13.4 Carbon Balance Assessment

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13 Carbon Balance Assessment

13.1 Executive Summary

13.1.1 This Carbon Balance Assessment uses the Scottish Government's Carbon Calculator for wind farms on peat to assess the benefit of displacing electricity from fossil fuels with renewable generated electricity, compared to the emissions of carbon required for the construction and operation of Beinn Ghlas Wind Farm Repowering (the Proposed Development) over its 35-year lifetime, including the removal of the existing turbines and losses of stored carbon from disturbed peatland. The Carbon Calculator assessment is detailed in provides an estimate of the carbon payback time for the Proposed Development.

13.1.2 The results of the Carbon Calculator show that the Proposed Development is estimated to save over 32,000 tonnes of CO_2e per year, by generating electricity from renewable energy rather than using fossil fuels such as gas to generated grid electricity. The saving is calculated using the current average fossil fuel grid mix emission factor.

13.1.3 The assessment of the Proposed Development estimates losses of 64,000 tonnes of CO_2e. The largest proportion of these is from the manufacture of the turbines, followed by the provision of grid backup. It is likely that the methodology used overestimates these losses due to improvements in turbine technology that have not increased embodied emissions in recent years and future improvements to grid storage capacity, reducing the need for back up of intermittent sources. Ecological site-based losses account for just over 10,000 tCO_2e while restoration of areas of degraded bog are estimated to produce gains over the lifetime of the Proposed Development through blocking of drains and re-wetting of peat; these gains are estimated at nearly 16,000 tonnes of CO_2e, which is greater than the ecological site-based losses.

13.1.4 The estimated payback time of the Proposed Development, using the Scottish Government Carbon Calculator, is 1.5 years, with a minimum/maximum range of 0.8 to 2.3 years, based on the fossil fuel mix of the electricity grid. There are no current guidelines about what payback time constitutes a significant impact, but 1.5 years is around 4% of the anticipated lifespan of the Proposed Development. The carbon intensity of the electricity produced by the Proposed Development is estimated at 0.019 $kgCO_2$e/kWh. This is well below the outcome indicator for maintaining the electricity grid carbon intensity below 0.05 $kgCO_2$e/kWh required by the Scottish Government in the Climate Change Plan update (Scottish Government, 2020) and the UK Clean Power 2030 Action Plan, and therefore the Proposed Development is evaluated to have an overall beneficial effect on carbon emissions associated with energy generation.

13.2 Introduction

13.2.1 This Carbon Balance Assessment has been undertaken by Clare Wharmby on behalf of Fluid Environmental Consulting. Clare is a Full member of IEMA and a Chartered Environmentalist with over 15 years of experience undertaking carbon balance assessments for wind farms on peat across the UK.

13.2.2 Increasing atmospheric concentrations of greenhouse gases (GHGs), also called carbon emissions, are resulting in global heating which will 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, 31.5% of electricity was generated from fossil fuels in 2024 (Department for Energy Security and Net Zero, 2025). 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 Delivery Plan (Department for Energy Security and Net Zero, March 2023) and the update to the Climate Change Plan (Scottish Government, 2020)).

13.2.3 However, no form of electricity generation is completely carbon free; for onshore wind farms there will be emissions resulting from the manufacture of turbines and batteries, as well as emissions from both construction and decommissioning materials, transport and activities.

13.2.4 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. 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 peatlands on which they are sited, need to be evaluated to understand the consequences of permitting such developments.

13.2.5 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 13: Other Issues of the Environmental Impact Assessment Report (EIA-R). 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.

13.3 Legislation, Policy and Guidelines

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

Legislation

13.3.1 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

13.3.2 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 Britian 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. The update to the Climate Change Plan (Scottish Government, 2020) recognises the need to continue the process of decarbonising the electricity grid and increasing generation capacity to support the delivery of electric heating and transport. However, the Climate Change Plan Update also recognises the importance of maintaining and restoring carbon storage in peat.

13.3.3 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.

13.3.4 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.

13.3.5 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.

13.3.6 Onshore wind turbines: Planning Advice (Scottish Government, updated 2014) which under the heading of Securing Sufficient Information to Determine Planning Applications, for wind turbines proposed on peatland, refers to guidance on carbon calculations.

Guidance

13.3.7 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.

13.4 Consultation

13.4.1 Consultation on the EIA Scoping Report was undertaken and responses were sought from the list of consultees and Argyll & Bute Council responded in relation to the carbon balance assessment; see Table 13.1 below.

Table 13.1 Scoping opinions relating to the carbon balance assessment

Organisation	Scoping opinion
Argyll & Bute Council	The Council is satisfied with the intended approach as detailed in the Scoping Report. Carbon balance calculations should be undertaken and included within the EIAR with a summary of the results provided focussing on the carbon payback period for the wind farm.

13.4.2 This Appendix Report forms the response to this opinion.

13.5 Assessment Methodology

13.5.1 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 2.14.1).

13.5.2 GHG emissions are measured in tonnes of carbon dioxide equivalents (tCO_2e) which is a quantity that describes, for a given mixture and amount of GHG, the amount of carbon dioxide (CO_2) 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

13.5.3 The stored carbon within the Proposed Development red line boundary (the 'Site') was estimated from the estimated volume of peat, which was calculated from the average depth of peat at the Site from the 100 m peat grid peat probes across the Site to reduce the sampling bias from detailed peat probing for infrastructure multiplied by the total Site area. This volume was multiplied by the estimated percentage of carbon content and dry soil bulk density. Tonnes of carbon were converted to carbon dioxide (tCO_2) by multiplying with the factor of 3.67, which converts from the atomic weight of carbon ('C') to the molecular weight of CO_2. Table 13.2 shows the parameters used to estimate the baseline of stored carbon. The source and references for these parameters are provided in Table 13.4 at the end of this section.

Table 13.2 Parameters used to estimate baseline stored carbon within the Site Boundary

Parameter	Expected	Minimum	Maximum
Size of Site based on red line boundary (ha)	428	407	449
Average peat depth across Site (m)	0.57	0.51	0.63
Carbon content of dry peat (% by weight)	56%	49%	62%
Dry soil bulk density (g/cm^3)	0.11	0.08	0.13

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

13.5.4 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 peatland. Accompanying this methodology was an excel spreadsheet tool called the 'Carbon Calculator for wind farms on peat' (abbreviated to the Carbon Calculator) 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.

13.5.5 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 Carbon Calculator 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 peatland hydrology and decomposition of organic matter.

13.5.6 The most recent version of the Carbon Calculator (v1.8.1) is a web-based application and central database, where all the data entered is stored in a structured manner. This web-based tool replaces all earlier versions of the Excel-based calculator and incorporates high-level automated checking, detailed user guidance and cells for identification of data sources and relevant data calculations. However, as of 01/10/24, the online version is not accessible and there is no published timeframe for when the online version will be available again. Therefore, this Appendix Report has used the Excel version of the tool (v2.14.1) which produces the same results as the online tool. Table 13.4 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.

13.6 Scope of Carbon Calculator

13.6.1 Table 13.3 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 13.3 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.	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. Since this is a re-powered site, there are also the existing turbines to be dismantled and disposed of; the Carbon Calculator does not contain the facility to include these emissions however, an Outline Circular Decommissioning Strategy (Nadara, 2025) for the existing turbines has been developed to optimise material reuse. .
	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 removal and restocking and compensatory planting. This element is not included in the basic

Project phase	Included in assessment	Excluded from assessment
		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 and from the manufacture and supply of materials for maintenance and repair 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.
	Carbon savings resulting from the generation of electricity by wind turbines and displacement of grid electricity generated by fossil fuels.	
		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.	
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.	-

Temporal Scope

13.6.2 The temporal scope for savings is set as the same period as the proposed operational period 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

13.6.3 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.

13.6.4 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.

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Table 13.4 Input parameters used in the Carbon Calculator

Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
Wind Farm Characteristics					
Dimensions					
No. of turbines	7	7	7	Chapter 2 - Proposed Development and Design Evolution states that the Proposed Development is for a renewable energy development that comprises a generating station incorporating up to 7 onshore wind turbines of up to 149.9 m to tip and associated infrastructure.	None
Lifetime of wind farm (years)	35	35	35	Chapter 2 states that the Proposed Development is anticipated to have an operational life of 35 years (excluding construction which is estimated to take approximately 23 months and decommissioning which is estimated to take 1 year).	None
Performance					
Turbine capacity (MW)	4.8	4.8	4.8	Chapter 2 states that the development will re power the currently operating Beinn Ghlas Wind Farm. The Proposed Development would involve the removal of the 14 operational turbines (total generating capacity of 8.4 MW). Since the current Beinn Ghlas Wind Farm has planning consent to operate until August 2033 and the removal of these turbines for repowering is not due to happen until 2032, the loss of current operating capacity is assessed to be minimal and therefore has not been included in the calculation. Therefore, this parameter is the Proposed	None

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Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
				Development of up to seven wind turbines of approximately 4.8 MW.	
Capacity factor – using direct input of capacity factor (percentage efficiency)	25.94	24.6	27.2	The load factor is calculated by RenewableUK as a rolling average of the past five years using data (on an Unchanged Configuration Basis) from the Digest of UK Energy Statistics (DESNZ, 2024) published by the Department for Energy Security and Net Zero, using years 2019-2023. The value for onshore wind is 25.94%.	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 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 2023, Scotland generated 53% of electricity via onshore wind (DESNZ, 2024).	This input parameter assumes no improvement in external grid management techniques, including demand side management or smart metering over the lifetime of the wind farm.
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.	Extra emissions due to reduced thermal efficiency of the reserve power generation ≈ 10% (Dale et al 2004 referenced by the Carbon Calculator).
Carbon dioxide emissions from turbine life - (e.g. manufacture,	Calculate with installed capacity			Chapter 2 states that the candidate turbine model to be installed as part of the Proposed Development would be selected through a competitive procurement process. In the EIA, a worst-case scenario of the turbine	None

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Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
construction, decommissioning)				dimensions/characteristics is used. Therefore, the default methodology within the Carbon Calculator which uses an estimate of installed capacity, has been used, rather than the direct input of emissions based on a specific candidate turbine.	
Characteristics of peatland before wind farm development					
Type of peatland	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. Based on Chapter 7: Ecology, the vegetation comprises mostly of a mosaic of wet heath and bogs, interspersed with areas of acid and marshy grassland ; this corresponds most closely to acid bog.	None
Average air temperature at site (°C)	7.5	7.3	7.8	Based on average annual temperature data for North Scotland for the time period 2005 – 2024. The data is sourced from the Meteorological Office (2025). Mean: 8.5 Count: 20 Standard Error: 0.10	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.
Average depth of peat at the site (m)	0.57	0.51	0.63	The peat depth distribution from the Peat Management Plan was used to estimate the average peat depth across the site, using the mid-point of the peat depth ranges and the areas of peat depth distribution across the survey area	A range of +/- 10% has been used to calculate the likely minimum and maximum.

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Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
				to estimate total volume of peat. The total volume was divided by the total area of the site boundary.	
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)	31	21	42	The average extent of drainage has been estimated using Von Post data from 25 cores on-site. Von Post scores were recorded at intervals throughout the peat core. The average score for acrotelm and catotelm was calculated and 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 13.7 below.	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)	0.17	0.12	0.21	The expected annual water table depth is estimated at the average depth of the acrotelm/catotelm boundary, measured from 25 cores.	A range of +/- 25% has been used to calculate the likely minimum and maximum.
Dry soil bulk density (g/cm^3)	0.11	0.08	0.13	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 13.7 below. The estimated bulk density of $0.11g/cm^3$ 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.
Characteristics of bog plants					

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Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
Time required for regeneration of bog plants after restoration (years)	22.5	15	30	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.	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 30 years. The estimated 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 $t\ C\ ha^{-1}\ yr^{-1}$.
Forestry Plantation Characteristics					

Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
Area of forestry plantation to be felled (ha)	1.61	1.45	1.77	Chapter 13 states that the total felling required for the Site Access would be 1.61 ha, of which 1.02 ha would be permanent and 0.59 ha would be temporary. Although there will be restocking of the temporary felling and compensatory planting for the permanent felling, the total felled area has been included in this section as a worst case scenario.	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})	3.96	2.97	4.95	Based on the species composition of current forestry onsite (Table 13.16) and the age class structure of the current baseline forestry onsite (Table 13.15), the woodland, the sequestration rate has been modelled on Sitka Spruce, age 30-35 years, Yield class 12, non-thin, 2m planting spacing. Using the Woodland Carbon Code Carbon Calculation Spreadsheet (v2.4.1, April 2024), the average total annual sequestration rate for this type of woodland over the lifetime of the wind farm is estimated at 13.44 tCO_2e/ha/yr. This is converted to units of tC/ha/yr by dividing by 3.67.	A range of +/- 25% has been used to calculate the likely minimum and maximum.
Counterfactual emission factors					
Coal-fired plant emission factor (tCO_2 MWh^{-1})	0.945	0.945	0.945	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	0.207	0.207	0.207		

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Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
(tCO_2 MWh^{-1})					
Fossil fuel- mix emission factor (tCO_2 MWh^{-1})	0.424	0.424	0.424		
Borrow Pits					
Number of borrow pits	0	0	0	Chapter 2 states that the total estimated required quantity of aggregate is expected to be won as a result of the works required to create the upgraded and new access tracks and turbine foundations, therefore there is no requirement for additional borrow pits.	None
Foundations and hard-standing area associated with each turbine					
Method used to calculate CO_2 loss from foundations and hard-standing	Rectangular, with vertical sides			The simple method of calculation for turbine foundations was used for this application because this are no clear groups of turbines in terms of peat depth.	None
Average length of turbine foundations (m)	22	21	23	Chapter 2 states that the turbine foundations would be set down to the depth of suitable bearing strata with an approximate diameter of 25 m with a circular or octagonal plan shape. The area of a 25 m circular foundation has been translated to an equivalent dimensions of a square of the same size.	A range of + 5% has been used to calculate the likely expected and maximum values of both length and width.
Average width of turbine foundations (m)	22	21	23		

Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
Average depth of peat removed from turbine foundations (m)	0.39	0.35	0.43	The volume of peat at each turbine/hardstanding location was taken from the Peat Management Plan excavation calculations (total volume of peat excavated, including slopes and drains). The total volume of peat was divided by the total infrastructure area (temporary and permanent hardstandings, which includes the turbine foundations and additional excavated area for slopes and drains) to get an average peat depth removed from these excavations.	A range of +/- 10% has been used to calculate the likely minimum and maximum.
Average length of hard-standing (m)	103	98	108	The hardstanding area is made up of both permanent and temporary excavated areas, the turbine foundations and additional excavated area for slopes and drains. The total excavated area was taken from the PMP, minus the turbine foundation area. An average length and width were calculated using the square root of the average hardstanding area, although in reality the shapes are irregular and vary slightly depending on the location.	A range of +/- 5% has been used to calculate the likely minimum and maximum.
Average width of hard-standing (m)	103	98	108		
Average depth of peat removed from hard-standing (m)	0.39	0.35	0.43	The volume of peat at each turbine/hardstanding location was taken from the Peat Management Plan excavation calculations (total volume of peat excavated, including slopes and drains). The volume of peat was divided by the total infrastructure area (temporary and permanent hardstandings, which includes the turbine foundations and additional excavated area for slopes and drains) to get an average peat depth removed from these excavations.	A range of +/- 10% has been used to calculate the likely minimum and maximum.

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Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
Volume of concrete used in entire area (m^3)	12,028	11,427	12,629	Chapter 2 states that for the purposes of this EIA Report, a maximum (worst-case) scenario for turbine foundations of a 3 – 4 m depth and 25 m diameter circular or octagonal footprint has been assumed. The volume of this shape has been used to estimate the volume of concrete required for each turbine base and multiplied by the number of turbines.	A range of +/- 5% has been used to calculate the minimum and maximum.
Access tracks					
Total length of access track (m)	12,830	12,889	13,472	Chapter 2 states that the total length of the Site Access and Internal Access Tracks would be approximately 12.83 km of which 2.71 km is new access track (1.6 km floating) with associated new watercourse crossings and 8.52 km is existing access track and watercourse crossings which would need to be upgraded.	A range of +/- 5% has been used to calculate the minimum and maximum.
Existing track length (m)	0	0	0	Although there is approximately 8.52 km of existing access track, since this would require upgrading, it has been included in the excavated track section below.	None
Length of access track that is floating road (m)	1,600	1,520	1,680	Chapter 2 states that where it is not possible to avoid areas of deepest peat, floating track construction would be used. It is anticipated that there would be approximately 1.6 km of floating track where consistent peat depths of 1.2 m or greater are identified, which is generally where there are shallow gradient slopes (below 5%).	A range of +/- 5% has been used to calculate the minimum and maximum.

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Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
Floating road width (m)	10.8	10.3	11.4	The average width of the floating road has been calculated as the area of the floating track plus the associated earthworks, divided by the estimated length of floating track, which is 1.6 km.	A range of +/- 5% has been used to calculate the minimum and maximum.
Floating road depth (m)	0.0	0.0	0.50	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 PMP provides the average peat depth over infrastructure area for floating tracks (1.0 m) and a cautious estimate of 50% of this depth has been entered for the maximum to represent the worst-case scenario.	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)	1,600	1,520	1,680	Chapter 2 states that the track surface would have a cross fall for the runoff to drain into ditches on the downhill side of the track where necessary. Lateral and cross drains would also be installed, with erosion protection, where required. Therefore, it is assumed that all floating track is drained.	A range of +/- 5% has been used to calculate the minimum and maximum.
Average depth of drains associated with floating roads (m)	0.43	0.39	0.47	It is assumed that the drainage ditch on the upside slope would be a V shape of around 0.5m which equates to a depth of around 0.43m.	A range of +/- 10% has been used to calculate the likely minimum and maximum

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Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
Length of access track that is excavated road (m)	11,230	10,669	11,792	Chapter 2 states that general terms, the construction method would see topsoil, including peat, being removed and stored adjacent to the construction area until required for reinstatement. Excavations would continue to expose a suitable horizon or bedrock on which to construct the track. Upgraded existing track has been included in this total length. The length of access track to be excavated is the sum of the new track and the upgraded existing track.	A range of +/- 5% has been used to calculate the likely minimum and maximum
Excavated road width (m)	5.0	4.75	5.25	The average width of the new excavated track and the upgraded track has been estimated from the Peat Management Plan calculations based on the total volume of peat extracted and the area of the infrastructure.	A range of +/- 5% has been used to calculate the likely minimum and maximum
Average depth of peat excavated for road (m)	0.25	0.23	0.28	The average peat depth across the new and upgraded excavated track was calculated from the PMP as the total volume of peat extracted for both these track types (including verges and drains) divided by the area.	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	0	0	0	Chapter 2 states that the majority of the underground power cables would run parallel to access tracks, connecting each turbine with Supervisory Control and Data	Assume all cable trenches follow access track routes.

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Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
a permeable membrane (e.g. sand) (m)				Acquisition (SCADA) cables which will be buried in the electrical cable trenches.	
Additional peat excavated (not accounted for above)					
Volume of additional peat excavated (m3)	2,042	1,940	2,145	The volume of additional excavated peat has been calculated from the Peat Management Plan excavation calculations for the additional infrastructure components listed below: • Temporary Construction Compounds • Met Mast The sum of total volume of peat excavated, includes additional areas excavated for slopes and drains.	A range of +/- 5% has been used to calculate the likely minimum and maximum
Area of additional peat covered by infrastructure (m^2)	12,860	12,217	13,503	The PMP provides the total excavated footprint area (including additional areas excavated for slopes and drains) for the additional infrastructure components listed above.	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)	71.7	64.5	78.9	The Outline Biodiversity Enhancement and Habitat Management Plan (OBE-HMP) states that Objective 2 is peatland restoration. As a result, the OBE-HMP has identified areas where blocking the drainage ditches and blocking and reprofiling erosion features would help to re-wet the peatland habitat and help to establish a more natural drainage pattern. In total:	A range of +/- 10% has been used to calculate the likely minimum and maximum

Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
				• c. 7,940 m drainage ditches that are suitable for infilling resulting in an area of c. 43 ha of surrounding habitat that will be re-wetted; and • c. 6.2 ha of Actively Eroding blanket bog has been identified and is suitable for infilling and/or reprofiled resulting in an additional area of c. 24.4 ha of surrounding habitat that will be re-wetted. However, a total of 0.03ha of Actively Eroding bog is predicted to be lost by the permanent land-take (Technical Appendix 7.12) with a total loss of Actively Eroding bog at construction of 0.132. Removing these, and the associated 3m buffer resulted in a total of c. 6.1ha of Actively Eroding blanket bog suitable for restoration and 22.6ha of surrounding habitat that will be re-wetted. The gives a total of c. 71.7ha of peatland restoration potential.	
Water table depth in degraded bog before improvement (m)	0.35	0.26	0.44	This parameter has not been directly measured but from experience in other similar environments, in peat that is degraded, the water table to be down between 30-40 cm.	A range of +/- 25% has been used to calculate the likely minimum and maximum.
Water table depth in degraded bog after improvement (m)	0.10	0.09	0.11	Target optimum water table depth for restoring peat is around 0.1m.	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	12.5	10	15	The restoration is coming from a combination of replacement and re-profiling and ditch blocking; estimated time for restoration of hydrology and habitat would be a minimum of 10 years.	The minimum has been set at 10 years and a range of + 25% & +50% has been used to calculate the likely expected and maximum.

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Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
previous state on improvement (years)					
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
Removal of drainage from foundations and hardstanding					
Removal of drainage from foundations and hardstanding	0	0	0	It is usual for hardstanding areas to be required for turbine maintenance during operational years and therefore it is assumed that the drainage of these structure will remain in place. It should be noted that there is no significant improvement to the payback by completing this section.	None
Restoration of Application Site after decommissioning					
Will hydrology of the Proposed Development site be restored on decommissioning?	No	No	No	Chapter 2 states the removal of infrastructure at the end of the operational life of the Proposed Development would be the reverse of the erection process, involving similar cranes and technical procedures. When the Proposed Development reaches the end of its lifetime, the best practice industry guidance for decommissioning and restoring wind farms at that time will be adhered to and the Applicant is committed to adopting	None
Will habitat of the Proposed Development	No	No	No		

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Parameter	Expected	Minimum	Maximum	Data Source	Key Assumptions
site be restored on decommissioning?				a circular economy approach to decommissioning, prioritising reuse, recycling and minimising environmental impacts, as demonstrated by the Outline Circular Decommissioning Strategy (Nadara, 2025). However, there is insufficient information at this state to respond to these questions and therefore they have been marked as ‘no’ as a worst-case scenario. However, it should be noted this response has no impact on the overall carbon payback at this site.	
Choice of methodology for calculating emission factors	Site specific			As required for planning applications.	

13.7 Detailed Methodology Statements

13.7.1 Table 13.2 details the Site-based parameters and conversion factors used for the baseline assessment and Table 13.4 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

13.7.2 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.

13.7.3 Cores were taken at 25 locations and the range of Von Post score for humification (H score) was recorded in the acrotelm and then at metre intervals down the peat column. 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 acrotelm layer (mean = 2.3, count 25)

Calculate the average Von Post scores for catotelm layer (mean = 6.3, count 33)

Calculate an average weighted Von Post score, using the average depth of acrotelm and catotelm to weight the score (weighted average score = 5.6)

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

Estimating Average Drainage Distance from Drainage Features

13.7.4 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 if 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)

13.7.5 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).

13.7.6 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.

13.8 Results of Carbon Balance Assessment

Baseline Conditions

13.8.1 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.

13.8.2 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.

13.8.3 Table 13.5 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 13.5 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 428 ha multiplied by average peat depth of 0.57 m)	2,433,000	2,080,000	2,810,000
Estimated amount of carbon in soils (tC)	149,000	82,000	226,000
Estimated equivalent emissions of CO_2 (tCO_2)	545,000	299,000	831,000

13.8.4 Table 13.5 shows that there are approximately 0.14 million tonnes of stored carbon onsite and if this were fully oxidised, this would equate to approximately 0.5 million tonnes of CO_2 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

13.8.5 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.

13.8.6 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 13.6 Estimated Carbon Emissions during the Construction Phase

Emission source	Estimated emissions (tCO_2e)			% of overall emissions (expected scenario)
	Expected	Minimum	Maximum	
Losses due to production of turbines and construction materials	31,922	31,732	32,112	49.9%
CO_2 loss from excavated peat	4,209	-143	11,880	6.6%

Emission source	Estimated emissions (tCO_2e)			% of overall emissions (expected scenario)
	Expected	Minimum	Maximum	
Subtotal of emissions during construction	**36,131**	**31,589**	**43,992**	**56.5%**

13.8.7 Table 13.6 shows that around 57% of the 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 other materials used in construction (for example concrete for foundations). However, this is based on the estimation methodology that is inbuilt into the Carbon Calculator since the candidate turbine is unknown. This methodology is likely to overestimate emissions for more modern higher-powered turbines. The emissions from the oxidation of peat excavated for infrastructure construction contributes 6.6% to the overall losses, but the Carbon Calculator assumes that all the peat excavated is fully oxidised whereas the Outline Peat Management Plan is designed to reduce these losses by reusing and restoring this peat around the Site. As a result, it is expected that losses will be less through good peat management techniques.

Table 13.7 Estimated Carbon Emissions during the Operational Phase

Emission source	Estimated emissions (tCO_2e)			% of overall emissions (expected scenario)
	Expected	Minimum	Maximum	
Losses due to grid backup	21,840	21,840	21,840	34.1%
Losses due to reduced carbon fixing potential	5,112	1,689	11,507	8.0%
Losses due to Dissolved Organic Carbon (DOC) & Particulate Organic Carbon (POC) leaching	99	22	205	0.2%
CO_2 loss from drained peat	-	-	-	0.0%
Losses due to reduced carbon sequestration potential of felled forestry	818	553	1,124	1.3%
Subtotal of emissions during operation	**27,869**	**24,104**	**34,676**	**43.5%**

13.8.8 Table 13.7 shows that just under 44% of the emissions occur during the operational phase of the Proposed Development. The most significant of these is due to the requirement of grid backup due to the intermittent nature of wind generation. The backup assumed to be by fossil-fuel-mix of electricity generation and does not take into account renewable sources of backup, grid system storage or time-based demand management so this is likely to be an overestimate of the losses from this category. A further total 9.3% of losses come from the loss of carbon sequestering vegetation (bog and forestry). It should be noted that gains from compensatory woodland planting are not included in the Carbon Calculator. There are minimal losses from DOC/POC leaching and no losses from drained peat due to the avoidance of placing infrastructure in deeper peat areas.

13.8.9 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

13.8.10 Table 13.8 shows the estimated carbon gains over the lifetime of the Proposed Development from restoration of blanket bog habitat (Objective 2 of the OBE-HMP). The gains from restoration 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 13.8 Estimated Carbon Gains

Source of gains	Estimated gains (tCO_2e)			% of overall gains (expected scenario)
	Expected	Minimum	Maximum	
Change in emissions due to improvement of degraded bogs	-15,930	-7,867	-25,537	100.0%
Total estimated gains	**-15,930**	**-7,867**	**-25,537**	**100.0%**

Comparison with the Baseline

13.8.1 The soil carbon losses from the Proposed Development are estimated at 9,420 tonnes of CO_2e. This represents 1.7% of the estimated total stored carbon onsite (as set out in Table 13.5) and includes anticipated losses from excavated peat, losses due to leaching and losses from reduced carbon fixing potential. In reality, this percentage is likely to be lower because the method used by the Carbon Calculator tool assumes that all excavated peat will be oxidised, whereas good management and re-use at Site is likely to prevent at least a proportion of this oxidation.

Comparison of Ecological Carbon Losses with Carbon Gains from Restoration

13.8.2 Table 13.9 shows a comparison of ecological carbon losses (all the losses included in soil carbon above with the addition of losses of forestry sequestration) with the estimated carbon gains from restoration. The estimated carbon is shown for the expected value within the carbon calculator.

Table 13.9 Comparison of soil carbon losses with restoration gains

Soil carbon loss category	Expected tCO_2e	Restoration gain category	Expected tCO_2e
CO_2 loss from removed peat	4,209	Change in emissions due to improvement of degraded bogs	-15,930
Losses due to reduced carbon fixing potential	5,112		
Losses due to Dissolved Organic Carbon (DOC) & Particulate Organic Carbon (POC) leaching	99		

Losses due to reduced carbon sequestration potential of felled forestry	818		
Total soil carbon losses	**10,238**	**Total restoration gains**	**-15,930**

13.8.3 Table 13.9 shows that the ratio between soil carbon loss and restoration gains is around 1:1.6; there are over 1.5 times more gains than losses.

Carbon Balance Assessment – Savings

13.8.4 Table 13.10 shows the estimated annual and lifetime CO_2 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 13.10 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_2e per year)		
	Expected	Minimum	Maximum
Coal-fired electricity generation	72,151	68,544	83,820
Grid-mix of electricity generation	15,805	15,014	18,361
Fossil fuel - mix of electricity generation	**32,373**	**30,754**	**37,608**
Counterfactual emission factor – lifetime savings	**Estimated savings (tCO_2e over lifetime)**		
Coal-fired electricity generation	2,525,301	2,399,036	2,933,691
Grid-mix of electricity generation	553,161	525,503	642,618
Fossil fuel - mix of electricity generation	**1,133,045**	**1,076,393**	**1,316,281**

Payback Time and Carbon Intensity

13.8.5 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.

13.8.6 Table 13.11 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 13.11 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	0.7	0.4	1.0
Grid-mix of electricity generation	3.0	1.6	4.7
Fossil fuel - mix of electricity generation	**1.5**	**0.8**	**2.3**
Carbon intensity of electricity generated	**Carbon intensity (kgCO_2e/kWh)**		
Carbon intensity of units generated	0.019	0.011	0.029

13.8.7 Table 13.11 shows that the Proposed Development is estimated to have a payback of 1.5 years based on the fossil fuel mix, and the carbon intensity of units produced would be significantly lower than the current grid mix (the value of 0.207 kgCO_2e/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.

13.9 Summary

13.9.1 The results of the Carbon Calculator show that the Proposed Development is estimated to save over 32,000 tonnes of CO_2e 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 depends on the rate of electrification of transport and heat in buildings, it is reasonable to anticipate that over the lifetime of the Proposed Development that generated electricity will displace existing fossil fuel usage.

13.9.2 The assessment of the Proposed Development estimates losses of 64,000 tonnes of CO_2e. The largest proportion of these from the manufacture of the turbines, followed by the provision of grid backup. It is likely that the methodology used overestimates these losses due to improvements in turbine technology that have not increased embodied emissions in recent years and future improvements to grid storage capacity, reducing the need for back up of intermittent sources. Ecological site-based losses account for just over 10,000 tCO_2e but it should be noted that the Carbon Calculator assumes that all extracted peat is oxidised and does not include any reduction from peat that is reinstated. The baseline assessment demonstrated that less than 2% of the soil carbon within the Site boundary would be affected by the Proposed Development. Restoration of areas of degraded 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 16,000 tonnes of CO_2e, which is greater than the ecological site-based losses.

13.9.3 The estimated payback time of the Proposed Development, using the Scottish Government Carbon Calculator, is 1.5 years, with a minimum/maximum range of 0.8 to 2.3 years, based on the fossil fuel mix of the electricity grid. There are no current guidelines about what payback time constitutes a significant impact, but 1.5 years 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 1.5 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 0.019 $kgCO_2e/kWh$. This is well below the outcome indicator for maintaining the electricity grid carbon intensity below 0.05 $kgCO_2e/kWh$ required by the Scottish Government in the Climate Change Plan update (Scottish Government, 2020) and the UK Clean Power 2030 Action Plan, and therefore; the Proposed Development is evaluated to have an overall beneficial effect on carbon emissions associated with energy generation.

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