018) UKCP18 Science Overview Report
[17] 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 28/03/2025)
[18] DESNZ (2023). Data Tables 1-19. Available at: https://assets.publishing.service.gov.uk/media/6567994fcc1ec5000d8eef17/data-tables-1-19.xlsx [accessed on 13/04/2025]. This set of tables supports the Treasury Green Book supplementary appraisal guidance on valuing energy use and greenhouse gas (GHG) emissions. The appraisal guidance, background analysis and calculations toolkit may be found on the Green Book supplementary guidance section of GOV.UK website: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal [accessed on 13/04/2025]

reducing to approximately 10% of their 2024 values by 2035. These numbers, however, depend on substantial increases in the proportion of total electricity generation coming from low-carbon sources, from projects such as the Development. Whilst there remains considerable uncertainty associated with the numbers used in the spreadsheet, it is clear that electricity generated from the Development would displace electricity generated from, on average, higher-carbon sources, with these savings being substantial for at least a few years (and much longer than the predicted “pay-back” time). As a result, the qualitative conclusions of the assessment may be relied on, notwithstanding uncertainties in the quantified values.

10.3.7 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 built to withstand strong windspeeds and to harness energy;
- Turbine spacing (3 x 5 rotor distance) sufficient to reduce turbulence effects on turbines downwind;
- Turbines are located to maximise energy generation while minimising environmental impacts;
- The Development design aims to minimise environmental impacts e.g., through use of the existing track layout;
- Turbines, and associated infrastructure, have been sited to avoid the small areas of deep peat at the site, to minimise peat disturbance;
- Any required areas of felling have been reduced as far as practicable, such as through key-holing and re-use of existing tracks, and will be replanted through compensatory planting off-site;
- A detailed Construction Environmental Management Plan (CEMP) and Peat Management Plan (PMP) will be drafted and agreed prior to construction, to minimise environmental impacts and peat disturbance in the post-consent detailed design process, with specific turbine technologies proposed at that time; and
- 50 m buffers from watercourses have been incorporated in the layout design as far as practicable, protecting water quality and also protecting Development infrastructure from flooding.

10.4 BASELINE CONDITIONS

In the future, it is expected the GHG/carbon intensity will continue to decline in Scotland due to legislative and policy changes and decarbonisation of industry, energy supply and transportation.

However, 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.

The State of the UK Climate 2023[19] provides the latest report on observed UK climate data for the most recent decade (2014-2023). Key findings are:

- The most recent decade (2014–2023) has been on average 0.42°C warmer than the 1991–2020 average and 1.25°C warmer than 1961–1990. This is the warmest 10-year period in both the UK series from 1884 and CET series from 1659;
- The most recent decade (2014–2023) has had almost a week fewer air frosts per year than the 1991–2020 average and over a fortnight fewer than 1961–1990;
- The most recent decade (2014–2023) has had over a week fewer ground frosts per year than the 1991–2020 average and almost a month fewer than 1961–1990;

[19] Met Office (2024) State of the UK climate. Available at: https://www.metoffice.gov.uk/research/climate/maps-and-data/about/state-of-climate (Accessed 28/03/2025).

- The most recent decade (2014–2023) has been 2% wetter than 1991–2020 and 10% wetter than 1961–1990;
- UK winters for the most recent decade (2014–2023) have been 9% wetter than 1991–2020 and 24% wetter than 1961–1990, with smaller increases in summer and autumn and none in spring; and
- There have been fewer occurrences of max gust speeds exceeding 40/50/60 Kt in the last two decades compared with the 1980s and 1990s.

10.4.1 Wind Speed

The latest UKCP Fact Sheet for Wind, updated in August 2022[20], states that the global projections over the UK show an increase in near surface (10 metre [m] height) wind speeds over the UK in the second half of the 21st century, in the winter season when higher wind speeds are experienced.

This would be accompanied by an increase in frequency of winter storms over the UK. The increase is modest when compared to inter-annual variability.

There are no significant changes forecast in the wind speeds over the first part of the century.

10.4.2 Precipitation

The UKCP18 Science Overview Report states that throughout the UK, the changes to precipitation projected for 2041-2060 (compared to 1981-2000) for RCP8.5 (unmitigated scenario) are an increase of 7% in winter for the 50th percentile (results for the 10th to 90th percentile range are between -5% and +21%).

For summer precipitation, this is projected to decrease by 15% (results for the 10th to 90th percentile range are between -35% and +0%)[21].

10.4.3 Temperature

UKCP18 Science Overview Report states that for period 2041-2060, projected changes to annual mean temperature (compared to 1981-2000) is projected at +1.8 °C (50th percentile) for RCP8.5 (unmitigated scenario). Results for the 10th to 90th percentile range are between +0.9°C to +2.7°C[22].

Other key observations from the latest UKCP Fact Sheet for Temperature (Met Office, 2022c) are that:

- Both winters and summers will be warmer, with more warming in the summer; and
- In summer there is a pronounced north/south divide with greater increases in maximum summer temperatures over the southern UK compared to Northern Scotland.

10.5 ASSESSMENT OF POTENTIAL EFFECTS

As a large energy asset of generation in excess of 50 MW, the Development can be classed as an asset of regional importance and is classed as medium sensitivity for the following assessments.

10.5.1 Vulnerability of the Development to Climate Change

10.5.1.1 Wind

As energy content of the wind varies with the cube of the average wind speed[23], small increases in wind speed can result in large increases in wind power. There is a higher risk of

[20] Met Office (2021) UKCP18 Fact Sheet: Wind. Available at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-fact-sheet-wind_march21.pdf [Accessed 28/03/2025].
[21] Lowe *et al* (2018) UKCP18 Science Overview Report November 2018 (Updated March 2019)
[22] Lowe *et al* (2018) UKCP18 Science Overview Report November 2018 (Updated March 2019) (Table 2.2, Page 16)
[23] Energy Savings Trust (2019) Wind Turbine: Measuring Wind Speed [Online] Available at: https://www.energysavingtrust.org.uk/sites/default/files/reports/wind%20turbine_measuring%20wind%20speed.pdf (Accessed 28/03/2025)

damage from strong winds; winds associated with major storm events can be some of the most damaging and disruptive events for the UK with implications for infrastructure.

Wind turbines are designed to capture wind energy, and built to withstand extreme conditions associated with exposed locations. However, wind energy developments could potentially be sensitive to significant changes in variables, including atmospheric circulation and land cover changes as well as changes in the frequency of extreme events (e.g., storms), which could damage wind turbines or alter their efficiency.

Over the lifetime of the Development, UKCP18 states that there are no compelling trends in storminess (as a result of maximum gust speeds) over the last four decades and for wind speed change there is little long-term trend evident. Therefore, the natural variability which exists in wind speed, and subsequently storms, will have a negligible magnitude of change on energy projections and on the efficient operation of the Development.

Given the negligible magnitude of the effect and the medium sensitivity of the Development as a receptor, the effect is assessed as negligible, and **not significant** in terms of the EIA Regulations.

10.5.1.2 Temperature

Wind energy developments are sensitive to cold weather events and ice forming on blades. When icing does occur, the turbine's own vibration sensors are likely to detect the imbalance and inhibit the operation of the machines. With the projected trend to warmer conditions, the predicted magnitude of change is negligible. The effect is assessed as negligible and therefore **not significant** in terms of the EIA Regulations.

10.5.1.3 Precipitation

The risk from increased precipitation is the potential for flooding, particularly if it is associated with extreme events. For the Development this increases the risk for potential destruction/disruption of infrastructure, e.g., loss of watercourse crossing, flooding to control building. Buffers from watercourses are embedded in the turbine locations and hardstandings of the Development, where access tracks or watercourse crossing are required, these are designed in lined with best practice with a CEMP implemented during construction. As such, the Development has low sensitivity to increase in precipitation.

UKCP18 show that over the winter season precipitation in this area of Scotland is projected to increase by up to 30% at the medium estimate. Given the embedded mitigation, the magnitude of effect on the operation of the Development is assessed as low and the overall effect is minor and therefore, **not significant**.

10.5.2 Influences of the Development on Climate Change

10.5.2.1 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 (coal or gas) power station, and therefore presents carbon savings.

The electricity produced from the wind farm is assumed to substitute energy production by entirely coal-fired generation, or 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 coal fired generation, which is a possibility if coal is at the bottom of the cost merit order of 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 calculator (TA A10.1).

The potential annual carbon emission savings for the Development are provided in Table 10.6. Based on a site-specific capacity factor provided by the Applicant's wind modelling team of between 38% and 48%, it is expected the Development would result in the production of approximately 325,451 MWh annually, equating to 13,018,061 MWh over the operational life of the Development. This equates to displacing approximately 142,222 tonnes of fossil fuel mix generation equivalent CO_2 emissions over the operational life which is a beneficial 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 10.6: Carbon Savings for the Development (Expected Scenario)

Type of Electricity Generation	Expected CO2 Saving (t $C0_2yr^{-1}$)
Coal fired electricity generation	340,422
Grid mix electricity generation	55,652
Fossil fuel mix electricity generation	142,222

10.5.2.2 *Carbon Losses*

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. Carbon losses associated with reduced carbon fixing potential and loss of soil organic matter occurs through excavation of peat for construction and drainage effects (albeit the amounts of peat are very low on this Site compared to many Scottish upland sites).

Organic soils (peatlands) in Scotland act as carbon sinks, whereby they absorb carbon dioxide then they release it due to land use change, such as 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.

A peat depth survey was undertaken across the Site where it was established that the average peat depth within the Site is 0.17 m and that areas of deep peat were localised, with the only appreciable area found in a shallow gulley. The design process sought to avoid disturbance to deposits of deep peat. The re-use of existing tracks has been proposed where practicable to minimise the disturbance to peat and peaty soils and cable trenches will follow the on-site access tracks.

Carbon losses for the expected scenario are summarised in Table 10.7.

Table 10.7: Carbon Losses for the Development (Expected Scenario)

Losses	Carbon Losses (tCO_2) Expected Value
Losses due to turbine life (e.g., manufacture, construction, decommissioning)	75,496
Losses due to back-up	66,150
Losses due to reduced carbon fixing potential	1,476
Losses from soil organic matter	171
Losses due to Dissolved Organic Carbon (DOC) and Particulate Organic Carbon (POC) leaching	0
Losses due to felling forestry	77,447
Total losses	**220,740**

10.5.2.3 *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 expected payback period for the Development is 1.6 years compared to the fossil fuel-mix of electricity generation. In comparison, the expected payback period of the Development for the grid-mix and coal-fired electricity generation is 4.0 years and 0.6 years, respectively. Table 10.8 below goes into further detail regarding the carbon payback period for the Development.

Table 10.8: Payback in Years for each Scenario used in the Carbon Calculator

Generation Source	Counterfactual emission factors (2021) (t CO_2 MWh^{-1})	Carbon Payback Period (years)		
		Expected Value	Minimum Value	Maximum Value
Coal-fired plant	1.046	0.6	0.4	1.1
Grid-mix	0.171	4.0	2.7	6.8
Fossil fuel-mix	0.437	1.6	1.1	2.7

The CO_2 emission savings for the operational lifetime of the Development (expected to be 40 years) would be a net benefit with regards to reducing climate change by reducing greenhouse gas emissions. In accordance with the criteria in Section 10.3.5.4, the Development "*causes GHG emissions to be avoided – the development actively reverses the risk of severe climate change. Classed as a major* ***beneficial significant effect***."

10.6 MITIGATION AND RESIDUAL EFFECTS

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. This has been maximised by optimising the number and size of turbines in the Development whilst balanced against the limited adverse environmental effects.

10.7 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 meet its ambitious greenhouse gas emissions targets.

The Development will contribute approximately 86 MW of installed capacity which will contribute to increasing renewable energy generation capacity within Scotland the UK.

The cumulative effect of the Development with other UK renewables generation will be a fundamental change in the climate effects of UK energy supply. This represents a major, positive effect that is **significant** under the EIA Regulations.

10.8 SUMMARY OF EFFECTS

Table 10.9 provides a summary of the effects detailed within this Chapter.

Table 10.9: Summary of Effects

Receptor	Potential Effect	Significance of Effect	Mitigation Proposed	Residual Effect
Vulnerability of Development to Climate Change				
Wind Turbines	Changes in the frequency of extreme events (e.g., storms), which could damage wind turbines or alter their efficiency.	Negligible No Significant Effects	None	None
Wind Turbines	Wind energy developments are sensitive to cold weather events and ice forming on blades.	Negligible No Significant Effects	Embedded mitigation in that when icing does occur, the turbine's own vibration sensors will detect the	None

Receptor	Potential Effect	Significance of Effect	Mitigation Proposed	Residual Effect
			imbalance and inhibit the operation of the machines.	
Potential destruction/disruption of infrastructure	The risk from increased precipitation is the potential for flooding impacts to infrastructure. E.g., loss of watercourse crossing, flooding to control building.	Minor No Significant Effects	Embedded mitigation through watercourse buffers for turbine locations and hardstandings. Access tracks and watercourse crossings are designed in line with best practice, with a CEMP implemented during construction.	None
Influence of the Development on Climate Change				
Climate - average temperatures as linked to GHG emissions.	Reduction in GHG emissions through offsetting of existing conventional generation.	Major beneficial Significant Cumulative effects: Major beneficial Significant	None Embedded mitigation has reduced payback period and maximised beneficial impact.	Significant contribution individual and cumulatively to GHG emission reductions.

10.9 STATEMENT OF SIGNIFICANCE

The Development will have a beneficial effect on carbon savings, which is a **significant beneficial** effect on the reduction of greenhouse gas emissions both individually and cumulatively.

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