

Technical Appendix 12.1: Carbon Balance Assessment

12.1 Carbon Balance Assessment

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12 Carbon Balance Assessment

12.1 Executive Summary

- 12.1.1 This Carbon Balance Assessment uses the Scottish Government's Carbon Calculator for Wind Farms on Peat to assess the benefit of generating renewable electricity, compared to the emissions of carbon required for the construction and operation of Glenouther Wind Farm (the Proposed Development) over its 35-year lifetime. The Carbon Calculator provides an estimate of the carbon payback time for the Proposed Development.
- 12.1.2 The results of the Carbon Calculator show that the Proposed Development is estimated to save nearly 50,000 tonnes of CO₂e per year, through the displacement of grid electricity, based on the current fossil fuel grid mix. Displacement of existing sources of generating capacity depends on the time of day and how the grid needs to be balanced. Although it does depend on the rate of electrification of transport and heat in buildings, it is reasonable to anticipate that, over the lifetime of the Proposed Development, the electricity generated will displace existing fossil fuel usage.
- 12.1.3 The assessment of the Proposed Development estimates losses of about 68,000 tonnes of CO₂e over the lifetime of the Proposed Development. The largest proportion of these are from grid backup and turbine lifecycle which are not within the direct control of the Developer. Losses from grid backup are likely to be overestimated as they do not account for future developments in electricity storage or demand management by the grid. The most significant category of site-based losses is from reduced future carbon sequestration potential from felled forestry. However, future gains from forestry restocking and compensatory planting are not included in the Carbon Calculator, and therefore the losses of future sequestration are likely to be overstated. Soil carbon losses account for around 5.4% of losses, but it should be noted that the Carbon Calculator assumes that all extracted and drained peat is oxidised and does not include any reduction from peat that is successfully reinstated. The baseline assessment demonstrated that less than 0.2% of the soil carbon within the Site boundary would be affected by the Proposed Development. Restoration of areas of degraded bog and forestry to bog are estimated to produce gains over the lifetime of the Proposed Development through blocking of drains, re-wetting of peat and restoring surface vegetation; these gains are estimated at nearly 10,000 tonnes of CO₂e, which is approximately 6,300 tonnes of CO₂e more than that which is lost through peat excavation and drainage.
- 12.1.4 The estimated payback time of the Proposed Development, using the Scottish Government Carbon Calculator, is 1.2 years, with a minimum/maximum range of 0.7 to 1.7 years, based on the fossil fuel mix of the electricity grid. This is around 4% of the anticipated lifespan of the Proposed Development. Compared to fossil fuel electricity generation projects, which also produce embodied emissions during the construction phase and then significant emissions during operation due to combustion of fossil fuels, the Proposed Development has a low carbon footprint, and after 1.2 years the electricity generated is estimated to be carbon neutral and will displace grid electricity generated from fossil fuel sources or directly displace fossil fuel use for transport and heating. The carbon intensity of the electricity produced by the Proposed Development is estimated at 0.015 kgCO₂e/kWh. This is well below the outcome indicator for maintaining the electricity grid carbon intensity below 0.04 kgCO₂e/kWh required by the Scottish Government in the Climate Change Plan (Scottish Government, 2026), and therefore; the Proposed Development is evaluated to have an overall beneficial effect on carbon emissions associated with energy generation.

12.2 Introduction

- 12.2.1 This Carbon Balance Assessment has been undertaken by Clare Wharmby on behalf of OWC Ltd. Clare is a Full member of ISEP and a Chartered Environmentalist with over 20 years of experience undertaking carbon balance assessments for wind farms on peat across the UK.
- 12.2.2 Increasing atmospheric concentrations of greenhouse gases (GHGs), also called carbon emissions, are resulting in global heating which are predicted to cause catastrophic changes to our climate. A major contributor to this increase in GHG emissions is the burning of fossil fuels for primary energy or electricity generation; in the UK, 34.9% of electricity was generated from fossil fuels in 2025 (Department for Energy Security and Net Zero, 2026). With concern growing over climate change, reducing its cause is of utmost importance. The replacement of traditional fossil fuel power generation with renewable energy sources provides high potential for the reduction of GHG emissions. This is reflected in UK and Scottish Governments' delivery plans for climate targets (Carbon Budget and Growth Delivery Plan (Department for Energy Security and Net Zero, October 2025) and Scotland's Climate Change Plan: 2026–2040 (Scottish Government, 2026)).
- 12.2.3 However, no form of electricity generation is completely carbon free; for onshore wind farms, there will be emissions resulting from the manufacture of turbines, as well as emissions from resulting from the construction, operation and decommissioning of the site.
- 12.2.4 In addition to the lifecycle emissions from the turbines and associated wind farm infrastructure, where a wind farm is located on carbon rich soils such as peat, there are potential emissions resulting from direct action of excavating peat for construction and the indirect changes to hydrology that can result in losses of soil carbon. The footprint of a wind farm's infrastructure can also decrease the area covered by carbon-fixing vegetation such as forestry. Conversely, restoration activities undertaken post-construction or post-decommissioning could have a beneficial effect on stored carbon through the restoration of modified bog habitat. Carbon losses and gains during the construction and lifetime of a wind farm, and the long-term impacts on the peatland and forestry on which they are sited, need to be evaluated to understand the consequences of permitting such developments.
- 12.2.5 The aim of this Appendix Report is to provide clear information about the whole life carbon balance of the Proposed Development which in turn supports the assessment of effects on climate change set out in Chapter 12: Climate Change of the Environmental Impact Assessment Report (EIA Report). Whilst the application for the Proposed Development will be made under the Town and Country Planning Act and therefore there is no stated requirement for submission of a Carbon Balance Assessment, the applicant is providing it as a tool to help exemplify the potential carbon balance of the Proposed Development to inform the Overall Planning Balance. This Appendix Report explains the policy basis for assessing carbon balance, details the methodology and input parameters used and provides an estimate of the expected net carbon savings over the lifetime of the Proposed Development, once carbon losses from materials and ecological disturbance have been considered.

12.3 Legislation, Policy and Guidelines

This assessment has been carried out in accordance with the principles contained within the following legislation and policy.

Legislation

- 12.3.1 One of the key drivers for the development of renewable energy is the Climate Change (Emissions Reduction Targets) (Scotland) Act 2019, which sets a net-zero target for the Scottish emissions account by 2045.

Policy

- 12.3.2 The Clean Power 2030 Action Plan which was published at the end of 2024 emphasises that all routes to a Clean Power system by 2030 (defined as using clean sources to generate as much power as Great Britain consumes) will require mass deployment of offshore wind, onshore wind, and solar but also states that ‘new energy infrastructure should be built in a way that protects the natural environment by following a “mitigation hierarchy” to do what is possible to avoid damage to nature, and then minimising, restoring and delivering compensation when damage is impossible to avoid’.
- 12.3.3 Scotland’s Climate Change Plan (Scottish Government, 2026) recognises the need to continue to grow renewable energy capacity with a strong pipeline of future projects that will play a key role in decarbonising the GB power system. However, the CCP also recognises that the extensive area of peatland and forestry in Scotland, are critical to climate goals for the whole of the UK.
- 12.3.4 The Scottish Energy Strategy (Scottish Government, 2017) set a whole-system target to supply the equivalent of 50% of all the energy for Scotland’s heat, transport, and electricity consumption from renewable sources by 2030. The new Draft Energy Strategy and Just Transition Plan was published 10 January 2023 and is currently undergoing post-consultation review. The draft strategy recognises that the peatland impacts of onshore wind farms can be significant, and Scotland needs to balance the benefits from onshore wind deployment and the impact on carbon rich habitats. The draft strategy commits to convening an expert group, including representatives from industry, agencies, and academia to provide advice to the Scottish Government on how guidance could be developed to support both peatland and onshore wind aims. Furthermore, the strategy states that the Scottish Government will ensure that adequate tools and guidance are available to inform the assessment of net carbon impacts of development proposals on peatlands and other carbon-rich soils.
- 12.3.5 National Planning Framework 4 (Scottish Government, 2023) sets the national spatial strategy for Scotland, including spatial principles, regional priorities, national developments, and national planning policy.
- 12.3.6 Policy 1 states:
When considering all development proposals significant weight will be given to the global climate and nature crises.
Policy 5 states that:

c) Development proposals on peatland, carbon rich soils and priority peatland habitat will only be supported for:

ii. The generation of energy from renewable sources that optimises the contribution of the area to greenhouse gas emissions reductions targets;

d) Where development on peatland, carbon-rich soils or priority peatland habitat is proposed, a detailed site specific assessment will be required to identify:

iii. the likely net effects of the development on climate emissions and loss of carbon.

Guidance

12.3.7 The Environmental Impact Assessment Guide to Assessing Greenhouse Gas Emissions and Evaluating their Significance (IEMA, 2022) provides guidance for assessing the baseline against which the impact of a new project can be compared against, how to set an appropriate study boundary and how to communicate the impacts. This guidance has been considered in the content of this Appendix Report.

12.4 Assessment Methodology

12.4.1 The assessment has used the following methodologies to estimate the overall impact of the Proposed Development on the carbon balance at the Site:

- the baseline assessment of carbon stored in soils at the Site has been calculated using desk and field data and standard values for carbon content of peat; and
- the carbon payback of the wind turbine component of the Proposed Development has been estimated using the Scottish Government's Carbon Calculator, (excel version 2.15.6).

12.4.2 GHG emissions are measured in tonnes of carbon dioxide equivalents (tCO₂e) which is a quantity that describes, for a given mixture and amount of GHG, the amount of carbon dioxide (CO₂) that would have the same global warming potential (GWP), when measured over a 100-year timescale. These units therefore enable comparison of different GHGs emitted, or saved, at different project stages.

Baseline Assessment Methodology

12.4.3 The stored carbon within the Proposed Development red line boundary (the 'Site') was estimated from the estimated volume of peat. The volume was calculated from the average depth of peat at the Site based on the Phase 1 peat probes within the red line boundary (as detailed in Technical Appendix 9.2: Peat Survey Report of the EIA Report) to reduce the sampling bias from detailed peat probing for infrastructure. The average depth was multiplied by the total Site area to estimate volume. This volume of peat was multiplied by the estimated percentage of carbon content and dry soil bulk density. Tonnes of carbon were converted to carbon dioxide (tCO₂) by multiplying with the factor of 3.67, which converts from the atomic weight of carbon ('C') to the molecular weight of CO₂. Table 12.1 shows the parameters used to estimate the baseline of stored carbon. The source and references for these parameters are provided in Table 12.3 at the end of this section.

Table 12.1 Parameters used to estimate baseline stored carbon within the Site Boundary

Parameter	Expected	Minimum	Maximum
Size of Site based on red line boundary (ha)	205	205	205

Parameter	Expected	Minimum	Maximum
Average peat depth across Site (m)	2.91	2.67	3.15
Carbon content of dry peat (% by weight)	56%	49%	62%
Dry soil bulk density (g/cm ³)	0.12	0.09	0.15

The Scottish Government's Carbon Calculator for Wind Farms on Peat Lands

- 12.4.4 The Scottish Government methodology, titled 'Calculating potential carbon losses and savings from wind farms on Scottish Peat lands: a new approach' (Nayak, et al, 2008), was designed in response to concerns on the reliability of methods used to calculate reductions in GHG emissions arising from large scale wind farm developments on peatlands. Accompanying this methodology was an excel spreadsheet tool called the 'Carbon Calculator for wind farms on peat' which estimates the benefit of displacing conventionally generated electricity in the grid compared to the predicted direct and indirect emissions of carbon from construction, operation and decommissioning of a wind farm. It provides an estimate of the carbon payback time for the Proposed Development based on predicted emissions from construction materials and grid backup and losses and gains of stored carbon on site but excludes minor sources such as result of traffic generated during construction or operation.
- 12.4.5 This method built further on the Technical Guidance note produced by Scottish Natural Heritage (SNH, now NatureScot) in 2003 for calculating carbon 'payback' times for wind farms. However, this guidance did not take account of the wider impacts on the hydrology and stability of peatlands. The current methodology provides a straightforward way to model the impacts of installation and operation of wind farms on peat soils, considering the wider potential impacts on peat land hydrology and decomposition of organic matter.
- 12.4.6 The most recent version of the Carbon Calculator is the Excel version of the tool (v2.15.6), dated 14/07/26. Table 12.3 at the end of this section outlines the input parameters used in the Carbon Calculator. Individual aspects of the methodology will be discussed further within this Appendix Report, in the context of actual inputs and outputs of the model.

12.5 Scope of Carbon Calculator

- 12.5.1 Table 12.2 shows the following potential sources, and savings, of carbon emissions from the three key project stages that are covered by the Carbon Balance Assessment.

Table 12.2 Carbon emissions and savings included in the assessment

Project phase	Included in assessment	Excluded from assessment
Construction	Carbon emissions resulting from the extraction, production and manufacture of turbine components and concrete required for foundations. The turbine Lifecycle Carbon Assessment (LCA) values are taken from the literature and put into the carbon calculator as direct input of values.	Carbon emissions resulting from manufacture and transport of other materials required for foundations and tracks e.g., steel, sand, rock and geotextile. These materials are not explicitly included in the Scottish Government Carbon Calculator for wind farms on peat.

Project phase	Included in assessment	Excluded from assessment
	Carbon emissions resulting from the direct excavation of peat on-site for building tracks, hardstanding, turbine foundations and other infrastructure.	Carbon emissions resulting from the transport of labour to the construction-site. This element is not included in the Scottish Government Carbon Calculator for wind farms on peat.
		Carbon emissions from the use of plant and equipment for construction of the Proposed Development. This element is not included in the Scottish Government Carbon Calculator for wind farms on peat.
		Carbon emissions from the use of plant, equipment and materials from the forestry restocking, peat translocation and compensatory planting. This element is not included in the basic forestry calculations of the Scottish Government Carbon Calculator for wind farms on peat.
Operation	Carbon emissions from the indirect impact of drainage on peat surrounding the Proposed Development infrastructure.	Carbon emissions resulting from transport of labour required throughout the lifetime of the Proposed Development. These elements are not explicitly included in the Scottish Government Carbon Calculator for wind farms on peat and are also not included within the boundary of the LCA.
	Carbon savings resulting from the generation of electricity by wind turbines and displacement of grid electricity generated by fossil fuels.	
	Carbon emissions from the manufacture and supply of materials for maintenance and repair are included within the boundary of the LCA.	Emissions from use of diesel in generators used to restart turbines following shutdown. This is likely to be a very small emission source.
	Carbon emissions during the lifetime of the Proposed Development resulting from the loss of active carbon-absorbing habitat, including forestry and bog habitat.	Carbon removals resulting from the creation or restoration of active carbon-absorbing habitat such as peatland or restocked woodland. The Scottish Government Carbon Calculator does not estimate future sequestration from restored vegetation, only the change to the existing carbon balance of soils in restored areas.
	Changes to the methane/CO ₂ balance resulting from the restoration of forestry and degraded bog habitat.	

Project phase	Included in assessment	Excluded from assessment
Decommissioning	Carbon emissions from the dismantling and disposal of turbine and associated infrastructure are included within the boundary of the LCA but these are not separated from the overall embodied emissions of the turbines in the Carbon Calculator.	Carbon emissions from the use of plant, vehicles and equipment for the decommissioning of the Proposed Development.
		Carbon emissions resulting from transport of labour required for decommissioning.

Temporal Scope

- 12.5.2 The temporal scope for savings is set as the same period as the lifespan of the consent for the operation of the Proposed Development, i.e., 35 years but, unless it is specified that the Site will be restored with respect to hydrology and habitat upon decommissioning, the losses through the indirect effects on peat will continue until the Carbon Calculator estimates that there is no more oxidisable peat within the vicinity of the infrastructure.

Study Area

- 12.5.3 The baseline assessment looks at the estimated stored soil carbon within the Site Boundary under existing conditions, as this will enable the percentage loss of this carbon through the Proposed Development to be estimated.
- 12.5.4 For the carbon payback assessment, since GHG emissions and savings are both ultimately a global 'pool', this assessment is not restricted solely to those emissions or savings that occur within the Site. Land-based emissions from peat and habitat losses are based on the Proposed Development footprint, but other activities, for example, emissions resulting from the extraction and production of steel for turbines, are still attributable to the Proposed Development even though they are likely to occur in other parts of the world.

12.6 Input Parameters

- 12.6.1 In determining whether an application to build and operate a wind farm should be consented, the assessment of potential carbon losses and savings is a material consideration for Scottish Ministers. It is one important consideration among many, and currently there are no official guidelines about what constitutes an acceptable or unacceptable payback time, therefore this assessment looks at a range of metrics, including the payback, the carbon intensity of electricity produced and the ratio of soil carbon losses to gain, to evaluate the impact of the Proposed Development on carbon emissions.

Table 12.3 Input parameters used in the Carbon Calculator

Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
Wind Farm Characteristics					
Dimensions					
No. of turbines	5	5	5	Chapter 4: Development Description states that the Proposed Development will be composed of up to five wind turbines with a maximum blade tip height of 200 metres (m).	None
Lifetime of wind farm (years)	35	35	35	Chapter 4 states that the Proposed Development has a lifetime of up to 35 years.	None
Performance					
Turbine capacity (MW)	7.2	7.2	7.2	Chapter 4 states that the Vestas V162 (7.2 Megawatt) (MW) turbine has been chosen as a representative candidate turbine that may be installed, giving an indicative capacity of 36 MW.	None
Capacity factor – using direct input of capacity factor (percentage efficiency)	34.7	33.0	36.4	Chapter 4 states that the overall site output based on a site derived capacity factor of 34.7%.	A range of +/- 5% has been used to calculate the likely minimum and maximum.
Backup					
Extra capacity required for backup (%)	5	5	5	The Carbon Calculator indicates that if over 20% of national electricity is generated by wind energy, the extra capacity	This parameter assumes there is no significant improvement in demand

Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
				required for backup is 5% of the rated capacity of the wind plant. SEPA has indicated that, for this parameter, the electricity generation capacity of Scotland, rather than the UK, should be considered. In 2024, Scotland generated 58% via wind (Scottish Government, 2025).	side management or energy storage for intermittent generation over the lifetime of the wind farm and therefore this represents the worst case scenario for estimating emissions from backup.
Additional emissions due to reduced thermal efficiency of the reserve generation (%)	10	10	10	Fixed value within the Carbon Calculator for scenario where extra capacity for backup is required. This parameter is not used as the % of back up required is set to zero.	Extra emissions due to reduced thermal efficiency of the reserve power generation $\approx$ 10% (Dale et al 2004 referenced by the Carbon Calculator).
Carbon dioxide emissions from turbine life - (e.g. manufacture, construction, decommissioning)	Direct input of total emissions			Chapter 4 states that the candidate turbine for assessment purposes is the Vestas V162. There is a Lifecycle Assessment available for a Vestas onshore V162-6.2 MW wind plant (Vestas, 2022) which is considered to provide a good estimate of embodied carbon for the candidate turbine, as they are the same height and the emissions can be scaled to output.	
Total CO ₂ emission from turbine life (tCO ₂ MW ⁻¹)	377	339	415	The LCA assessment is in units of gCO ₂ e per kWh generated of electricity over the assessment time period of 20-year design life. These have been converted to tCO ₂ e per MWh and then scaled to electricity generation over 35 years in order to not overestimate the emissions for the longer lifetime and higher output of the Proposed Development.	A range of +/- 10% has been used to calculate the likely minimum and maximum.
Characteristics of peat land before wind farm development					

Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
Type of peat land	Acid Bog	Acid Bog	Acid Bog	There are only two options, of which one has to be selected within the Carbon Calculator; acid bog and fen. Chapter 7: Ecology states that while most of the site is covered by conifer plantation, other more extensive habitat is wet modified bog (10.6 %), followed by blanket bog (8 %). Therefore, acid bog has been selected as the most appropriate option.	None
Average air temperature at site (°C)	8.5	8.3	8.7	Based on average annual temperature data for West Scotland for the time period 2006 – 2025. The data is sourced from the Meteorological Office (2025). Mean: 8.5 Count: 20 Standard Error: 0.11	A 95% confidence level has been calculated as the mean +/- 2 SE to estimate the likely minimum and maximum values of the range. Although, it is probable that average site temperatures are rising due to impacts of global climate change, the overall payback is not sensitive to temperature and therefore this parameter is not included in the sensitivity analysis.
Average depth of peat at the site (m)	2.91	2.67	3.15	Peat probing was carried out across the Site in accordance with the Scottish Government's Guidance on Developments on Peatland. Phase 1 probing on a 100 m grid was undertaken in 2024 (see Technical Appendix 9.2). The average depth is based only on Phase 1 probes within the red line boundary in order not to bias the estimated site average. Mean: 2.91	A 95% confidence level has been calculated as the mean +/- 2 SE to estimate the likely minimum and maximum values of the range.

Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
				Count: 205 Standard Error: 0.12	
Carbon (C) Content of dry peat (% by weight)	56	49	62	The default values for carbon content of peat 49% and 62% is provided in the Carbon Calculator.	Upper and lower range provided as default. Midpoint used as expected value.
Average extent of drainage around drainage features at site (m)	26	16	38	The average extent of drainage has been estimated using average Von Post data from 13 cores on-site. The average score was used to estimate the bulk density of the peat on the site, which was then used to estimate hydraulic conductivity and consequently estimated drainage distance using equations from Nayak et al (2008). More detail is provided in Section 12.7.	The minimum and maximum values are based on an estimated input range of +/-25% for the bulk density. The wide range of values reflects the difficulty in measuring this parameter with accuracy.
Average water table depth at site (m)	0.05	0.0	0.1	Technical Appendix 9.2 states that all of the peat soil cores taken consisted of catotelmic peat, with the water table sitting directly at or just below the ground surface level. Therefore, it is assumed that the water table currently sits close to the surface.	A range of 0.0 to 0.1 has been used to calculate the likely minimum and maximum with the expected as the mid-point of these. The range of values reflects the difficulty in measuring this parameter with accuracy.
Dry soil bulk density (g/cm ³)	0.12	0.09	0.15	The bulk density for the site has been estimated from the Von Post scores of peat cores on-site using the equation described by Päiväinen (1969) and detailed in Section 12.7. The estimated bulk density of 0.12g/cm ³ sits within the estimated range provided by SEPA for blanket peat.	A range of +/- 25% has been used to calculate the likely minimum and maximum.

Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
Characteristics of bog plants					
Time required for regeneration of bog plants after restoration (years)	75	50	100	This parameter needs to be estimated and there are relatively few studies available on the average time taken for bog plant communities to regeneration following restoration. Rochefort et al (2003) estimate that a significant number of characteristic bog species can be established in 3–5 years, a stable high water-table in about a decade, and a functional ecosystem that accumulates peat in perhaps 30 years. However, more recent research (Rydgren et al, 2025) showed that for an experimentally restored, formerly afforested blanket bog in northern Scotland, predicted time to recovery for species assemblage varies between 50–100 years and 120–285 years applying a relaxed or strict criterion for restoration success, respectively.	The overall Proposed Development site payback is not particularly sensitive to this parameter due to the slow rate of carbon fixation by bogs. The maximum value has been set at the limit of 100 years. The expected value has been estimated at -25% of the maximum and the minimum at -50%.
Carbon accumulation due to C fixation by bog plants in un-drained peats (t C ha ⁻¹ yr ⁻¹)	0.215	0.12	0.31	Suggested acceptable literature values from Carbon Calculator. The overall result is not very sensitive to this input, so the default value can be used if measurements are not available.	The range suggested in the methodology from the literature for apparent C accumulation rate in peatland is 0.12 to 0.31 t C ha ⁻¹ yr ⁻¹ (Turunen et al., 2001, Global Biogeochemical Cycles, 15, 285-296; Botch et al., 1995, Global Biogeochemical Cycles, 9, 37-46, referenced by the Carbon Calculator). The SNH guidance uses a value of 0.25 t C ha ⁻¹ yr ⁻¹ . Range of 0.12 to 0.31 t C ha ⁻¹ yr ⁻¹ .

Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
Forestry Plantation Characteristics					
Area of forestry plantation to be felled (ha)	105	95	116	Chapter 4 and Technical Appendix 4.1: Wind Farm Forestry Plan states that during construction, approximately 105 ha of forestry will be removed within the Site to facilitate construction of infrastructure and wider forest management. Of the 105 ha felled, approximately 28 ha will be removed for the construction of infrastructure (and working buffers) and 77 ha for management felling (comprising 73.5 ha to provide wind farm boundaries to the adjoining compartments and 3.5 ha as purely forest-to-bog restoration).	A range of +/- 10 % has been used to calculate the likely minimum and maximum.
Average rate of carbon sequestration in timber (tC ha ⁻¹ yr ⁻¹)	1.90	1.71	2.09	For the purposes of the Carbon Calculator, the felled forestry has been estimated to be mainly Sitka Spruce (over 90% of the area) with an average Yield Class of 8 and an average age since planting of 50-55 years. The Woodland Carbon Calculation Spreadsheet (August 2025) provides an estimate of total annual carbon sequestered (in tCO ₂ e/ha/year) for each 5-year age period. The average annual sequestration rate for the next 35 years (the expected lifetime of the Proposed Development) was calculated and then this was converted to tC ha ⁻¹ yr ⁻¹ by dividing by 3.67.	A range of +/- 10 % has been used to calculate the likely minimum and maximum.
Counterfactual emission factors					

Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
Coal-fired plant emission factor (tCO ₂ MWh ⁻¹)	0.919	0.919	0.919	Fixed counterfactual emission factors are provided in the Carbon Calculator and cannot be altered. Values for both coal-fired and fossil fuel-mix emission factors are updated from DUKES data for the UK which is published annually. The source for the grid-mix emission factor is the list of emission factors used to report on greenhouse gas emissions by UK organisations published by BEIS.	
Grid-mix emission factor (tCO ₂ MWh ⁻¹)	0.177	0.177	0.177		
Fossil fuel- mix emission factor (tCO ₂ MWh ⁻¹)	0.448	0.448	0.448		
Borrow Pits					
Number of borrow pits	0	0	0	Chapter 4 states that as no borrow pits are proposed, the required stone aggregate will be fully sourced offsite from nearby quarries, with the nearby Floak Quarry or North Drumboy Quarry being options at this stage. The emissions resulting from transport associated with rock importation have therefore been included in lieu of emissions from borrow pits on site. The emissions are estimated at 52 tCO ₂ e based on 4,630 return vehicle movements at an estimated distance of around 6.5 km and a 50% average load and using a standard HGV emission factor of 0.87 kgCO ₂ e/km (DESNZ, 2026). These have been added into Table 12.5 in the Results section below.	None.
Foundations and hard-standing area associated with each turbine					

Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
Method used to calculate CO ₂ loss from foundations and hard-standing	Enter detailed information			The construction input tab was used to enter data for the proposed windfarm as two different construction methods will be used. Chapter 4 states that whilst every effort has been made to position turbines on shallow peat, this has not always been possible due to other environmental and technical constraints. As a result, T1, T2, and T3 will be located on peat depths of between 3-4 m. To minimise the excavation of large volumes of peat for the construction of these turbines, it is proposed that a piled construction method will be used. Peat depths are shallower at T4 and T5 (between 1-2 m), so it is intended to adopt a conventional excavated foundation method at these locations. Therefore, the site has been split into two areas within the carbon calculator.	None.
Area 1 – Turbines 1, 2 and 3					
Number of turbines in this area	3	3	3	Turbines T1, T2, and T3 will be using a piled construction method and therefore they have been grouped into one construction area.	None
Turbine foundations					
Average depth of peat removed when constructing foundations (m)	0	0	0	Chapter 4 states that to minimise the excavation of large volumes of peat for the construction of these turbines, it is proposed that a piled construction method will be used. This will involve installing concrete piles at suitable intervals around the perimeter of the foundation area using a rotary rig. The pile foundation drilling will extend	None

Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
				down to 5 m into competent rock. Therefore, it is assumed that no peat will need to be removed when constructing these foundations.	
Approximate geometric shape of hole dug when constructing foundations	Rectangular			This is the only option available within the Carbon Calculator.	None
Length at surface (m)	22.2	21.0	23.3	Chapter 4 states that the turbine foundation will typically measure up to approximately 25 m diameter – this has been converted into the dimensions of a rectangle of the same area. Although these are piled construction method, it has been assumed that the dimensions are the same at the surface and the bottom.	A range of + 5% has been used to calculate the likely expected and maximum values of both length and width.
Width at surface (m)	22.2	21.0	23.3		
Length at bottom (m)	22.2	21.0	23.3		
Width at bottom (m)	22.2	21.0	23.3		
<u>Hardstanding</u>					
Average depth of peat removed when constructing hardstanding (m)	0	0	0	Chapter 4 states that mobile cranes will be used to erect the turbine components into position on the Site. To do this, a permanent crane hardstanding will be built adjacent to each wind turbine. The crane hardstandings will also be used as laydown areas to provide safe access for maintenance and repairs and will therefore remain in place for the operation of the Proposed Development. Similar to the turbine foundations noted above, the hardstanding construction technique has also been determined by peat depths. The crane hardstandings for T1, T2 and T3 will therefore be piled. The additional areas of temporary	None

Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
				hardstandings at each turbine will be used as laydown areas for the blades and towers before being lifted into position. The temporary hardstandings for T1, T2 and T3 will be floated. Therefore, it is assumed that no peat will need to be removed when constructing these hardstandings in this area.	
Approximate geometric shape of hole dug when constructing foundations	Rectangular			This is the only option available within the Carbon Calculator.	
Length at surface (m)	63.1	59.9	66.2	Chapter 4 states that a permanent crane hardstanding with a total area of 1,365 m² will be built adjacent to each wind turbine. Although these are piled construction method, it has been assumed that the dimensions are the same at the surface and the bottom. Additional temporary auxiliary hardstanding areas measuring approximately 3,106 m² will be required for each turbine, and these will be positioned directly adjacent to the permanent crane hardstanding and these will be floated. The precise area has been calculated from the Peat Management Plan and the estimated area of the foundations have been removed from this area as they have already been counted above. The square root of the total area has been used to estimate the dimensions although in reality the shape will be irregular.	A range of + 5% has been used to calculate the likely expected and maximum values of both length and width.
Width at surface (m)	63.1	59.9	66.2		
Length at bottom (m)	63.1	59.9	66.2		
Width at bottom (m)	63.1	59.9	66.2		

Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
				The clearance areas required around the temporary auxiliary crane pads have been included in the additional area section below as Chapter 4 states that these areas will be cleared of any vegetation that could impede turbine erection but will not require any physical works.	
Is piling used?	Yes	Yes	Yes	See stated construction method above.	None
Volume of concrete used (m³)	5,100	4,845	5,355	Chapter 4 states that each turbine foundation will require up to approximately 1,700 m³ of concrete.	A range of + 5% has been used to calculate the likely expected and maximum values.
Area 2 – Turbines 4 and 5					
Number of turbines in this area	2	2	2	Chapter 4 states that peat depths are shallower at T4 and T5 (between 1-2 m), so it is intended to adopt a conventional excavated foundation method at these locations and therefore these have been grouped into another area.	None
<u>Turbine foundations</u>					
Average depth of peat removed when constructing foundations (m)	1.01	0.91	1.11	The volume of peat extracted for the turbine/hardstanding locations is taken from Table 4.2 in Technical Appendix 9.3: Outline Peat Management Plan. The total volume is the sum excavated peat for: 1) Permanent hardstanding 2) Temporary hardstanding	A range of +/- 10 % has been used to calculate the likely minimum and maximum.

Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
				The average peat depth is calculated as the total volume divided by the sum of the total area of turbine/hardstanding for Turbines T4 & T5.	
Length at surface (m)	22.2	21.0	23.3	Chapter 4 states that the turbine foundation will typically measure up to approximately 25 m diameter – this has been converted into the dimensions of a rectangle of the same area. It has been assumed that the dimensions are the same at the surface and the bottom.	A range of + 5% has been used to calculate the likely expected and maximum values of both length and width.
Width at surface (m)	22.2	21.0	23.3		
Length at bottom (m)	22.2	21.0	23.3		
Width at bottom (m)	22.2	21.0	23.3		
<u>Hardstanding</u>					
Average depth of peat removed when constructing hardstanding (m)	1.01	0.91	1.11	The volume of peat extracted for the turbine/hardstanding locations is taken from Table 4.2 in Technical Appendix 9.3. The total volume is the sum excavated peat for: 1) Permanent hardstanding 2) Temporary hardstanding The average peat depth is calculated as the total volume divided by the sum of the total area of turbine/hardstanding for Turbines T4 & T5.	A range of +/- 10 % has been used to calculate the likely minimum and maximum.
Length at surface (m)	64.3	61.1	67.5	Chapter 4 states that a permanent crane hardstanding with a total area of 1,365 m² will be built adjacent to each wind turbine. It has been assumed that the dimensions are the same at the surface and the bottom. Additional temporary auxiliary hardstanding areas measuring approximately	A range of + 5% has been used to calculate the likely expected and maximum values of both length and width.
Width at surface (m)	64.3	61.1	67.5		
Length at bottom (m)	64.3	61.1	67.5		

Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
Width at bottom (m)	64.3	61.1	67.5	3,106 m² will be required for each turbine, and these will be positioned directly adjacent to the permanent crane hardstanding. The precise area has been calculated from Technical Appendix 9.3: Outline Peat Management Plan and the estimated area of the foundations have been removed from this area as they have already been counted above. The square root of the total area has been used to estimate the dimensions although in reality the shape will be irregular. The clearance areas required around the temporary auxiliary crane pads have been included in the additional area section below, along with the area and volume of peat required for earthworks.	
Is piling used?	No	No	No	Chapter 4 states that the foundations and hardstandings for T4 & T5 will be excavated.	None
Volume of concrete used (m ³)	3,400	3,230	3,570	Chapter 4 states that each turbine foundation will require up to approximately 1,700 m ³ of concrete.	A range of + 5% has been used to calculate the likely expected and maximum values.
Access tracks					
Total length of access track (m)	4,100	3,895	4,305	Chapter 4 states that approximately 4.1 km of new access track comprising approximately 1.3 km of excavated track and approximately 2.8 km of floated track.	A range of +/- 5% has been used to calculate the minimum and maximum.

Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
Existing track length (m)	0	0	0	It is assumed that all the on-site track will need to be constructed.	None
Length of access track that is floating road (m)	2,800	2,660	2,940	Chapter 4 states that owing to the deep peat design considerations, approximately 2.8 km of new track will be of a floated design (on sections where tracks are on slopes that are less than 3 degrees and peat is ≥ 0.5 m over spans of ≥ 100 m).	A range of +/- 5% has been used to calculate the likely minimum and maximum.
Floating road width (m)	6.3	6.0	6.6	Chapter 4 states that the new permanent track will have a minimum running surface of 6 m.	A range of +5% and +10% has been used to estimate the expected and maximum values.
Floating road depth (m)	0	0	0.93	This parameter accounts for sinking of floating road. The Carbon Calculator states that it should be entered as the average depth of the road expected over the lifetime of the Proposed Development. If no sinking is expected, enter as zero. It is anticipated that sinking of the floating track would be minimal and therefore this parameter has been set as zero for the expected and minimum values. The average peat depth for the floating track has been taken from the Peat Management Plan excavation calculations.	Zero value for expected and minimum values. The maximum is estimated at 50% of the average peat depth for all the floating track locations on-site.
Length of floating road that is drained (m)	0	0	0	Chapter 4 makes no mention of lateral drainage for floated track; therefore, it is assumed that it is not drained.	None
Length of access track that is excavated road (m)	1,300	1,235	1,365	Chapter 4 states that 1.3 km will be of a conventional excavated design.	A range of +/- 5% has been used to calculate the likely minimum and maximum.

Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
Excavated road width (m)	6.3	6.0	6.6	Chapter 4 states that the new permanent track will have a minimum running surface of 6 m.	A range of +5% and +10% has been used to estimate the expected and maximum values.
Average depth of peat excavated for road (m)	1.22	1.10	1.34	To calculate an average depth of peat removed for excavated track, the volume of peat has been taken from Technical Appendix 9.3: Outline Peat Management Plan excavation calculations and divided by the infrastructure area to get an average depth across the infrastructure.	A range of +/- 10% has been used to calculate the likely minimum and maximum
Cable Trenches					
Length of any cable trench on peat that does not follow access tracks and is lined with a permeable membrane (e.g. sand) (m)	0	0	0	Chapter 4 states that cables will be routed along the side of the access tracks to minimise ground disturbance	Assume all cable trenches follow access track routes.
Additional peat excavated (not accounted for above)					
Volume of additional peat excavated (m ³)	14,874	13,387	16,361	The volume of additional peat extracted is calculated from the Technical Appendix 9.3: Outline Peat Management Plan calculations. The total volume is the sum of both permanent and temporary excavated peat for:	A range of +/- 10% has been used to calculate the likely minimum and maximum.

Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
				1) Earthworks (both cut and fill_excavated categories) 2) Substation compound 3) Construction compound	
Area of additional peat excavated (m ²)	23,395	22,225	24,565	The area of additional peat excavated is assumed to be the total area of these infrastructure components where peat is permanently or temporarily excavated. In addition, the clearance areas on peat where the vegetation will be cleared has been added for completeness, although no peat will be excavated.	A range of +/- 5% has been used to calculate the likely minimum and maximum.
Improvement of C sequestration at site by blocking drains, restoration of habitat etc.					
Improvement of degraded bog					
Area of degraded bog to be improved (ha)	26.59	23.93	29.25	Technical Appendix 7.6: Outline Biodiversity Enhancement Management Plan (OBEMP) states that 26.59 ha of other open peatland restoration/enhancement measures will be carried out on site.	A range of +/- 10% has been used to calculate the likely minimum and maximum.
Water table depth in degraded bog before improvement (m)	0.20	0.15	0.25	The OBEMP states that the condition of the open area of blanket bog in the north-west of the Site is in relatively good condition and generally has a near-natural surface pattern, therefore it is assumed that the water table is already close to optimum and management would involve removal of self-seeding conifer trees and blocking/reprofiling of any drainage features/furrows.	A range of +/- 25% has been used to calculate the likely minimum and maximum.

Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
Water table depth in degraded bog after improvement (m)	0.10	0.09	0.11	The OBEMP states that a functional blanket bog should have a water table consistently close to the surface, with minimal fluctuation. The layer below 10 cm should remain waterlogged year-round so that oxygen cannot penetrate, and plant material partially decomposes slowly and becomes more compact and less permeable to water	A range of +/- 10% has been used to calculate the likely minimum and maximum
Time required for hydrology and habitat of bog to return to its previous state on improvement (years)	9.0	6.0	12.0	Since the condition of the open area of blanket bog in the north-west of the Site is in relatively good condition and generally has a near-natural surface pattern, it is assumed that restoration of the water table would be relatively rapid. However, the open rides are in poorer condition and need high-density self-seeding conifers removing and drains blocked. Research by Fundira et al (2025) shows that post-restoration, water table recovery occurs within 6–10 years, but full stabilization may require 20+ years. Although the input parameter mentions habitat restoration, the Carbon Calculator outputs are based only on the hydrological restoration of the area.	The minimum range has been set at 6 years and the expected/maximum value have been set at +50% and +100%.
Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years)	35	35	35	The Carbon Calculator states that if the time required for hydrology and habitat to return to its previous state is 10 years and the restoration can be guaranteed over the lifetime of the Proposed Development (35 years), the period of time when the improvement can be guaranteed should be entered as 35 years.	None.
Improvement of felled plantation land					

Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
Area of felled plantation to be improved (ha)	41.27	37.14	45.40	Technical Appendix 7.6: Outline Biodiversity Enhancement Management Plan (OBEMP) states that 41.27 ha will be priority peatland restoration and enhancement through forest to bog restoration.	A range of +/- 10% has been used to calculate the likely minimum and maximum.
Water table depth in felled area before improvement (m)	0.5	0.38	0.63	It is assumed that the conifer plantation would produce a lower water table in these areas at the start of restoration due to disturbance from removal as well as existing drainage.	A range of +/- 25% has been used to calculate the likely minimum and maximum.
Water table depth in felled area after improvement (m)	0.10	0.09	0.11	The OBEMP states that a functional blanket bog should have a water table consistently close to the surface, with minimal fluctuation. The layer below 10 cm should remain waterlogged year-round so that oxygen cannot penetrate, and plant material partially decomposes slowly and becomes more compact and less permeable to water	A range of +/- 10% has been used to calculate the likely minimum and maximum
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)	22.5	10	35	It is estimated that the time for restoration of hydrology and habitat would be a minimum of 10 years. As mentioned previously, research by Fundira <i>et al</i> (2025) shows that post-restoration, water table recovery occurs within 6–10 years, but full stabilization may require 20+ years. For this more disturbed area, a more conservative estimate of the time taken to recover the water table is used. Although the input parameter mentions habitat restoration, the Carbon Calculator outputs are based only on the hydrological restoration of the area.	The minimum has been set at 10 years, with the maximum range set at the same length as the planning consent. The expected value is the mid-point of these two values.

Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years)	35	35	35	The Carbon Calculator states that if the time required for hydrology and habitat to return to its previous state is 10 years and the restoration can be guaranteed over the lifetime of the Proposed Development (35 years), the period of time when the improvement can be guaranteed should be entered as 35 years.	None
Early removal of drainage from foundations and hardstanding					
Removal of drainage from foundations and hardstanding	0	0	0	Chapter 4 states that permanent hardstanding areas at each turbine location will be retained for use during operation and decommissioning, however the edges of these permanent areas as well as all temporary hardstanding areas, will, as far as possible, be blended to the adjacent contours and natural vegetation allowed to re-establish. Therefore, it is assumed that these areas remain drained.	No variance required.
Restoration of Application Site after decommissioning					
Will hydrology of the Proposed Development site be restored on decommissioning?	No	No	No	Chapter 4 states the decommissioning requirements will be agreed with EAC and other appropriate regulatory authorities in line with best practice guidance and requirements of the time. This would be done through the preparation and agreement of a Decommissioning Management Plan (DMP). Therefore, the response to this question has been marked as 'no' as a worst case scenario. However, it should be noted, changing this response has no impact on the overall carbon payback at this site.	None
Will habitat of the Proposed Development site be restored on decommissioning?	No	No	No		

Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
Choice of methodology for calculating emission factors	Site specific			As required for planning applications.	

12.7 Detailed Methodology Statements

- 12.7.1 Table 12.1 details the Site-based parameters and conversion factors used for the baseline assessment and Table 12.3 details all the input parameters and assumptions used within the carbon calculator. Two of the parameters have been estimated using data collected from peat cores and published equations in the literature. Detailed methodology describing the data and equations are provided below.

Methodology for Estimating Dry Soil Bulk Density

- 12.7.2 Within Lindsay's Peatbogs and Carbon; A critical synthesis (2010), several studies document the relationship between bulk density and Von Post scale of humification. Work by Päiväinen in 1969 documented linear relationships for different types of peat. The relationship for Sphagnum-based peat is described as $Y = 0.045 + 0.011 x$, where x is the Von Post score for humification.

- 12.7.3 Cores were taken at 13 locations and the range of Von Post score for humification (H score) was recorded. Where a range of H scores was given, the midpoint of the scores for the sample was calculated. The coverage of Von Post data across the Site meant that it was possible to use this equation to estimate the overall bulk density at the Site. The methodology used was:

Calculate the average Von Post scores for the peat column (average H score 6.81)

Use this weighted average score to estimate bulk density using Päiväinen's equation, calculating a minimum and maximum range as +/-25% of the expected bulk density.

Estimating Average Drainage Distance from Drainage Features

- 12.7.4 The calculated estimate of dry soil bulk density has been used to estimate the hydraulic conductivity of the peat, according to the relationship curve described within Peatbogs and Carbon (Lindsay, 2010). Hydraulic conductivity describes the ease with which a fluid can move through pore spaces and fractures in soils. There are two equations for hydraulic conductivity, where y is hydraulic conductivity in m/day and x is bulk density:

If the bulk density is less than 0.13 g/cm^3 , the equation is $y = 7683.3 * (\exp(-74.981 * x))$

If the bulk density is greater than 0.13 g/cm^3 , the equation is $y = 10^{-8} * (x^{-8.643})$

- 12.7.5 The value of hydraulic conductivity given by this equation is then used to estimate the average drainage distance, using the equation given in Nayak et al (2008). This equation is given as $y = 11.958x - 9.361$, where x is the log value of hydraulic conductivity measured in millimetres per day (mm/day).

- 12.7.6 It should be noted that the minimum value for bulk density produces the highest estimate for hydraulic conductivity (the less densely packed material allows freer movement of water) and therefore drainage distance. Therefore, the Carbon Calculator is modelling a worst-case scenario, as it is highly unlikely that the maximum bulk density of peat (with the greatest amount of stored carbon) would also have the maximum average drainage distance.

12.8 Results of Carbon Balance Assessment

Baseline Conditions

- 12.8.1 It is not easy to set a simple baseline for the climate change impact of development projects because each individual project has a very small overall impact on a very large global atmospheric pool of GHG emissions, but there are many small projects, and therefore; effective climate change mitigation relies on reducing the impacts of all of these.

- 12.8.2 However, the key carbon balance impact of constructing a wind farm on peatland is the potential release of stored carbon and therefore, the baseline looks at the estimated stored soil carbon on-Site under existing conditions, as this will enable the percentage loss of this carbon through the Proposed Development to be estimated.
- 12.8.3 Table 12.4 shows the estimate of stored carbon in peat within the Site. Estimated volume and emissions have been rounded up to the nearest thousand cubic metres/tonnes.

Table 12.4 Estimated Stored Carbon in Peat at the Proposed Development Site (Based on Red Line Boundary)

Parameter	Expected	Minimum	Maximum
Estimated volume of peat (m ³) (based on site area 205 ha multiplied by average peat depth of 2.91 m)	5,966,000	5,479,000	6,452,000
Estimated amount of carbon in soils (tC)	397,000	241,000	599,000
Estimated equivalent emissions of CO ₂ (tCO ₂)	1,457,000	886,000	2,200,000

- 12.8.4 Table 12.4 shows that there are just under 0.4 million tonnes of stored carbon onsite and if this were fully oxidised, this would equate to approximately 1.5 million tonnes of CO₂ emissions. It is hard to assess the future of this stored carbon onsite in the absence of the Proposed Development, but it is probable that future climate change impacts will negatively affect this store of carbon, even in the absence of development.

Carbon Balance Assessment - Emissions

- 12.8.5 The results from the Carbon Balance Assessment have been divided into losses from activities resulting in the emission of carbon, savings from the avoidance of carbon emissions by displacing grid electricity from other fuel sources and gains from Site restoration activities that should result in uptake of atmospheric carbon. Exclusions mentioned in Table 12.2 should be noted.
- 12.8.6 This section looks at the two key project stages of construction and operation (specific decommissioning activities are not included in the Carbon Calculator) and allocates emissions to those two stages. However, it should be noted that for some of the key sources of emissions, such as oxidation of soil carbon, it is hard to be precise about when they will occur in the Proposed Development life cycle.

Table 12.5 Estimated Carbon Emissions during the Construction Phase

Emission source	Estimated emissions (tCO ₂ e)			% of overall emissions (expected scenario)
	Expected	Minimum	Maximum	
Losses due to production of turbines lifecycle and concrete	13,572	12,215	14,929	20.1%
CO ₂ loss from excavated peat	-1,699	-1,389	2,602	-2.52%
Subtotal of emissions during construction	11,873	10,826	17,531	17.6%

Emission source	Estimated emissions (tCO ₂ e)			% of overall emissions (expected scenario)
	Expected	Minimum	Maximum	
Estimated emissions from stone transport in lieu of borrow pits	52	52	52	0.08%

12.8.7 Table 12.5 shows that around 18% of total losses occur during the Proposed Development construction phase. The majority of these are from the manufacture of the turbines with a small proportion due to concrete used in construction. The emissions from the oxidation of peat excavated for infrastructure construction are assessed as negative by the Carbon Calculator due to the relatively small amounts of peat excavated. This is because shallow peat deposits are estimated to be net emitters when left *in situ*. The estimated emissions from transporting stone from local quarries in lieu of an onsite borrow pit are shown to demonstrate that they do not add significantly to the overall emissions. These are not included in the overall payback calculation further down as there is no place to enter these within the Carbon Calculator.

Table 12.6 Estimated Carbon Emissions during the Operational Phase

Emission source	Estimated emissions (tCO ₂ e)			% of overall emissions (expected scenario)
	Expected	Minimum	Maximum	
Losses due to grid backup	24,724	24,724	24,724	36.6%
Losses due to reduced carbon fixing potential	1,841	541	4,650	2.7%
Losses due to Dissolved Organic Carbon (DOC) & Particulate Organic Carbon (POC) leaching	76	10	211	0.11%
CO ₂ loss from drained peat	3,396	1,435	1,435	5.0%
Losses due to reduced carbon sequestration potential of felled forestry	25,605	20,740	30,982	37.9%
Subtotal of emissions during operation	55,642	47,450	62,002	82.4%

12.8.8 Table 12.6 shows that just over 82% of the emissions occur during the operational phase of the Proposed Development. The most significant of these losses are from reduced future carbon sequestration potential over the lifetime from the reduction in area of stocked woodland in the forestry which contributes nearly 38% of total losses. It should be noted that gains from restocking following temporary felling or compensatory woodland planting are not included in the Carbon Calculator in the simple forestry model, as noted in Table 12.2. The next most significant source of losses is due to the requirement of grid backup for intermittent sources, which is assumed to be fossil fuel based. However, this requirement for grid backup does not consider future developments in demand

management or energy storage over the lifetime of the Proposed Development, and therefore; these losses are likely to be over-estimated. Around 5% of losses come from draining peat in the vicinity of infrastructure. This should be partially mitigated through the reinstatement of disturbed areas post construction. The other sources of losses during operation are reduced carbon fixing potential and carbon leaching from peat contribute minimal losses. In total, almost 68,000 tonnes of CO₂e will be lost during both construction and operation of the Proposed Development.

- 12.8.9 Emissions produced during the decommissioning phase are not included separately in the Carbon Calculator assessment, although an estimate of these are included within the lifecycle assessment of the turbines. Calculating emissions from this phase is difficult because the exact activities are not known, but they are unlikely to be significant compared to the emission sources during construction and operation.

Carbon Balance Assessment – Gains

- 12.8.10 Table 12.7 shows the estimated carbon gains over the lifetime of the Proposed Development from improvement of areas of degraded bog and felled forestry. The gains are negative because they represent avoided emissions resulting from the predicted increase in the water table in these areas. It should be noted that the Carbon Calculator is conservative about estimating the gains from restoration, only accounting for changes in the balance of methane to carbon dioxide emissions from the re-wetting of peat.

Table 12.7 Estimated Carbon Gains

Source of gains	Estimated gains (tCO ₂ e)			% of overall gains (expected scenario)
	Expected	Minimum	Maximum	
Change in emissions due to improvement of degraded bogs	-2,223	-601	-4,605	22.4%
Change in emissions due to improvement of felled forestry	-7,690	-	-19,625	77.6%
Total estimated gains	-9,913	-601	-24,230	100%

Comparison with the Baseline

- 12.8.1 The soil carbon losses from the Proposed Development are estimated at around 3,600 tonnes of CO₂e. This represents 0.2% of the estimated total stored carbon onsite (as set out in Table 12.4) and includes anticipated losses drained peat as well as losses due to leaching and from reduced carbon fixing potential. It also contains a small negative loss due to the emissions from excavated peat being assessed as lower than leaving the peat *in situ*.

Comparison of Soil Carbon Losses with Carbon Gains from Restoration

- 12.8.2 Table 12.8 shows a comparison of soil carbon losses with the estimated carbon gains from restoration. The estimated carbon is shown for the expected value within the carbon calculator.

Table 12.8 Comparison of soil carbon losses with restoration gains

Soil carbon loss category	Expected tCO ₂ e	Restoration gain category	Expected tCO ₂ e
CO ₂ loss from removed peat	-1,699	Change in emissions due to improvement of degraded bogs	-2,223
CO ₂ loss from drained peat	3,396	Change in emissions due to improvement of felled forestry	-7,690
Losses due to reduced carbon fixing potential	1,841		
Losses due to Dissolved Organic Carbon (DOC) & Particulate Organic Carbon (POC) leaching	76		
Total soil carbon losses	3,615	Total restoration gains	-9,913

12.8.3 Table 12.8 shows that the ratio between soil carbon loss and restoration gains is around 0.4; there are estimated to be more gains from restoration of the Site than losses from constructing the Proposed Development, which has been aided by proposing construction techniques which reduce the volume of peat to be excavated i.e. piled and floated infrastructure.

Carbon Balance Assessment – Savings

12.8.4 Table 12.9 shows the estimated annual and lifetime CO₂ savings, based on the three different counterfactual emission factors. The highest estimated savings are for replacement of coal-fired electricity generation, but from September 2024 (when the UK's last coal power station closed) there is no more coal-fired generation remaining in the UK to be displaced. The average grid-mix of electricity generation represents the overall carbon emissions from the grid per unit of electricity and includes nuclear and renewables as well as fossil fuels. The fossil fuel mix represents displacement of existing fossil fuel electricity generation plant, the majority of which uses natural gas which is planned to be removed over the lifetime of the Proposed Development. However, to meet Net Zero targets, renewable electricity will be required to displace existing transport (diesel and petrol) and heating (natural gas and burning oil) fuels and therefore, the fossil fuel mix is probably the closest representation of the energy that the Proposed Development's generated electricity would be displacing.

Table 12.9 Estimated Annual and Lifetime Carbon Savings from the Operation of the Proposed Development from the Displacement of Grid Electricity

Counterfactual emission factor – annual savings	Estimated savings (tCO ₂ e per year)		
	Expected	Minimum	Maximum
Coal-fired electricity generation	100,566	95,538	105,594
Grid-mix of electricity generation	19,369	18,401	20,338
Fossil fuel - mix of electricity generation	49,025	46,573	51,476

Counterfactual emission factor – lifetime savings	Estimated savings (tCO ₂ e over lifetime)		
Coal-fired electricity generation	3,519,810	3,343,830	3,695,790
Grid-mix of electricity generation	677,915	644,035	711,830
Fossil fuel - mix of electricity generation	1,715,875	1,630,055	1,801,660

Payback Time and Carbon Intensity

- 12.8.5 There are two useful metrics for comparing different projects and different technologies. The Carbon Calculator tool calculates an estimated payback time, which is the net emissions of carbon (total of carbon losses and gains) divided by the annual estimated carbon savings. However, an alternative metric is the carbon intensity of the generated units of electricity. This calculation divides the net emissions by the total units of electricity expected to be produced over the lifetime of the Proposed Development. This calculation is useful as it is independent of the emission factor used for displaced electricity.
- 12.8.6 Table 12.10 shows the estimated payback time, if the electricity generated by the Proposed Development is assumed to displace electricity generated by the grid for a range of different displaced fuels, and the carbon intensity of the units produced.

Table 12.10 Estimated Payback Time in Years and Carbon Intensity of the Units of Electricity Produced

Counterfactual emission factor	Estimated time to payback (years)		
	Expected	Minimum	Maximum
Coal-fired electricity generation	0.6	0.3	0.8
Grid-mix of electricity generation	3.0	1.7	4.3
Fossil fuel - mix of electricity generation	1.2	0.7	1.7
Carbon intensity of electricity generated	Carbon intensity (kgCO ₂ e/kWh)		
Carbon intensity of units generated	0.015	0.008	0.022

- 12.8.7 Table 12.10 shows that the Proposed Development is estimated to have a payback time of 1.2 years based on the fossil fuel mix, and the carbon intensity of units produced would be significantly lower than the lowest counterfactual emission factor which is the current grid mix (the value of 0.177 kgCO₂e/kWh is currently used in the Carbon Calculator). It should also be noted that the assessment boundary of the carbon intensity of electricity generated by the Proposed Development is far wider than the direct operational emissions included in the measurement of carbon intensity of the grid mix; if these were included, the impact of the Proposed Development would be shown to be even more beneficial.

Sensitivity analysis

- 12.8.8 The assessment of the payback of the Proposed Development is limited by both the Carbon Calculator and the parameters used to estimate the Site characteristics. Within the Carbon Calculator there are several parameters known to have a potentially material impact on overall estimated payback time; for some of these parameters there is also a degree of uncertainty over the inputs due to data collection restraints. To demonstrate the robustness of the estimated payback, the sensitivity analysis below shows the impact of varying four of the key Site parameters on the payback time under a fossil mix counterfactual emission factor, whilst holding all other parameters constant, as shown in Table 12.11

Table 12.11 Impact of changing individual parameters on expected payback in years

Sensitivity analysis	Estimated time to payback (years) (based on expected scenario, fossil fuel mix electricity factor)		
	As assessed: Expected	Reduce parameter	Increase parameter
Average extent of drainage around drainage features at Site (m) – 26m, impact of decreasing and increasing by 50%	1.2	1.1	1.2
Average rate of carbon sequestration in timber (tC ha ⁻¹ yr ⁻¹) – 2.08 tC ha ⁻¹ yr ⁻¹ , impact of decreasing and increasing by 50%	1.2	0.9	1.4
Average water table depth at Site (m) – 0.05 m, impact of decreasing and increasing by 50%	1.2	1.1	1.2
Water table depth in felled plantation (m) before improvement – 0.50m, impact of decreasing and increasing by 50%	1.2	1.3	1.1

- 12.8.9 Table 12.11 shows that increasing or decreasing key site-based parameters by 50% has minimal impact on the overall expected payback, which improves the confidence around the payback range. The parameter with the highest impact is the estimated average rate of carbon sequestration in timber. However, since the losses from felling forestry do not take into account the gains from restocking or compensatory planting, it is reasonable to assume the losses from forestry sequestration are overestimated within the Carbon Calculator.

12.9 Summary

- 12.9.1 The results of the Carbon Calculator show that the Proposed Development is estimated to save nearly 50,000 tonnes of CO₂e per year, through the displacement of grid electricity, based on the current fossil fuel grid mix. Displacement of existing sources of generating capacity depends on the time of day and how the grid needs to be balanced. Although it does depend on the rate of electrification of transport and heat in buildings, it is reasonable to anticipate that, over the lifetime of the Proposed Development, the electricity generated will displace existing fossil fuel usage.

- 12.9.2 The assessment of the Proposed Development estimates losses of around 68,000 tonnes of CO₂e. The largest proportion of these are from grid backup and turbine lifecycle which are not within the direct control of the Developer. Losses from grid backup are likely to be overestimated as they do not account for future developments in electricity storage or demand management by the grid. The most significant category of site-based losses is from reduced future carbon sequestration potential from felled forestry. However, future gains from forestry restocking and compensatory planting are not included in the Carbon Calculator and therefore the total losses are likely to be overstated. Soil carbon losses account for around 5.4% of losses, but it should be noted that the Carbon Calculator assumes that all extracted and drained peat is oxidised and does not include any reduction from peat that is successfully reinstated. The baseline assessment demonstrated that less than 0.2% of the soil carbon within the Site boundary would be affected by the Proposed Development. Restoration of areas of degraded bog and forestry to bog are estimated to produce gains over the lifetime of the Proposed Development through blocking of drains, re-wetting of peat and restoring surface vegetation; these gains are estimated at nearly 10,000 tonnes of CO₂e, which is approximately 6,300 tonnes of CO₂e more than that which is lost through peat excavation and drainage.
- 12.9.3 The estimated payback time of the Proposed Development, using the Scottish Government Carbon Calculator, is 1.2 years, with a minimum/maximum range of 0.7 to 1.7 years, based on the fossil fuel mix of the electricity grid. This is around 3% of the anticipated lifespan of the Proposed Development. Compared to fossil fuel electricity generation projects, which also produce embodied emissions during the construction phase and then significant emissions during operation due to combustion of fossil fuels, the Proposed Development has a low carbon footprint, and after 1.2 years the electricity generated is estimated to be carbon neutral and will displace grid electricity generated from fossil fuel sources, or directly displace fossil fuel use for transport and heating. The carbon intensity of the electricity produced by the Proposed Development is estimated at 0.015 kgCO₂e/kWh. This is well below the outcome indicator for maintaining the electricity grid carbon intensity below 0.04 kgCO₂e/kWh required by the Scottish Government in the Climate Change Plan (Scottish Government, 2026), and therefore; the Proposed Development is evaluated to have an overall beneficial effect on carbon emissions associated with energy generation.

12.10 References

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