
# Bloch Wind Farm

## Technical Appendix 9.7
## Climate and Carbon Balance Assessment

7 October 2022

**RES**

# Document history

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| Issue | Date | Revision Details |
|---|---|---|
| A | 10 October 2022 | Initial Draft |
| B | 20 October 2022 | Update |

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# Contents

# 1. Introduction

This Technical Appendix of the Environmental Impact Assessment (EIA) Report evaluates the effects of Bloch Wind Farm on climate change and carbon balance. This report has been prepared by Natural Power Consultants Ltd. for Bloch Wind Farm (hereafter known as the proposed development) which consists of 21 wind turbines and ancillary infrastructure.

This appendix includes the following elements:

- Legislation, policy and guidance;
- Scoping responses and consultations;
- Climate change impacts;
- Effects of future climate change; and
- Carbon balance assessment.

# 2. Legislation, Policy and Guidance

Scotland has legislated to achieve net-zero carbon emissions. In October 2019, The Climate Change (Emissions Reduction Targets) (Scotland) Bill received Royal Assent. The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 builds on a number of energy policy documents that recognise the Scottish Governments commitment to tackling climate change and promoting the growth of renewable energy.

Carbon balance assessments are undertaken to support the requirements within the EIA Regulations within Scotland which transpose the EIA Directive into law stating broadly that the following should be included within environmental statements/environmental impact assessment reports;

"…*A description of the likely significant effects of the project on the environment resulting from, inter alia …*

*The impact of the project on climate (for example the nature and magnitude of greenhouse gas) emissions) and the vulnerability of the project to climate change*…"

In the UK, Scotland is at the forefront in terms of providing a guidance framework through which the impact of development upon peatlands can be minimised. The carbon balance assessment reveals the likely nature and magnitude of greenhouse gas (GHG) emissions resulting from proposed wind developments through employing the Scottish Government's Carbon Calculator Tool [1], which is currently the best method to date to undertake this kind of assessment and is endorsed by SEPA and the Scottish Government.

The carbon balance assessment has been undertaken in accordance with guidance[2] 'Calculating Carbon Losses & Savings from Wind Farms on Scottish Peatlands – Technical Note 2.10.0[3]. As well as Technical Note 2.10.0, this report has been produced giving consideration to the following guidance documents:

- D.R. Nayak *et al.* Calculating Carbon Budgets of Wind Farms in Scottish Peatlands (May 2010);
- Calculating carbon savings from wind farms on Scottish peat lands - A New Approach by Nayak *et al.,* 2010;

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[1] Available online from: https://informatics.sepa.org.uk/CarbonCalculator/index.jsp [Accessed 30/09/2022]

[2] Available online from: http://www.gov.scot/Topics/Business-Industry/Energy/Energy-sources/19185/17852-1/CSavings/CCguidance2-10-0 [Accessed 30/09/2022]

[3] Available online from: https://www.gov.scot/publications/calculating-carbon-savings-wind-farms-scottish-peat-lands-new-approach/pages/13/ [Accessed 30/09/2022]

- Smith *et al.* Carbon Implications of Windfarms Located On Peatlands – Update Of The Scottish Government Carbon Calculator Tool (2011);
- Scottish Natural Heritage (SNH) (now NatureScot): Carbon rich soil, deep peat and priority peatland habitats map (2016);
- NatureScot (2020) Advising on carbon-rich soils, deep peat and priority peatland habitat in development management[4].
- CCW Guidance Note: Assessing the impact of windfarm developments on peatlands in Wales (Jan 2010);
- Natural England Commissioned Report: Investigating the impacts of windfarm development on peatlands in England (Jan 2010);
- Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and the Minimisation of Waste. Scottish Renewables (2014);and
- Scottish Government, SNH and SEPA - Peatland Survey - Guidance on Developments on Peatland – 2017.

In addition, advice from the authors of the carbon calculator tool sought for previous assessments has been employed, and the completion of the carbon balance assessments for the proposed development has required input from hydrology, peat, ecology and site investigation specialists.

Other information sources are referenced as footnotes throughout this appendix.

# 3. Scoping Responses and Consultation

Consultation for this Technical Appendix topic was undertaken with the organisations shown in Table 3.1

**Table 3.1: Summary of consultation**

| Consultee | Issues raised and recommendations | Scoping response addressed |
|---|---|---|
| NatureScot | Peat in the Scottish soil classification is soil with more than 60% organic carbon and exceeding 50cm in thickness. We advise that the proposed development should avoid or minimise impacts on areas of peat that exceed 50cm in thickness. | Mitigations incorporated into design of development and see Technical Appendix 9.2 Peat Management Plan |
| SEPA | Scottish Planning Policy states (Paragraph 205) that "Where peat and other carbon rich soils are present, applicants must assess the likely effects of development on carbon dioxide ($CO_2$) emissions. Where peatland is drained or otherwise disturbed, there is liable to be a release of $CO_2$ to the atmosphere. Developments must aim to minimise this release."<br>Dependent upon the volumes of peat likely to be encountered and the scale of the development, applicants must consider whether a full Peat Management Plan is | See Technical Appendix 9.2 Peat Management Plan |

[4] Available online from: https://www.nature.scot/doc/advising-carbon-rich-soils-deep-peat-and-priority-peatland-habitat-development-management [Accessed 30/09/2022]

| Consultee | Issues raised and recommendations | Scoping response addressed |
|---|---|---|
| | required or whether the information would be best submitted as part of the schedule of mitigation.<br>Please note we do not validate carbon balance assessments except where requested to by Scottish Government in exceptional circumstances. Our advice on the minimisation of peat disturbance and peatland restoration may need to be taken into account when you consider such assessments. | |
| Natural England | Soils are a valuable, finite natural resource and should also be considered for the ecosystem services they provide, including for food production, water storage and flood mitigation, as a carbon store, reservoir of biodiversity and buffer against pollution. It is therefore important that the soil resources are protected and sustainably managed.<br>The ES should identify how the development impacts the natural environment's ability to store and sequester greenhouse gases, in relation to climate change mitigation and the natural environment's contribution to achieving net zero by 2050. | See Technical Appendix 9.2 Peat Management Plan and Technical Appendix 9.7 Climate Impact Assessment |

# 4. Climate Change Impacts

The most relevant climate change impacts are considered through the assessment of the likely magnitude of GHG emissions resulting from proposed wind developments in comparison to the baseline scenario with no development (where no emissions are produced as no construction takes place).

Current best practice and advice from consultees (Table 3.1) includes undertaking carbon balance assessments to assess effects with reference to the magnitude of carbon emissions released from peat by the construction of proposed wind developments on upland peat and the period of time it takes to payback those carbon emissions.

The carbon balance assessment employs the Scottish Government's Carbon Calculator Tool[5] and quantifies the $CO_2$ emissions savings over the life of the proposed development against the release of $CO_2$ from other energy generation methods as a result of implementing the project. It also reports on the time it takes to pay back any carbon debt and the potential effects of the proposed development on climate change in terms of carbon savings produced.

[5] Available online from: https://www.gov.scot/publications/carbon-calculator-for-wind-farms-on-scottish-peatlands-factsheet/ [Accessed 30/09/2022]

# 5. Effects of Future Climate Change

The potential for environmental receptors to be impacted by the proposed development is assessed in Chapters 5-14 of this EIA Report. Of these, ornithological, ecological and hydrological receptors are the most sensitive to climate change and are discussed further in Table 5.1.

**Table 5.1: Climate change effects on environmental receptors**

| EIA Report Report Baseline | Receptor | Climate Change Effect | Effect on Receptor |
|---|---|---|---|
| Chapter 7 | Ecology – Habitats, Protected Species | Temperature – up to + 2°C<br>Shift to wetter winters and dryer summers.<br>Negligible change in wind speeds | While changes in temperature could affect the composition and growth rates of plant communities and invertebrates, and hence protected species and habitats, the uncertainties are high and it is not clear that the effect of the proposed development on those receptors would alter substantially as a result. |
| Chapter 8 | Ornithology | Temperature – up to + 2 °C<br>Shift to wetter winters and dryer summers.<br>Negligible change in wind speeds. | A rise in temperature has the potential to impact on habitats which in turn may affect the behaviour of bird interests.<br>Uncertainties are high and the type and significance of effects identified from the proposed development are not anticipated to alter as a result. |
| Chapter 9 | Hydrology, Hydrogeology, Geology and Soils | Shift to wetter winters and dryer summers. | Limited change to future baseline and to the identified effects of the proposed development. |

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

In terms of the potential effects of climate change on the proposed development to ensure adequate resilience of the project to climate change, it is considered that many of the key climate trends[6] such as increased temperature, changes in rainfall and sea level rise will not affect the proposed development due to its location and high elevation. And during severe windstorms, wind turbines engage installed braking mechanisms to shut wind turbines down.

# 6. Carbon Balance Assessment

This report presents the carbon balance findings for the proposed development and has been produced to assist consultees and Scottish Ministers with their review of the proposed development's impact on peat and to assess the impact in terms of $CO_2$ emissions against the total potential carbon savings attributed to the proposed development.

[6] Available online from: https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index [Accessed 30/09/2022]

This report should be read in conjunction with the Hydrology, Hydrogeology, Geology and Soils (Chapter 9), Ecology (Chapter 7), and Proposed Development Description (Chapter 2) chapters and relevant appendices of the EIA Report which describe the proposed development in more detail and provide important information on the peat resource within the site.

Version V1.6.1 of the carbon calculator is currently the latest version of the online tool available (as of 28 September 2022). The inputs from the online carbon calculator tool run are presented in Annex A of this report (Reference: 3R3V-923T-GRNX v4). As the online tool does not allow any amendments to functionality and cannot be changed, the carbon balance assessment was undertaken subject to the specifications that the tool dictates. The tool does not currently allow users to describe the sources of the input data or the detailed information that is inserted to conduct the analysis. Therefore, Table 6.1 below presents this source information for the assessment. The data and infrastructure dimensions used have been based on the best data available at the time and, in cases where infrastructure design or construction methods were not yet clear, the worse-case values were used to ensure that the assessment presented a worse-case scenario in any areas of uncertainty. This carbon balance assessment is based on the data and infrastructure dimensions that reflect the final design of the proposed development, as far as is possible, as provided by the Applicant.  Some of the infrastructure dimensions may vary slightly to those presented in Chapter 2: Proposed Development as dimensions also include working and disturbance areas.

It is important to highlight that the assessment used a robust and comprehensive peat depth dataset that was collected throughout all stages of the design work and which provides a fair representation of peat depths across the site as well as the final layout, as described in Chapter 9: Hydrology, Hydrogeology, Geology and Soils.

Table 6.1: Record of data sources

| Input | Source of Information |
|---|---|
| **Wind turbine capacity and lifespan** | **RES:** Twenty-one wind turbines each with a rated output of up to 6MW. Proposals are for a fixed lifespan of up to 50 years. |
| **Capacity factor** | Based on client current forecasts of capacity factors for current candidate wind turbines  as well as an average capacity factors from published data from https://www.gov.uk/government/statistics/energy-trends-section-6-renewables (accessed on 30/09/2022).<br>It is important to note that the capacity factors used here will not typically reflect the final capacity factor of the proposed development and are considered to be lower than energy yield assessments for this proposed development and candidate wind turbines indicate; the capacity factor would be anticipated to be greater, as modern wind turbines are more efficient and taller than many of the older wind turbines on operational wind farms where the Energy Trends data is derived from. |
| **Fraction of output to backup** | The extra capacity that would be needed for back-up power generation is currently estimated at 5% of the rated capacity of wind plant as UK wind power regularly contributes more than 20% to the National grid. |
| **Type of peatland** | **Ecology Consulting**<br>In the tool, the choice of peatland habitats is limited to acid bog or fen. In this case, acid bog was selected as no other relevant option is available and was considered to be more representative of the site. The ecological surveys (Chapter 7: Ecology) identified that the site is located mostly in marshy grassland, with a large proportion of the land also being blanket/wet modified bog or neutral grassland.<br>As described in Chapter 9: Hydrology, Geology, Hydrogeology and Soils, the generalised soil type according to the National Soil Map of Scotland[7] (shown in |

[7] National Soil Map of Scotland, available online: http://map.environment.gov.scot/Soil_maps/?layer=1 [Accessed 30/09/2022]

| Input | Source of Information |
|---|---|
| | Figure 9.4 found in Volume 2a) within the site is predominantly peat gleys. Within the site, the Scotland's Carbon and Peatland Map (2016)[8] shows that the majority of the site is of Class 3 soils (not priority peatland habitat as only occasionally are peatland habitats found), with smaller pockets of Class 1 (nationally important) intermixed with other pockets of a mix of Class 4 and 5 (predominantly mineral soils and no peatland vegetation) soils (Figure 9. 5). |
| **Average air temp. at site** | Site specific temperature based on 29 years (1981-2010) data collected from the closest **Met Office** weather station to the proposed development. The Eskdalemuir Climate Station is positioned approximately 19km north of the proposed development.<br>The expected value is the average annual temperature over the data collection period. The minimum value is the minimum average annual temperature and maximum value is the maximum average annual temperature. https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/gcvdxj13y (accessed 06/10/2022). |
| **Average depth of peat on site** | **Hydrology Dept., Natural Power Consultants Ltd.**<br>These values are informed by Phase 1 (100m grid) peat probe data collection in March 2022 (850 peat probes). The total number of probes (2568) from Phase 1 and Phase 2 surveys (undertaken in July and August 2022) is illustrated in the interpolated peat depth map in Figure 9.6 (found in Volume 2a).<br>As advised by the authors of the original Excel tool, the arithmetic mean was calculated from this data to represent the 'expected' value, and the minimum and maximum values provided represent the lower and upper bound values of the 95% confidence intervals of the sample data collected. |
| **C content of dry peat** | **i2 Analytical Ltd**. results Sept 2022 – see Annex A.<br>Twelve peat cores were collected at locations of wind turbines and tracks, where the deepest peat depths were found during peat surveys. Collection of cores was minimised as depths experienced at other locations (where cores would typically be collected) were too shallow. Accordingly, these results present a worst-case scenario.<br>**Note:** the online tool will not accept C content values of < 19%. Therefore, as none of the results from the site cores exceeded 18% (see Annex A), 19% was inserted across all three scenarios as worst case, as the tool will assume these peat characteristics across the whole site. |
| **Extent of drainage** | **Hydrology Dept., Natural Power Consultants Ltd.**<br>Based on site observation, literature review and previous experience on similar sites. |
| **Average water table depth** | **Hydrology Dept., Natural Power Consultants Ltd.**<br>Based on water table depth observations across the site during site visits, literature review and previous experience on similar sites. |
| **Dry soil bulk density** | **i2 Analytical Ltd**. results August 2022 – see Annex B.<br>Twelve peat cores were collected at locations of wind turbines and tracks, where the deepest peat depths were found during peat surveys. Collection of cores was |

[8] Available online from: https://map.environment.gov.scot/Soil_maps/?layer=10 [Accessed 30/09/2022]

| Input | Source of Information |
|---|---|
| | minimised as depths experienced at other locations (where cores would typically be collected) were too shallow. Accordingly, these results present a worst-case scenario as the tool will assume these peat characteristics across the whole site. |
| **Time for regeneration of bog plants** | **Ecology Consulting.**<br>This has been estimated to be 7 years (5 years minimum and 10 years maximum). The time period for successful regeneration of bog plant species is dependent on numerous factors including relevant seed source, successional rate, the level of herbivore disturbance and the successful stabilisation of the water table in a restoration area. The values provided are based on the professional experience of project ecologists and the quality of the existing vegetation.<br>Potential opportunities for habitat management and peat restoration have been investigated and are reported in Chapter 7: Ecology of the EIA Report. To present a worst-case scenario for this assessment however, it is assumed that no peat restoration will take place. |
| **Carbon accumulation due to C fixation by bog plants** | Values have been inserted from the online tool notes that quote published primary literature and NatureScot guidance values. |
| **Coal-fired emission factor** | Fixed value of the carbon calculator tool. |
| **Grid mix emission factor** | Fixed value of the carbon calculator tool. |
| **Fossil fuel mix emission factor** | Fixed value of the carbon calculator tool. |
| **No. of borrow pits and dimensions** | **RES:** Three borrow pits are proposed for stone for use in construction of wind turbine foundations, hardstands, compounds and access tracks, as required. There is limited peaty soils/peat overlying the selected borrow pits however dimensions have been included to represent a worst-case scenario. |
| **Average depths of peat removed from infrastructure** | **Hydrology Dept., Natural Power Consultants Ltd.**<br>Informed by Phase 1 and Phase 2 survey data. Nearly 2600 probes were collected within the site. These values are derived from interrogation of the peat depth data collected underlying each type of infrastructure including a 100m micrositing allowance for wind turbines.<br>As advised by the authors of the original Excel tool, the arithmetic mean was calculated from this data to represent the 'expected' value, and the minimum and maximum values provided represent the lower and upper bound values of the 95% confidence intervals of the sample data collected. |
| **No. of foundations/ hardstands and dimensions** | **RES:** The foundations will be made from reinforced concrete, delivered to the proposed development. Expected dimension of the actual foundations is 28m x 28m as a worst case, which includes an 8m working area.<br>Dimensions for hardstands consider the permanent crane hardstand area and a 2m working area. |
| **Volume of concrete** | **RES:** Calculated to accommodate for wind turbine foundations (529m$^3$ each) and concrete for ancillary foundations found in the substation, transformer plinths and battery storage compound. |

| Input | Source of Information |
|---|---|
| **Total length of access track** | This assessment used 13,082m of excavated access track and 1,720m of floating access track = 14,802m[9] in total length of access tracks. No existing tracks on site. |
| **Length of floating access tracks** | 1,720m of floating access tracks are to be considered. Areas where floating access tracks are to be utilised are along sections where peat is in excess of 1m for at least 100m. |
| **Excavated access track length** | This value includes 13,082m of excavated access track. |
| **Excavated access track width** | The minimum scenario value of 10m is based on a track surface width of 5m plus cable trench 1m, drainage 2m on one side + 2m spacing and 0m allowance for cut/fill area/batters. Expected (2m) and maximum (3m) scenarios should cover smallest and largest working areas. |
| **Average depth of peat for excavated access tracks** | Informed by Phase 1 and Phase 2 data collected. As advised by the authors of the original Excel tool, the arithmetic mean was calculated from this data to represent the 'expected' value, and the minimum and maximum values provided represent the lower and upper bound values of the 95% confidence intervals of the sample data collected. |
| **Length of rock filled access tracks** | All access tracks are assumed to be excavated or floating tracks. |
| **Additional peat excavated** | **RES/Natural Power:** An expected volume of 18,439m$^3$ of additional peat will be excavated. This input accounts for the substation compound, transformers, laydown areas and construction compound (including BESS) areas. Not all infrastructure is located on deep peat however, as pockets of peat exist on site, all infrastructure has been included in the tool to represent a worst-case scenario. Calculations are shown in Table 6.2 of this document. |
| **Area of improvement of felled plantation land** | No forestry will be felled for the proposed development. |
| **Area of degraded bog to be improved** | **Ecology Consulting**<br>Potential opportunities for habitat management and peat restoration have been investigated and are reported in in Chapter 7 Ecology of the EIA Report. To present a worse-case scenario for this assessment, it is assumed that no peat restoration/improvement of degraded bog will take place. |
| **Area of borrow pits to be restored** | **RES**<br>Borrow pits will be reinstated. The final reinstatement of the borrow pits would be agreed with the local authority in consultation with NatureScot prior to reinstatement works commencing.<br>However, as the borrow pits are not predominantly located on peat habitats, inputs for peat restoration have not been included to represent the worst-case scenario. |
| **Water table depth around foundations and** | **Hydrology Dept., Natural Power Consultants Ltd.**<br>The 'before restoration' water table depth is based on the scenario whereby drainage is not removed but left in situ. It assumes that the drainage left in place |

[9] The calculator can only input a length and width of access track. This total access track length makes allowance for the inclusion of wider sections of access track i.e. at bends and turning heads, converting these wider sections to equivalent lengths of access track. The access track length given in Chapter 2 represents the access track length as measured along its centreline.

| Input | Source of Information |
|---|---|
| **hardstands before and after restoration** | would cause some draw down on the existing water table. The 'after restoration' water depths are based on backfilling of the drainage which would bring the water table depth up to, and likely higher, than previous levels before construction. |
| **Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)** | **Hydrology Dept., Natural Power Consultants Ltd.**<br>Values of 3, 2 and 5 years used.<br>Based on professional judgement. |
| **Will the hydrology of the site be restored on decommissioning?** | **Hydrology Dept., Natural Power Consultants Ltd.**<br>Yes. During the construction and commissioning of the proposed development, drainage ditches will be blocked and therefore the water table will increase. Upon the decommissioning of the proposed development, best practice principles will be adopted. |
| **Will the habitat of the site be restored on decommissioning?** | **Ecology Consulting**<br>No. At the moment it is assumed that upon decommissioning, restoration of habitats will not be undertaken. There are no plans to control grazing or to reintroduce species using nurse crops or fertilisation, therefore a worst-case scenario of "no restoration" has been inputted into the carbon calculator tool. |

The following paragraphs report on the results of the carbon calculator calculations that are present within the online tool. For clarification of the calculations, the reader will need to view the online submission (Reference: 3R3V-923T-GRNX v4).

## 6.1. Wind Farm $CO_2$ Emission Savings

The amount of $CO_2$ emissions produced during energy production varies with the type of fuel used; therefore, the potential $CO_2$ savings from the proposed development depends on the type of fuel it replaces. The wind farm $CO_2$ emission savings over other types of generation (i.e. coal-fired, grid-mix, fossil fuel-mix) is calculated by multiplying the energy output of the proposed development by the emissions factor of the other type of generation.

Based on an averaged 6MW wind turbine model scenario, the expected potential annual energy output of the proposed development is 343,932MWh/yr (17,196,581MWh over 50 years), with minimum and maximum potential outputs at 237,765MWh/yr and 475,941MWh/yr. Note: For a conservative analysis, the potential energy generation from battery energy storage system (BESS) has not been included in assessment. However, infrastructure associated with BESS has been considered.

Based on the expected annual energy output of the proposed development (343,932MWh/yr), the potential expected emissions saved over coal-fired electricity generation is 316,417 tonnes of $CO_2$ per year ($tCO_2$/yr ); over grid-mix generation is 87,214$tCO_2$/yr and over fossil fuel-mix generation is 154,769$tCO_2$/yr.

## 6.2. Emissions due to Wind Turbine Life

Energy is consumed and associated $CO_2$ emissions are released during manufacture of wind turbine components, site construction (including access tracks and wind turbine foundations etc.), and during decommissioning of a development.

The carbon calculator includes a module for assessing the carbon emissions due to wind turbine life. Nayak *et al*. (2010) explain that the wind turbine life calculation within the carbon calculator is based on generic data as it does not accommodate a site-specific full life-cycle analysis. Therefore, the wind turbine life emissions for the proposed development are estimated utilising an equation for ≥1 MW wind turbines that has been derived from data from numerous European sites, and which shows a significant relationship across the European sites examined.

The carbon calculator reveals an expected emissions figure of 111,419 tonnes of $CO_2$ ($tCO_2$) equivalent (equiv.) emitted due to the manufacture, construction and decommissioning of the wind turbines. Based on the calculated emissions savings for fossil fuel-mix generation, the payback time for wind turbine life is expected to take approximately 9 months.

## 6.3. Capacity Required due to Back Up

In order to maintain security of energy supply, a second-by-second balance between generation and demand must be maintained by the grid operators. It has been noted that the inherent variable nature of wind energy may affect this balance and therefore, a certain proportion of power is required to stabilise the supply to the customer. The electricity system, however, is designed and operated in such a way as to cope with large and small fluctuations in supply and demand. No power station is totally reliable, and demand, although predictable to a degree, is also uncertain. Therefore, the system operator establishes reserves that provide a capability to achieve balance, given the statistics of variations expected over different timescales. The variability of wind generation is but one component of the generation and demand variations that are considered when setting reserve levels.

It should also be noted that an individual wind turbine will generally generate electricity for 70-85% of the time, and its electricity output can vary between zero and full output in accordance with the wind speed. However, the combined output of the UK's entire wind power portfolio shows less variability, given the differences in wind speeds over the country as a whole. Whilst the amount of UK wind generation varies, it rarely, if ever, goes completely to zero, nor to full output at the same time throughout the UK.

The extra capacity that would be needed for back-up power generation is currently estimated to be approximately 5% of the rated capacity of the wind plant as UK wind power contributes more than 20% to the National Grid. The carbon calculator assumes that all back-up power generation will be via fossil fuels or grid-mix which does not account for any back-up energy generation from renewable sources directly or from renewable energy that has been stored in batteries. As such, the emissions figure required from back-up power generation for the proposed development is considered to be conservative as the calculator assumes a very worst-case scenario.

The carbon calculator assumes that backup is provided by a fossil fuel mix of energy generation and reveals an expected emissions figure of 124,173 $tCO_2$ equiv. due to the back-up. Based on the calculated emissions savings for fossil fuel-mix generation, the payback time for back-up is expected to take approximately 10 months.

## 6.4. Loss of Carbon Fixing Potential

Construction of the proposed development will involve the installation of infrastructure such as wind turbine foundations, access tracks and hardstands etc. Where vegetation and/or peat is removed or covered, the vegetation will no longer be able to photosynthesise and therefore, its ability to fix carbon will be lost. In addition, changes to drainage can have an effect on the vegetation of peatlands. Accordingly, the carbon calculator assumes that the carbon-fixing potential is lost from both the area occupied by infrastructure as well as working areas used to install the infrastructure and areas affected by drainage. In order to demonstrate a worst-case scenario of the proposed development's impact on carbon fixing potential through drainage, the extent of drainage around infrastructure is given as 5m expected and 3m and 10m as minimum and maximum values respectively.

The carbon calculator also assumes that the footprint of the proposed development has 100% coverage of bog plants that are still accumulating carbon for those areas where vegetation is either removed during construction or compromised due to disturbance or drainage. This assumption is considered to be very much a worst-case scenario as 100% bog habitat cover is not an accurate representation of the site's total habitat characteristics.

Habitat loss calculations for the proposed development's infrastructure have been calculated and are discussed in Chapter 7 of the EIA Report. The Phase 1 habitat survey (Figure 7.3 in Volume 2a) reveals that the site is largely comprised of marshy grassland, with large proportions of the land outwith marshy grassland being blanket/wet modified bog or neutral grass. Other habitats include smaller areas of bracken, wet heath, acid flush, scrub, swamp and broad leaved plantation/woodland.

Of the above habitats, peat habitat types (i.e. blanket bog, wet modified bog, wet heath, acid flush and some potential within marshy grassland) represent approximately 782 hectares (ha) of the *c.*1,242 ha of habitat types recorded across the area surveyed. However, only a small area of these peat habitats will be directly impacted by preparation and construction activities; with permanent loss confined to only *c.*13.14 ha in total in the worst-case scenario (approximately 1.7% of peat habitat types surveyed on site). In accordance with the carbon calculator's methodology however, the emissions from loss of $CO_2$ fixing potential is based on the footprint area of the proposed development, plus the expected area affected by drainage which is based on the 5m expected extent of drainage and assumes 100% bog/mire habitat cover of the footprint and drainage area. As such, Sheet 4 of the online tool assumes that approximately 54 hectares of bog plants will be lost compared to the *c.*13.14 ha habitats identified through site specific survey work.

Therefore, it is considered that the carbon calculator's assumption that 100% of the land lost through construction or drainage of the proposed development is covered in bog plants or peatland vegetation is considered to be highly precautionary in this instance as many other types of habitat exist.

The carbon calculator reveals that the expected total emissions attributable to the loss of carbon accumulation by bog plants is equivalent to 2,829 $tCO_2$ equiv. over the operational period of the proposed development. Based on the calculated emissions savings for fossil fuel-mix generation, the payback time for loss of carbon fixing potential is expected to be less than 1 month. However, as previously described above, it is important to recognise that 100% bog/mire habitat cover is not an accurate description of the site's characteristics.

## 6.5. Loss of Carbon Dioxide from Removed Peat (Direct Loss)

The 2017 Peatland Survey Guidance states that peat is defined as the partially decomposed remains of plants and soil organisms which have accumulated at the surface of the soil profile. Peat accumulates where the rate of input of organic material from the surface exceeds the rate of decomposition and 'turn-over' of this new material. A peat layer does not include a mineral fraction (hence being differentiated from topsoil).

Peat deposits are made up on an organic soil which contains more than 60% of organic matter and exceeds 50 cm in thickness. The peat depth data at the proposed development are taken from over 2,500 peat depth measurements collected across the proposed development. As advised by the authors of the tool, the arithmetic mean was calculated from this data to represent the 'expected' value, and the minimum and maximum values provided represent the lower and upper bound values of the 95% confidence intervals of the sample data collected. Peat depths of less than 0.5m are categorised as peaty soils with peat deposits being >0.5m in depth (JNCC, 2011[10]; Scottish Government *et al.,* 2017[11]).

Peat survey methodology was conducted in accordance with the guidance documentation 'Guidance on Developments on Peatland – Peatland Surveys 2017[12] The interpolated peat depths are illustrated in Figure 9.6 in Volume 2a of the EIA Report. The peat depth results show that the highest proportion of recorded peat depths were ≤0.5m (55%) with 45% >0.5m. Infrastructure elements have largely been placed to avoid areas of deeper peat (Technical Appendix 9.2, Table 4.1).

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[10] JNCC Report 445 (2011), Towards an assessment of the state of UK Peatlands.

[11] Scottish Government, NatureScot, SEPA (2017) Guidance on Developments on Peatland – Peatland Survey.

[12] Scottish Government, NatureScot, SEPA (2017) Peatland Survey. Guidance on Developments on Peatland, Available online from: Guidance+on+developments+on+peatland+-+peatland+survey+-+2017.pdf (www.gov.scot) [Accessed 06/10/2022]

To obtain site-specific information relating to the characteristics of the peat/soil, peat core samples were also collected using a Russian peat core and were retained for laboratory and geochemical analysis.

Carbon content of dry peat (% by weight) and dry soil bulk density (g $cm^{-3}$) were analysed in a laboratory (see Annexes A & B for results) and the expected, minimum and maximum values have been inserted in the carbon calculator (for dry soil bulk density). The online tool does not allow carbon content values of <19% to be entered and as the laboratory results showed a maximum of 18% across all samples, 19% was inputted across the three scenarios in the tool).

The excavated volumes calculated and reported within the assessment accommodate realistic working areas with the assumption built into the model that all peat/habitat in working areas or excavation areas is lost. Within this assessment, in order to represent a worst-case scenario the following working areas and assumptions have been incorporated into the analysis:

- An expected value for excavated access tracks width of 12m is based on 5m width (as described in Chapter 2: Proposed Development), 3m drainage/cable trench on one side, then 2m spacing allowance and 2m allowance for cut/fill area/batters. In some areas, spacing may be narrower or wider therefore, the minimum and maximum values of 10m and 13m have been provided respectively.
- Working or cut/fill areas, excavation areas and batters have been included around wind turbine foundations and hardstands and the detailed construction data has been used. In most cases, the wind turbine foundation footprint and working areas will overlap with the access tracks and hardstands/working areas/laydown areas. As such, all dimensions included within this assessment for wind turbine foundations should be considered worst-case as there is a considerable element of double counting.
- Expected dimensions for hardstands consider the permanent crane hardstand area including work area. The minimum and maximum values allow tolerance for smaller and larger permanent hardstands and work areas.

The working areas presented within this carbon balance assessment represent those areas where peat and/or peat vegetation may be removed or damaged/disturbed. As such, the peat volumes reported in the carbon balance assessment are considered to be highly precautionary and considered to be unrealistically worst-case. In fact, latest guidance[13] states that peat depth measurements of less than 0.5m are not categorised as peat (rather peaty soils), and peat deposits are considered being >0.5m in depth.

Some of these assumptions above will differ from those used to calculate peat extraction volumes within the Peat Management Plan (PMP) presented in Technical Appendix 9.2. The working areas presented within this carbon balance assessment represent those areas where peat and/or peat vegetation may be removed or damaged/disturbed whereas the PMP investigates only those areas where peat is extracted and stored, then available for re-use. As such, the peat volumes reported in the carbon balance assessment are considered to be precautionary and considered to be highly worst case.

The carbon calculator also requires information relating to other ancillary infrastructure not explicitly accounted for above, namely the substation, met mast and construction compounds. Table 6.2 utilises the expected dimensions of the additional infrastructure and peat depths used to calculate the total area and total volume of excavations.

**Table 6.2: Additional peat excavated calculations**

| Additional Peat Excavated | | | |
|---|---|---|---|
| | Expected | Minimum | Maximum |
| **Substation Compound ($m^2$)** | 6,554.75 | 5,769.75 | 7,389.75 |
| **Substation Compound** | 0.24 | 0.18 | 0.30 |

[13] Scottish Government, NatureScot, SEPA (2017) Peatland Survey. Guidance on Developments on Peatland, Available online from: Guidance+on+developments+on+peatland+-+peatland+survey+-+2017.pdf (www.gov.scot) [Accessed 06/10/2022]

| Additional Peat Excavated | | | |
|---|---|---|---|
| **Average Peat Depth (m)** | | | |
| **Construction Compound (includes BESS) ($m^2$)** | 7,406.00 | 6,396.00 | 8,466.00 |
| **Construction Compound (includes BESS) Average Peat Depth (m)** | 0.35 | 0.19 | 0.50 |
| **Transformers ($m^2$)** | 588.00 | 588.00 | 588.00 |
| **Transformers Average Peat Depth (m)** | 0.64 | 0.60 | 0.68 |
| **Hardstanding Laydown Areas ($m^2$)** | 21,714.00 | 11,214.00 | 33,264.00 |
| **Hardstanding Laydown Area Average Peat Depth (m)** | 0.64 | 0.60 | 0.68 |
| | | | |
| **Total Area of Peat Removed ($m^2$)** | **36,262.75** | **23,967.75** | **49,707.75** |
| **Total Volume of Peat Removed ($m^3$)** | **18,438.52** | **9,335.00** | **29,469.29** |

Sheet 5, Table 5a of the carbon calculator calculates the total expected area of land lost due to the proposed development construction as 33.74ha (does not include drained peat areas) and the expected volume of 'peat' removed over the footprint of the proposed development is expected to be 233,414m³. However, as previously described, only a small area of this 33.74ha will be directly impacted by preparation and construction activities; with permanent loss confined to only *c.*13.14ha in total in the worst-case scenario. Therefore, it is considered that the carbon calculator's assumption that 233,414m³ of peat will be lost through construction of the proposed development is considered to be highly precautionary as many other types of habitats and soils exist within the proposed development construction area, not only peat.

Total volumes and areas have been stated within the results of the tool, and these values are not rounded which conveys a false accuracy and it should be borne in mind that these values are only highly indicative as not all of the volume and areas reported as removed will be peat habitat.

The $CO_2$ release associated with the volume of peat excavated assumes a worst-case scenario that 100% of the peat is lost. However, this is not the case as the peat will be reused as part of peat reinstatement and restoration and as infrastructure avoids deeper peat (and carbon values are low), the total expected amount of $CO_2$ loss, attributable to peat removal only, (i.e. $CO_2$ emissions from peat that is excavated for the wind farm only, no impacts from drainage of peat) that is reported within the online submission is calculated to be -7,383t$CO_2$ equiv. This reduces the overall payback of the construction of the wind farm by about half a month.

## 6.6. Loss of Carbon Dioxide from Drained Areas (Indirect Loss)

Carbon is also lost from peat habitats through drainage that occurs in the peat around the proposed development. The carbon calculator and associated guidance refers to this $CO_2$ loss as an "indirect loss". The extent of the site affected by drainage assumes an expected, minimum and maximum extent of drainage around each drainage feature e.g. wind turbine foundation, access tracks etc. It is important to bear in mind that the extent of drainage is dependent on existing drainage conditions on site and also topography. The carbon calculator, however, assumes no existing drainage on site and flat terrain which is not representative of the actual site characteristics. Therefore, results using this parameter should only be considered as indicative at best.

Hydrological and site investigation specialists visually noted and recorded water table depths during surveys which informed the site design evolution. Extent of drainage is a reasonable estimation based on knowledge of the site (topography etc.), experience at similar sites and expert judgement. As such, a recommended average extent around the drainage feature of 5m was considered as an appropriate expected average for the calculation. Values of 3m and 10m were inserted as inputs to represent best- and worst-case scenarios respectively (also see Table 6.1).

Appendix 9.2 Peat Management Plan also notes that the extensive network of artificial drainage on site is likely to have already modified the condition of the peat through drainage and oxidation.

Sheet 5, Table 5 of the carbon calculator calculates the total expected $CO_2$ loss from drained peat as 0t$CO_2$ equiv. This is likely because infrastructure avoids deeper peat and, in Table 5d, the tool assumes that the emissions from drained and undrained peat have the same proportion over the emissions period. Therefore the net emissions due to drainage alone from infrastructure installation is 0t$CO_2$ equiv.

## 6.7. Loss of Carbon Dioxide from DOC and POC loss

Additional $CO_2$ emissions from organic matter can occur as carbon dioxide and methane, which can leach out of peat that is restored to conditions where the water table depth is higher after restoration than before restoration, and is a further consideration of the carbon calculator. Dissolved Organic Carbon (DOC) is defined as the organic matter that is able to pass through a filter (range in size generally between 0.7 and 0.22µm). Conversely, Particulate Organic Carbon (POC) is the fraction of soil carbon that is larger in particle size. The assessment tool assumes that 100% of the losses due to leaching DOC and POC from restored drained and improved land are eventually lost as gaseous $CO_2$.

Only restored drained and improved land has been included in the calculations within the carbon calculator for DOC and POC, because if the land is not restored or improved, then the carbon loss has already been accounted for in the calculations for excavated and drained peat (i.e. the carbon assessment assumes that if land is not restored then 100% of the carbon will be lost from the removed or drained volume of soil).

The carbon calculator calculates that there will be an expected 0t$CO_2$ equiv. lost due to DOC and POC leaching over the operational life of the proposed development.

## 6.8. Total Loss of Carbon Dioxide from Impact on Peat

The following calculations on total loss of $CO_2$ from impacts on peat have been based on a number of key assumptions (some of which are built into the tool itself), specifically in relation to peat, in order to demonstrate a worst-case (unrealistic) scenario using on-site data with input from ecology and hydrology specialists. In summary, these assumptions are:

- 100% of the area potentially affected by the proposed development is covered in peat forming mire habitat;
- The terrain is relatively flat with no existing drainage;
- Infrastructure dimensions for foundations, tracks and hardstands include working/laydown areas;
- 100% of the carbon stored in the excavated peat will be lost as carbon dioxide and not reinstated on site;
- 5m expected average extent of drainage to demonstrate a conservative expected scenario and 10m worst-case scenario;
- The average extent of drainage assumes that the depth of peat affected by drainage is equal to the depth of peat removed;
- Emissions from drained and undrained land have the same proportion over the emissions period;
- The peat depth data used to inform the volumes of peat removed assume that all recorded depths are in peat; and
- The model assumes no micrositing to further reduce impacts on peat.

The combined expected impact of the proposed development on peat and vegetation over the operational lifetime for the proposed layout is calculated as shown in Table 6.3.

Table 6.3: Total CO2 (tCO2 eq.) loss/gains on peat

| | $CO_2$ loss from plants + | $CO_2$ loss from removed peat + $CO_2$ loss from drained peat (i.e. soil organic matter loss) | + $CO_2$ DOC & POC loss |
|---|---|---|---|
| | 2,829 | -7,383 | 0 |
| **Total $CO_2$ loss/gains equiv.** | | **-4,554** | |

*Source: Online Tool Reference 3R3V-923T-GRNX v4*

Based on the calculated emissions savings for fossil fuel-mix generation, the payback time for loss of soil organic carbon is expected to be less than 1 month.

## 6.9. Carbon Gain Due to Site Improvement and Restoration

Restoration of areas within a proposed development can reverse emissions and act as carbon storage, reducing the total $CO_2$ emissions as a result of the proposed development. The carbon calculator can take into account reductions for emissions resulting from the improvement of degraded bog, felled plantation land as well as the restoration of borrow pits and early removal of drainage from wind turbine foundations.

The drainage associated with the hardstands and foundations will have an expected draw down on the water table during the construction period until such a time when they are removed/backfilled. This work will where possible, intend to raise the water table depth above that which is already present before construction. All construction ditches and drainage on site will be blocked to minimise indirect habitat damage and loss through drainage.

Potential opportunities for habitat management and peat restoration have been investigated and are reported in in Chapter 7 Ecology of the EIA Report. However, to present a worst-case scenario for this assessment, no values for improvement of degraded bog or peat restoration or restoration of borrow pits have been entered into the tool.

The results, as shown in Table 6.4, report -1,933 $tCO_2$ equiv. in carbon gains from the removal; of drainage measures from foundations and hardstanding in the expected scenario and -6,889 $tCO_2$ equiv. in carbon gains in the maximum (best-case) scenario. It is important to note that the minimum scenario does not show any carbon gains accrued from improvements of the site as the tool has assumed that no improvement has occurred at all.

## 6.10. Carbon Balance Summary

Table 6.4 reveals the carbon losses and carbon gains for each of the above parameters for the proposed development and also reveals the net $CO_2$ emissions.

Table 6.4: Expected $CO_2$ losses and gains

| Carbon Balance Input Parameter | Expected Results |
|---|---|
| 1. **Wind Farm $CO_2$ emission saving over other types of energy generation** | |
| Coal fired electricity generation ($tCO_2yr^{-1}$) | 316,417 |
| Grid mix of electricity generation ($tCO_2yr^{-1}$) | 87,214 |
| Fossil fuel mix of electricity generation ($tCO_2yr^{-1}$) | 154,769 |
| **Energy output from proposed development over lifetime (MWh)** | **17,196,581** |
| **Total $CO_2$ losses due to proposed development (tCO2 eq.)** | |

| Carbon Balance Input Parameter | Expected Results |
|---|---|
| 2 Losses due to wind turbine life (e.g. manufacture, construction, decommissioning) | 111,419 |
| 3. Losses due to backup | 124,173 |
| 4. Losses due to reduced carbon fixing potential | 2,829 |
| 5. Losses from soil organic matter | -7,383 |
| 6. Losses due to DOC & POC leaching | 0 |
| 7. Losses due to felling forestry | 0 |
| **Total losses ($tCO_2$ eq.)** | **231,039** |
| **8. Total $CO_2$ gains due to improvement of site ($tCO_2$ eq.)** | |
| 8a. Gains due to improvement of degraded bogs | 0 |
| 8b. Gains due to improvement of felled forestry | 0 |
| 8c. Gains due to restoration of peat from borrow pits | 0 |
| 8d. Gains due to removal of drainage from foundations and hardstands | -1,933 |
| **Total gains ($tCO_2$ eq.)** | **-1,933** |
| **Net $CO_2$ emissions ($tCO_2$ eq.)** | **229,106** |

*Source: Online Tool Reference 3R3V-923T-GRNX v4: Payback Time and $CO_2$ emissions page.*

The net emissions of $CO_2$ of the proposed development are calculated by deducting the total $CO_2$ gains produced by improvement and restoration of the site from the total $CO_2$ emissions from manufacture of, construction of, and impacts on peat from, the individual elements of the proposed development (described in the preceding paragraphs).

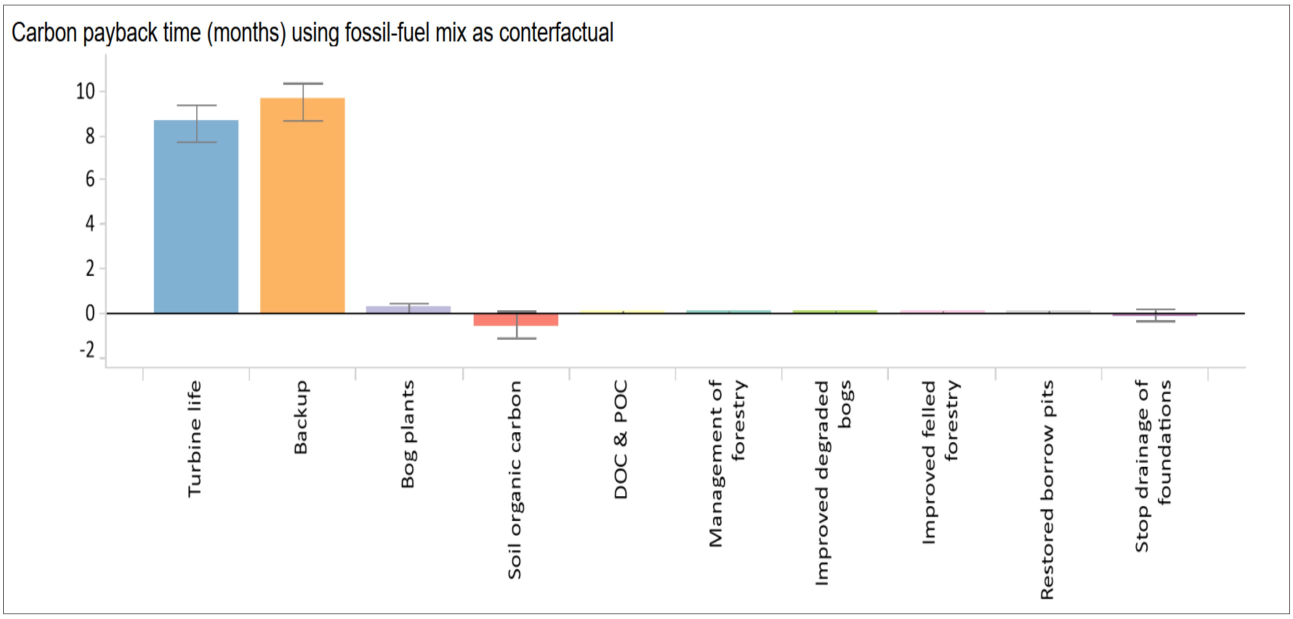
The proposed development $CO_2$ emissions savings of the proposed development over other types of generation (i.e. coal-fired, grid-mix, fossil fuel-mix) is calculated by multiplying the energy output of the proposed development by the emissions factor of the other type of generation. However, this parameter only takes into consideration the energy output of the proposed development and does not take into account any of the carbon losses or gains that are produced from manufacture of, construction of, and impacts on peat from, the individual elements of the proposed development. The parameter that takes all parameters into account is the carbon payback time and it is this value that provides an indication of the carbon balance of the proposed development.

The carbon payback time for the proposed development is calculated by comparing the net loss of $CO_2$ from the Site due to proposed development with the carbon savings achieved by the proposed development while displacing electricity generated from coal-fired generation, grid-mix generation or fossil-fuel mix electricity generation. Figures 6.1 and 6.2 below illustrate the payback times for the alternative proposed development in years.

| RESULTS | Exp. | Min. | Max. |
|---|---|---|---|
| | | | |
| Carbon Payback Time | | | |
| ...coal-fired electricity generation (years) | 0.7 | 0.5 | 1.2 |
| ...grid-mix of electricity generation (years) | 2.6 | 1.7 | 4.5 |
| ...fossil fuel-mix of electricity generation (years) | 1.5 | 0.9 | 2.5 |

*Source: Online Tool Reference 3R3V-923T-GRNX v4*

**Figure 6.1: Carbon payback time for the proposed development**




*Source: Online Tool Reference 3R3V-923T-GRNX v4*

**Figure 6.2: Carbon payback time for different elements of the assessment**

The results from the carbon calculator reveal that the proposed development would have effectively paid back its expected carbon debt from manufacture, construction, impact on habitat and decommissioning within 1.5 years if it replaced the fossil fuel-mix electricity generation method. Based on the minimum and maximum scenarios however, the analysis shows that the payback time for fossil fuel-mix generation ranges between 0.9 to 2.5 years respectively.

The Institute of Environmental Management and Assessment (IEMA) has identified the online carbon calculator tool for wind farm carbon assessments. This tool provides a consistent and the most comprehensive method for carbon assessment for wind farm developments on peat lands to date. However, the online tool does not define what level of impact on peat is considered to be a 'significant effect' as the existing carbon balance literature using this carbon assessment tool does not state this requirement.

In this regard, IEMA concludes that:

*"…when evaluating significance, all new Green House Gas (GHG) emissions contribute to a significant negative environmental effect; however; some projects will replace existing development that have higher GHG profiles. The significance of a project's emissions should therefore be based on its net impact, which may be positive or negative.*"

In this context, the results of this assessment reveal that the net impact of the proposed development will be positive overall, as over its 50-year lifespan, it is expected to generate over 48 years' worth of clean energy if it replaced fossil fuel-mix electricity generation and over 47 years' worth of clean energy even if it replaces cleaner grid-mix electricity generation. Therefore, over the expected 48 years that the wind farm is likely to be generating carbon-free electricity, this could result in expected $CO_2$ emission savings of over 7,428,912 tonnes[14] of $CO_2$ when replacing fossil fuel-mix electricity generation.

This illustrates a positive net impact on climate change through contributing significantly towards the reduction of GHG from energy production.

[14] Calculation is 48 years x 154,769 $tCO_2$ (as shown in Table 7.1 and online submission).

# Annex A –Lab Results Total Organic Carbon

UKAS TESTING 4041 MCERTS

i2 Analytical Environmental Science

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## Analytical Report Number : 22-76670

Replaces Analytical Report Number: 22-76670, issue no. 1
Additional analysis undertaken.

| | | | |
|---|---|---|---|
| **Project / Site name:** | Bloch Wind Farm | **Samples received on:** | 08/08/2022 |
| **Your job number:** | | **Samples instructed on/ Analysis started on:** | 08/08/2022 |
| **Your order number:** | | **Analysis completed by:** | 28/09/2022 |
| **Report Issue Number:** | 2 | **Report issued on:** | 28/09/2022 |
| **Samples Analysed:** | 12 soil samples | | |

**Signed:** Ashleigh Cunningham

Ashleigh Cunningham
Senior Customer Service Adviser
**For & on behalf of i2 Analytical Ltd.**

Standard Geotechnical, Asbestos and Chemical Testing Laboratory located at: ul. Pionierów 39, 41 -711 Ruda Śląska, Poland.

Accredited tests are defined within the report, opinions and interpretations expressed herein are outside the scope of accreditation.

Standard sample disposal times, unless otherwise agreed with the laboratory, are :

- soils - 4 weeks from reporting
- leachates - 2 weeks from reporting
- waters - 2 weeks from reporting
- asbestos - 6 months from reporting

Excel copies of reports are only valid when accompanied by this PDF certificate.

Any assessments of compliance with specifications are based on actual analytical results with no contribution from uncertainty of measurement.
Application of uncertainty of measurement would provide a range within which the true result lies.
An estimate

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The results included within the report are representative of the samples submitted for analysis.

**Analytical Report Number: 22-76670**
**Project / Site name: Bloch Wind Farm**

| **Lab Sample Number** | | | | 2380817 | 2380818 | 2380819 | 2380820 | 2380821 |
|---|---|---|---|---|---|---|---|---|
| **Sample Reference** | | | | T1 | T2 | T3 | T6 (NW) | T9 |
| **Sample Number** | | | | None Supplied | None Supplied | None Supplied | None Supplied | None Supplied |
| **Depth (m)** | | | | 1.00 | 1.00 | 0.75 | 0.80 | 1.00 |
| **Date Sampled** | | | | 03/08/2022 | 03/08/2022 | 03/08/2022 | 03/08/2022 | 03/08/2022 |
| **Time Taken** | | | | None Supplied | None Supplied | None Supplied | None Supplied | None Supplied |
| **Analytical Parameter (Soil Analysis)** | Units | Limit of detection | Accreditation Status | | | | | |
| Stone Content | % | 0.1 | NONE | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 |
| Moisture Content | % | 0.01 | NONE | 86 | 83 | 82 | 85 | 82 |
| Total mass of sample received | kg | 0.001 | NONE | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |

**General Inorganics**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| pH - Manual | pH Units | N/A | MCERTS | - | - | - | - | - |
| pH - Automated | pH Units | N/A | MCERTS | U/S | U/S | U/S | U/S | U/S |
| Organic Matter | % | 0.1 | MCERTS | 29 | 25 | 29 | 26 | 27 |
| Total Organic Carbon (TOC) - Manual | % | 0.1 | MCERTS | 17 | 14 | 17 | 15 | 16 |

U/S = Unsuitable Sample  I/S = Insufficient Sample

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The results included within the report relate only to the sample(s) submitted for testing.

**Analytical Report Number: 22-76670**
**Project / Site name: Bloch Wind Farm**

| **Lab Sample Number** | | | | 2380822 | 2380823 | 2380824 | 2380825 | 2380826 |
|---|---|---|---|---|---|---|---|---|
| **Sample Reference** | | | | T12(SE) | T17(NE) | T19 | T20 | T21 |
| **Sample Number** | | | | None Supplied | None Supplied | None Supplied | None Supplied | None Supplied |
| **Depth (m)** | | | | 1.00 | 0.60 | 0.25 | 1.00 | 0.50 |
| **Date Sampled** | | | | 03/08/2022 | 02/08/2022 | 02/08/2022 | 02/08/2022 | 02/08/2022 |
| **Time Taken** | | | | None Supplied | None Supplied | None Supplied | None Supplied | None Supplied |
| **Analytical Parameter (Soil Analysis)** | **Units** | **Limit of detection** | **Accreditation Status** | | | | | |
| Stone Content | % | 0.1 | NONE | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 |
| Moisture Content | % | 0.01 | NONE | 83 | 82 | 78 | 86 | 81 |
| Total mass of sample received | kg | 0.001 | NONE | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |

**General Inorganics**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| pH - Manual | pH Units | N/A | MCERTS | - | - | 4.7 | - | - |
| pH - Automated | pH Units | N/A | MCERTS | U/S | U/S | - | U/S | U/S |
| Organic Matter | % | 0.1 | MCERTS | 27 | 31 | 26 | 26 | 30 |
| Total Organic Carbon (TOC) - Manual | % | 0.1 | MCERTS | 16 | 18 | 15 | 15 | 17 |

U/S = Unsuitable Sample    I/S = Insufficient Sample

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The results included within the report relate only to the sample(s) submitted for testing.

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**Analytical Report Number: 22-76670**
**Project / Site name: Bloch Wind Farm**

| **Lab Sample Number** | | | | 2380827 | 2380828 |
|---|---|---|---|---|---|
| **Sample Reference** | | | | Track J T8-T9 | Track T15-T17 |
| **Sample Number** | | | | None Supplied | None Supplied |
| **Depth (m)** | | | | 1.00 | 0.90 |
| **Date Sampled** | | | | 02/08/2022 | 02/08/2022 |
| **Time Taken** | | | | None Supplied | None Supplied |
| **Analytical Parameter (Soil Analysis)** | Units | Limit of detection | Accreditation Status | | |
| Stone Content | % | 0.1 | NONE | < 0.1 | < 0.1 |
| Moisture Content | % | 0.01 | NONE | 91 | 87 |
| Total mass of sample received | kg | 0.001 | NONE | 0.3 | 0.3 |

**General Inorganics**

| | | | | | |
|---|---|---|---|---|---|
| pH - Manual | pH Units | N/A | MCERTS | - | - |
| pH - Automated | pH Units | N/A | MCERTS | I/S | U/S |
| Organic Matter | % | 0.1 | MCERTS | 29 | 21 |
| Total Organic Carbon (TOC) - Manual | % | 0.1 | MCERTS | 17 | 12 |

U/S = Unsuitable Sample    I/S = Insufficient Sample

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The results included within the report relate only to the sample(s) submitted for testing.

UKAS TESTING 4041 MCERTS

Analytical Environmental Science

**Analytical Report Number : 22-76670**
**Project / Site name: Bloch Wind Farm**

* These descriptions are only intended to act as a cross check if sample identities are questioned. The major constituent of the sample is intended to act with respect to MCERTS validation. The laboratory is accredited for sand, clay and loam (MCERTS) soil types. Data for unaccredited types of solid should be interpreted with care.

Stone content of a sample is calculated as the % weight of the stones not passing a 10 mm sieve. Results are not corrected for stone content.

| Lab Sample Number | Sample Reference | Sample Number | Depth (m) | Sample Description * |
|---|---|---|---|---|
| 2380817 | T1 | None Supplied | 1 | 3.5.19.3 |
| 2380818 | T2 | None Supplied | 1 | 3.5.19.3 |
| 2380819 | T3 | None Supplied | 0.75 | 3.5.19.3 |
| 2380820 | T6 (NW) | None Supplied | 0.8 | 3.5.19.3 |
| 2380821 | T9 | None Supplied | 1 | 3.5.19.3 |
| 2380822 | T12(SE) | None Supplied | 1 | 3.5.19.3 |
| 2380823 | T17(NE) | None Supplied | 0.6 | 3.5.19.3 |
| 2380824 | T19 | None Supplied | 0.25 | 3.5.19.3 |
| 2380825 | T20 | None Supplied | 1 | 3.5.19.3 |
| 2380826 | T21 | None Supplied | 0.5 | 3.5.19.3 |
| 2380827 | Track J T8-T9 | None Supplied | 1 | 3.5.19.3 |
| 2380828 | Track T15-T17 | None Supplied | 0.9 | 3.5.19.3 |

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The results included within the report relate only to the sample(s) submitted for testing.

**Analytical Report Number : 22-76670**
**Project / Site name: Bloch Wind Farm**

**Water matrix abbreviations:**
**Surface Water (SW) Potable Water (PW) Ground Water (GW) Process Waters (PrW) Final Sewage Effluent (FSE) Landfill Leachate (LL)**

| Analytical Test Name | Analytical Method Description | Analytical Method Reference | Method number | Wet / Dry Analysis | Accreditation Status |
|---|---|---|---|---|---|
| Moisture Content | Moisture content, determined gravimetrically. (30 oC) | In house method. | L019-UK/PL | W | NONE |
| Organic matter in soil | Determination of organic matter in soil by oxidising with potassium dichromate followed by titration with iron (II) sulphate. | In house method. | L023-PL | D | MCERTS |
| pH in soil (automated) | Determination of pH in soil by addition of water followed by automated electrometric measurement. | In house method. | L099-PL | D | MCERTS |
| pH at 20oC in soil | Determination of pH in soil by addition of water followed by electrometric measurement. | In house method. | L005-PL | W | MCERTS |
| Stones content of soil | Standard preparation for all samples unless otherwise detailed. Gravimetric determination of stone > 10 mm as % dry weight. | In-house method based on British Standard Methods and MCERTS requirements. | L019-UK/PL | D | NONE |
| Total organic carbon in soil | Determination of organic matter in soil by oxidising with potassium dichromate followed by titration with iron (II) sulphate. | In house method. | L023-PL | D | MCERTS |

**For method numbers ending in 'UK' analysis have been carried out in our laboratory in the United Kingdom.**
**For method numbers ending in 'PL' analysis have been carried out in our laboratory in Poland.**
**Soil analytical results are expressed on a dry weight basis. Where analysis is carried out on as-received the results obtained are multiplied by a moisture correction factor that is determined gravimetrically using the moisture content which is carried out at a maximum of 30oC.**

**Unless otherwise indicated, site information, order number, project number, sampling date, time, sample reference and depth are provided by the client. The instructed on date indicates the date on which this information was provided to the laboratory.**

This certificate should not be reproduced, except in full, without the express permission of the laboratory.
The results included within the report relate only to the sample(s) submitted for testing.

# Annex B –Lab Results Dry Bulk Density

UKAS TESTING 4041

## SUMMARY REPORT

**DETERMINATION OF BULK DENSITY - LINEAR MEASUREMENT METHOD**

Tested in Accordance with: BS EN ISO 17892-2: 2014: Clause 5.1

i2 Analytical Ltd
Unit 8 Harrowden Road
Brackmills Industrial Estate
Northampton NN4 7EB

Client: Natural Power Consultants Limited
Client Address: The Green House, Forrest Estate, St John's Town of Dalry, Castle Douglas, DG7 3XS
Contact: Sam Wainwright
Site Address: Bloch Wind Farm

Client Reference: 22-76675
Job Number: 22-76675
Date Sampled: 02/08 - 03/08/2022
Date Received: 08/08/2022
Date Tested: 19/08/2022
Sampled By: Not Given

*Testing carried out at i2 Analytical Limited, ul. Pionierow 39, 41-711 Ruda Slaska, Poland*

**Test results**

| Laboratory Reference | Hole No. | Sample Reference | Sample Depth Top (m) | Sample Depth Base (m) | Sample Type | Description | Remarks | Bulk density (Mg/m3) | Dry density (Mg/m3) | WC (%) | Preparation | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2380848 | T1 | Not Given | 1.00 | Not Given | U | Dark brown PEAT with rootlets | | 1.08 | 0.11 | 890 | | | |
| 2380853 | T12(SE) | Not Given | 1.00 | Not Given | U | Dark brown PEAT with rootlets | | 1.10 | 0.14 | 688 | | | |
| 2380854 | T17(NE) | Not Given | 0.60 | Not Given | U | Dark brown PEAT with rootlets | | 1.05 | 0.15 | 596 | | | |
| 2380855 | T19 | Not Given | 0.25 | Not Given | U | Black PEAT with rootlets | | 1.01 | 0.18 | 474 | | | |
| 2380849 | T2 | Not Given | 1.00 | Not Given | U | Dark brown PEAT with rootlets | | 1.13 | 0.11 | 919 | | | |
| 2380856 | T20 | Not Given | 1.00 | Not Given | U | Dark brown PEAT with rootlets | | 1.09 | 0.11 | 914 | | | |
| 2380857 | T21 | Not Given | 0.50 | Not Given | U | Black PEAT with rootlets | | 1.04 | 0.14 | 621 | | | |
| 2380850 | T3 | Not Given | 0.75 | Not Given | U | Dark brown PEAT with rootlets | | 1.09 | 0.17 | 546 | | | |
| 2380851 | T6(NW) | Not Given | 0.80 | Not Given | U | Dark brown PEAT with rootlets | | 1.08 | 0.13 | 726 | | | |
| 2380852 | T9 | Not Given | 1.00 | Not Given | U | Dark brown PEAT with rootlets | | 0.99 | 0.13 | 634 | | | |

Note: WC - Water Content

Comments:

Opinions and interpretations expressed herein are outside of the scope of the UKAS Accreditation. This report may not be reproduced other than in full without the prior written approval of the issuing laboratory. The results included within the report relate only to the sample(s) submitted for testing.

**Signed:** Dudzinska Anna

Anna Dudzinska
PL Deputy Head of Reporting Team
**for and on behalf of i2 Analytical Ltd**

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**Date Reported:** 24/08/2022

**GF 166.13**

UKAS TESTING 4041

# SUMMARY REPORT

**DETERMINATION OF BULK DENSITY - LINEAR MEASUREMENT METHOD**

Tested in Accordance with: BS EN ISO 17892-2: 2014: Clause 5.1

i2 Analytical Ltd
Unit 8 Harrowden Road
Brackmills Industrial Estate
Northampton NN4 7EB

Analytical i2 Environmental Science

Client: Natural Power Consultants Limited
Client Address: The Green House, Forrest Estate, St John's Town of Dalry, Castle Douglas, DG7 3XS
Contact: Sam Wainwright
Site Address: Bloch Wind Farm

Client Reference: 22-76675
Job Number: 22-76675
Date Sampled: 02/08 - 03/08/2022
Date Received: 08/08/2022
Date Tested: 19/08/2022
Sampled By: Not Given

*Testing carried out at i2 Analytical Limited, ul. Pionierow 39, 41-711 Ruda Slaska, Poland*

**Test results**

| Laboratory Reference | Hole No. | Sample | | | | Description | Remarks | Bulk density | Dry density | WC | Preparation | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Reference | Depth Top m | Depth Base m | Type | | | Mg/m3 | Mg/m3 | % | | | |
| 2380858 | Track J T8-T9 | Not Given | 1.00 | Not Given | U | Dark brown PEAT with rootlets | | 1.06 | 0.08 | 1 159 | | | |
| 2380859 | Track T15-T17 | Not Given | 0.90 | Not Given | U | Black PEAT with rootlets | | 1.08 | 0.12 | 818 | | | |
| | | | | | | | | | | | | | |
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Note: WC - Water Content

Comments:

Opinions and interpretations expressed herein are outside of the scope of the UKAS Accreditation. This report may not be reproduced other than in full without the prior written approval of the issuing laboratory. The results included within the report relate only to the sample(s) submitted for testing.

**Signed:** Dudzińska Anna

Anna Dudzinska
PL Deputy Head of Reporting Team
**for and on behalf of i2 Analytical Ltd**

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**Date Reported:** 24/08/2022

**GF 166.13**

# Annex C – Carbon Calculator Inputs

Carbon Calculator v1.6.1
Bloch Wind Farm Location: 55.139033 -3.025735
RES

## Core input data

| Input data | Expected value | Minimum value | Maximum value | Source of data |
|---|---|---|---|---|
| Windfarm characteristics | | | | |
| Dimensions | | | | |
| No. of turbines | 21 | 21 | 21 | Technical Appendix 9.7 Table 6.1 |
| Duration of consent (years) | 50 | 50 | 50 | Technical Appendix 9.7 Table 6.1 |
| Performance | | | | |
| Power rating of 1 turbine (MW) | 6 | 5.6 | 6.6 | Technical Appendix 9.7 Table 6.1 |
| Capacity factor | 31.16 | 23.08 | 39.2 | Technical Appendix 9.7 Table 6.1 |
| Backup | | | | |
| Fraction of output to backup (%) | 5 | 5 | 5 | Technical Appendix 9.7 Table 6.1 |
| Additional emissions due to reduced thermal efficiency of the reserve generation (%) | 10 | 10 | 10 | Fixed |
| Total CO2 emission from turbine life ($tCO2\ MW^{-1}$) (eg. manufacture, construction, decommissioning) | Calculate wrt installed capacity | Calculate wrt installed capacity | Calculate wrt installed capacity | |
| Characteristics of peatland before windfarm development | | | | |
| Type of peatland | Acid bog | Acid bog | Acid bog | Technical Appendix 9.7 Table 6.1 |
| Average annual air temperature at site (°C) | 7.7 | 4.05 | 11.4 | Technical Appendix 9.7 Table 6.1 |
| Average depth of peat at site (m) | 0.87 | 0.8 | 0.93 | Technical Appendix 9.7 Table 6.1 |
| C Content of dry peat (% by weight) | 19 | 19 | 19.1 | Technical Appendix 9.7 Table 6.1 |
| Average extent of drainage around drainage features at site (m) | 5 | 3 | 10 | Technical Appendix 9.7 Table 6.1 |

| Input data | Expected value | Minimum value | Maximum value | Source of data |
|---|---|---|---|---|
| Average water table depth at site (m) | 0.4 | 0.2 | 0.6 | Technical Appendix 9.7 Table 6.1 |
| Dry soil bulk density (g $cm^{-3}$) | 0.13 | 0.11 | 0.15 | Technical Appendix 9.7 Table 6.1 |
| Characteristics of bog plants | | | | |
| Time required for regeneration of bog plants after restoration (years) | 7 | 5 | 10 | Technical Appendix 9.7 Table 6.1 |
| Carbon accumulation due to C fixation by bog plants in undrained peats (tC $ha^{-1}$ $yr^{-1}$) | 0.25 | 0.12 | 0.31 | Technical Appendix 9.7 Table 6.1 |
| Forestry Plantation Characteristics | | | | |
| Area of forestry plantation to be felled (ha) | 0 | 0 | 0 | Technical Appendix 9.7 Table 6.1 |
| Average rate of carbon sequestration in timber (tC $ha^{-1}$ $yr^{-1}$) | 0 | 0 | 0 | Technical Appendix 9.7 Table 6.1 |
| Counterfactual emission factors | | | | |
| Coal-fired plant emission factor (t CO2 $MWh^{-1}$) | 0.92 | 0.92 | 0.92 | |
| Grid-mix emission factor (t CO2 $MWh^{-1}$) | 0.25358 | 0.25358 | 0.25358 | |
| Fossil fuel-mix emission factor (t CO2 $MWh^{-1}$) | 0.45 | 0.45 | 0.45 | |
| Borrow pits | | | | |
| Number of borrow pits | 3 | 3 | 3 | Technical Appendix 9.7 Table 6.1 |
| Average length of pits (m) | 250 | 200 | 300 | Technical Appendix 9.7 Table 6.1 |
| Average width of pits (m) | 100 | 50 | 150 | Technical Appendix 9.7 Table 6.1 |
| Average depth of peat removed from pit (m) | 0.58 | 0.49 | 0.67 | Technical Appendix 9.7 Table 6.1 |
| Foundations and hard-standing area associated with each turbine | | | | |
| Average length of turbine foundations (m) | 28 | 22 | 33 | Technical Appendix 9.7 Table 6.1 |
| Average width of turbine foundations (m) | 28 | 22 | 33 | Technical Appendix 9.7 Table 6.1 |

| Input data | Expected value | Minimum value | Maximum value | Source of data |
|---|---|---|---|---|
| Average depth of peat removed from turbine foundations(m) | 0.64 | 0.6 | 0.68 | Technical Appendix 9.7 Table 6.1 |
| Average length of hard-standing (m) | 56 | 54 | 59 | Technical Appendix 9.7 Table 6.1 |
| Average width of hard-standing (m) | 36 | 34 | 39 | Technical Appendix 9.7 Table 6.1 |
| Average depth of peat removed from hard-standing (m) | 0.64 | 0.6 | 0.68 | Technical Appendix 9.7 Table 6.1 |
| Volume of concrete used in construction of the ENTIRE windfarm | | | | |
| Volume of concrete ($m^3$) | 11107 | 9996 | 12218 | Technical Appendix 9.7 Table 6.1 |
| Access tracks | | | | |
| Total length of access track (m) | 14802 | 14800 | 14804 | Technical Appendix 9.7 Table 6.1 |
| Existing track length (m) | 0 | 0 | 0 | Technical Appendix 9.7 Table 6.1 |
| Length of access track that is floating road (m) | 1720 | 1719 | 1721 | Technical Appendix 9.7 Table 6.1 |
| Floating road width (m) | 6 | 6 | 6 | Technical Appendix 9.7 Table 6.1 |
| Floating road depth (m) | 0.8 | 0.79 | 0.81 | Technical Appendix 9.7 Table 6.1 |
| Length of floating road that is drained (m) | 1619 | 1618 | 1620 | Technical Appendix 9.7 Table 6.1 |
| Average depth of drains associated with floating roads (m) | 0.8 | 0.8 | 0.8 | Technical Appendix 9.7 Table 6.1 |
| Length of access track that is excavated road (m) | 13082 | 13081 | 13083 | Technical Appendix 9.7 Table 6.1 |
| Excavated road width (m) | 12 | 10 | 13 | Technical Appendix 9.7 Table 6.1 |
| Average depth of peat excavated for road (m) | 0.8 | 0.75 | 0.85 | Technical Appendix 9.7 Table 6.1 |

| Input data | Expected value | Minimum value | Maximum value | Source of data |
|---|---|---|---|---|
| Length of access track that is rock filled road (m) | 0 | 0 | 0 | Technical Appendix 9.7 Table 6.1 |
| Rock filled road width (m) | 0 | 0 | 0 | |
| Rock filled road depth (m) | 0 | 0 | 0 | |
| Length of rock filled road that is drained (m) | 0 | 0 | 0 | |
| Average depth of drains associated with rock filled roads (m) | 0 | 0 | 0 | |
| Cable trenches | | | | |
| Length of any cable trench on peat that does not follow access tracks and is lined with a permeable medium (eg. sand) (m) | 0 | 0 | 0 | Technical Appendix 9.7 Table 6.1 |
| Average depth of peat cut for cable trenches (m) | 0 | 0 | 0 | |
| Additional peat excavated (not already accounted for above) | | | | |
| Volume of additional peat excavated ($m^3$) | 18438.52 | 9335 | 29469.29 | Technical Appendix 9.7 Table 6.1 |
| Area of additional peat excavated ($m^2$) | 36262.75 | 23967.75 | 49707.75 | Technical Appendix 9.7 Table 6.1 |
| Peat Landslide Hazard | | | | |
| Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments | negligible | negligible | negligible | Fixed |
| 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) | 0 | 0 | 0 | Technical Appendix 9.7 Table 6.1 |
| Water table depth in degraded bog before improvement (m) | 0 | 0 | 0 | |
| Water table depth in degraded bog after improvement (m) | 0 | 0 | 0 | |
| Time required for hydrology and habitat of bog to return to its previous state on improvement (years) | 0 | 0 | 0 | |
| Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years) | 0 | 0 | 0 | |
| Improvement of felled plantation land | | | | |
| Area of felled plantation to be improved (ha) | 0 | 0 | 0 | Technical Appendix 9.7 Table 6.1 |
| Water table depth in felled area before improvement (m) | 0 | 0 | 0 | |
| Water table depth in felled area after improvement (m) | 0 | 0 | 0 | |

| Input data | Expected value | Minimum value | Maximum value | Source of data |
|---|---|---|---|---|
| Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years) | 0 | 0 | 0 | |
| Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years) | 0 | 0 | 0 | |
| Restoration of peat removed from borrow pits | | | | |
| Area of borrow pits to be restored (ha) | 0 | 0 | 0 | Technical Appendix 9.7 Table 6.1 |
| Depth of water table in borrow pit before restoration with respect to the restored surface (m) | 0 | 0 | 0 | |
| Depth of water table in borrow pit after restoration with respect to the restored surface (m) | 0 | 0 | 0 | |
| Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years) | 0 | 0 | 0 | |
| Period of time when effectiveness of the restoration of peat removed from borrow pits can be guaranteed (years) | 0 | 0 | 0 | |
| Early removal of drainage from foundations and hardstanding | | | | |
| Water table depth around foundations and hardstanding before restoration (m) | 0.5 | 0.3 | 0.7 | Technical Appendix 9.7 Table 6.1 |
| Water table depth around foundations and hardstanding after restoration (m) | 0.3 | 0.1 | 0.5 | Technical Appendix 9.7 Table 6.1 |
| Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years) | 3 | 2 | 5 | Technical Appendix 9.7 Table 6.1 |
| Restoration of site after decomissioning | | | | |
| Will the hydrology of the site be restored on decommissioning? | Yes | Yes | Yes | |
| Will you attempt to block any gullies that have formed due to the windfarm? | Yes | Yes | Yes | Technical Appendix 9.7 Table 6.1 |
| Will you attempt to block all artificial ditches and facilitate rewetting? | Yes | Yes | Yes | Technical Appendix 9.7 Table 6.1 |
| Will the habitat of the site be restored on decommissioning? | No | No | No | |
| Will you control grazing on degraded areas? | No | No | No | Technical Appendix 9.7 Table 6.1 |

| Input data | Expected value | Minimum value | Maximum value | Source of data |
|---|---|---|---|---|
| Will you manage areas to favour reintroduction of species | No | No | No | Technical Appendix 9.7 Table 6.1 |
| Methodology | | | | |
| Choice of methodology for calculating emission factors | Site specific (required for planning applications) | | | |

## Forestry input data

N/A

## Construction input data

N/A

Creating a better environment

naturalpower.com
sayhello@naturalpower.com

For full details on our ISO and other certifications, please visit our website.

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