Technical Appendix 2.1 Carbon Balance Assessment

Breezy Hill Energy Park

Breezy Hill Energy Limited

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Basis of Report

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1.0 Introduction

Increasing atmospheric concentrations of greenhouse gases (GHGs), including carbon dioxide (CO2), also referred to as carbon emissions, are resulting in climate change. A major contributor to this increase in GHG emissions is the burning of fossil fuels. With concern growing over climate change, reducing its cause is of upmost 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' climate change and renewable energy policy and commitments.

Whilst the Proposed Development will reduce carbon emissions by replacing the need to burn fossil fuels for power, no form of electricity generation is completely carbon free; for onshore wind farms, energy storage and solar photovoltaic (PV) installations, there will be emissions resulting from component manufacturing, transportation and installation processes associated with the Proposed Development.

In addition to the lifecycle emissions from the development equipment and infrastructure, where a development is located on carbon rich soils such as peat or within forestry, there are potential emissions resulting from direct action of excavating peat for construction and also the indirect changes to hydrology that can result in losses of soil carbon, as well as forestry felling. The footprint of a development's infrastructure will also decrease the area covered by carbon-fixing vegetation.

Conversely, restoration activities undertaken post-construction or post-decommissioning could have a beneficial effect on carbon uptake through the restoration of modified bog habitat. Carbon losses and gains during the construction and lifetime of a renewable energy generation development, 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.

Consideration of potential lifecycle emissions for onshore renewable energy development in Scotland has tended to focus on wind energy, given that wind farms are often constructed on peatlands or in forestry, resulting in associated carbon emissions from excavation of peat and forestry felling. The Scottish Government's industry-accepted 'Carbon Calculator' tool (see below) relates only to onshore wind energy projects, and there is no equivalent for energy storage or solar PV installations.

A technical review of energy displacement by the UK Energy Research Centre (UKERC) considered over two hundred studies and papers from all round the world for the UK Government and concluded that "it is unambiguously the case that wind energy can displace fossil fuel-based generation, reducing both fuel use and carbon dioxide emissions" (UKERC, 2006). Whilst the wind turbines will reduce carbon emissions by replacing the need to burn fossil fuels for power, there is the potential for carbon fixers and sinks to be lost through the clearing of vegetation and materials for construction. There must therefore be a sufficient balance between the carbon reduced and that which is produced and lost through associated processes.

1.1 Methodology

All applications that are over 50 MW are dealt with through the Scottish Government's Energy Consents Unit (ECU) in accordance with Section 36 of the Electricity Act 1989 and require a carbon balance assessment using the Scottish Government's online 'Carbon Calculator' tool, that can be used to calculate the greenhouse gas emissions and carbon payback times for wind farm developments on Scottish peatlands. This online tool is supported by two documents published by the Scottish Government and Scottish Renewables, and Scottish Environment Protection Agency (SEPA) to aid in calculating the potential carbon losses and savings.

At the time of submission, the online tool was not accessible, and therefore the assessment has been undertaken using the Carbon Assessment Tool spreadsheet (v2.14.1), issued by SEPA.

The Carbon Calculator compares an estimate of the carbon emissions from the construction, operation, and decommissioning of the Proposed Development to those emissions estimated from other electricity generation sources. Input parameters are based on the proposed site design, infrastructure dimensions, results from peat depth surveys and laboratory testing of peat, and other information gained from site survey work, desk study and, where applicable, assumptions relating to groundwater, drainage, and habitat regeneration. As no infrastructure is yet to be constructed for the Proposed Development, the assumptions relating to infrastructure have been based on information for the Proposed Development or from standard, default representative information.

2.0 Input Parameters

The carbon calculator submitted allows a range of data to be input to utilise expected, minimum and maximum values, where relevant and applicable. If several parameters are varied together, however, this can have the effect of 'cancelling out' a single parameter change. For this reason, the approach for this assessment has been to include 'maximum values' as those values which would result in longest (maximum) payback period; and 'minimum values' as those values which would result in the shortest (minimum) payback period. The expected value is based on the most realistic option for the site.

Information relating to the Proposed Development (including consideration of design, operation, and construction) has been collated, and includes details of the proposed infrastructure, local ecology, and restoration proposals associated with the Proposed Development. This collated information has been entered into the online carbon calculator and is outlined below.

2.1 Wind Farm Characteristics

The Proposed Development will comprise 20 turbines with a maximum power rating of 5 MW. The operational life of the Proposed Development is expected to be 40 years.

Capacity Factor

The expected capacity factor is 33 %, with ± 5 % used for minimum and maximum values.

Back Up

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. The values for 'fraction of output to backup' are therefore input as expected 5 % and maximum 5 % to represent full requirement for backup, and a minimum of 0 % to represent no backup required (Nayak et al., 2008). SEPA indicates that for this parameter, the electricity generation capacity of Scotland, rather than the UK, should be considered. In 2022, Scotland generated about 66 % of gross electricity consumption via onshore wind (Scottish Renewables Statistics, 2023). Where the balancing capacity is obtained from fossil fuel generating stations, emissions will increase by 10 % due to reduced thermal efficiency of the reserve generation stations (Dale et al., 2004). This value is fixed in the Carbon Calculator.

CO_2 Emissions from Turbine Life (tCO_2/MW)

CO_2 emissions during the life of a wind turbine include emissions that occur during the manufacturing, transportation, erection, operation, dismantling and removal of the structures.

As there is no direct Life Cycle Assessment for the Proposed Development available at this point in time, the inbuilt Carbon Calculator option which allows for emissions to be calculated according to wind turbine capacity has been selected.

Type of Peatland

The most appropriate habitat description available on the Carbon Calculator is Acid Bog, refer to **Chapter 6: Ecology**.

Average Annual Air Temperature at Site

The average annual air temperature of 9.67 °C is based on average annual temperature data from the Met Office UK climate averages (Met Office, 2025). The nearest climate station which provides this information is located approximately 15 km northwest of the Site, at Prestwick, Gannet.

Average Depth of Peat at Site

The average peat depth of 1.0 m was calculated based on peat probe data from within the site boundary of the Proposed Development.

The assessment is based on a series of average soil depths taken from peat surveys undertaken at the site. Probe locations sited on mineral/organic soils (<0.5 m) are conservatively included within the averages.

Carbon Content of Dry Peat

Site specific values were collected from laboratory testing of field samples, and are presented within Technical Appendix 8.1. The carbon content ranges from 26.5 % to 49.8 % with an expected value of 40.23 % used.

Average Extent of Drainage around Drainage Features at Site

Site specific values are not available, so the standard values from the ‘Windfarm Carbon Calculator Web Tool, User Guidance’ have been used. The expected value is 10 m, with a minimum of 5 m and maximum of 50 m.

Average Water Table Depth at Site

Site specific values are not available, so the values for ‘intact peat’ from ‘Windfarm Carbon Calculator Web Tool, User Guidance’ have been used as a worst-case scenario. The expected value is 0.3 m, with a minimum 0.1 m, and a maximum 0.5 m.

Dry Soil Bulk Density

Site specific samples were collected, and tested in laboratory, presented in Technical Appendix 8.1. The expected value is 0.48 g/cm^3, with a minimum of 0.39 g/cm^3 and a maximum of 0.72 g/cm^3.

Characteristics of Bog Plants

Regeneration of Bog Plants

This can vary widely depending on the location of the site and the target bog plants for restoration, and whether the ground was previously afforested or open moorland. The speed of regeneration will also depend on species present and their colonising ability and traits, as well as the methods of restoration and maintenance of hydrology. Typical bog plants may take longer to establish where suitable conditions exist. The values stated take this into account considering available literature and anecdotal observations of wind farms in Scotland.

As such, five years has been stated as a reasonable precautionary estimate for the regeneration time needed for most bog species, with a minimum of two years and a longer establishment time of 15 years.

Carbon Accumulation

The Carbon Calculator Guidance (Technical Note, Version 2.10.0, Scottish Government) suggests a mid-range value of 0.25 tC ha^{-1} yr^{-1} and a range of 0.12 to 0.31 t C $ha^{-1}yr^{-1}$.

Forestry Plantation Characteristics

Area of Forestry Plantation to be Felled

There is no net loss of forestry plantation from felling. Any crops that are cleared will be replanted back on the site or on a compensatory planting site so that the overall area of forestry is maintained.

Counterfactual Emission Factors

The counterfactual emission factors for three methods of energy generation are fixed in the carbon calculator. Values for both coal-fired and fossil fuel-mix emission factors are updated from Digest of UK Energy Statistics (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 the Department for Business, Energy & Industrial Strategy (BEIS).

Borrow Pits

Borrow pit search areas have been included for the Proposed Development (refer to Technical Appendix 8.4). Although not all proposed borrow pit search areas are sited on peatland or likely to be used for extraction, conservatively, each location has been included in the assessment. The final dimensions of each borrow pit have yet to be defined however initial calculations, based on a series of assumptions (including suitable aggregate being located close to surface), indicate that an average dimension of 100 x 100 m would provide sufficient yield. These dimensions have been included for each borrow pit.

The average peat depth in the borrow pit search areas is 0.51 m, conservatively, organic soils (<0.5 m) have also been included in the calculation of averages.

Foundations and Hardstand Areas

The wind turbine foundations for the Proposed Development are expected to be 22 m in diameter, with hardstands expected to be 87 m x 62 m.

The average peat depth in the turbine foundation areas is 0.82 m, and the average peat depth in the hardstand areas is 0.82 m. Conservatively, organic soils (<0.5 m) have also been used in the calculation of averages.

Access Tracks

There are approximately 15 km of existing tracks within the Proposed Development site. The total length of new access tracks proposed is approximately 12 km. Small changes to the access track layout may occur post consent (e.g., as a result of micrositing) leading to minor variations to the overall track length. Of the 12 km of new track, approximately 6 km are proposed to be floated (subject to detailed design following ground investigation post-consent).

The average peat depth on the route of the proposed cut access track is 0.71 m. Conservatively, organic soils (<0.5 m) have also been used in the calculation of averages.

Cable Trenches

The wind farm array cables on site will be laid in trenches, on a sand bed and backfilled using suitably graded material, and will mainly be located adjacent to the access tracks within the Proposed Development. See also Chapter 2: Proposed Development.

Additional Peat Excavated

The volume of additional peat predicted to be excavated is 50,487 m^3. Further information can be found in Technical Appendix 8.2 Outline Peat Management Plan.

Peat Landslide Hazard

The peat landslide hazard is a fixed value automatically defined by the Carbon Calculator, and is shown to be ‘negligible’.

Improvement of Carbon Sequestration at the Site

Improvement of Felled Plantation Land

The outline Biodiversity Enhancement Management Plan (OBEMP) (Technical Appendix 6.6) outlines the objective to deliver forest to bog peatland restoration within land under the control of the applicant. The area of forestry to be improved is up to 86.7 ha.

Restoration of Peat Removed from Borrow Pits

Technical Appendix 8.4 outlines that all borrow pits will be restored following the completion of construction. This is a total area of ~3 ha.

Restoration of Site after Decommissioning

Hydrology & Habitats

The OBEMP outlines the proposed habitat and conservation management measures in relation to the Proposed Development. The management recommendations include the aim of drain blocking to promote restoration of the hydrological conditions within the site and managing areas to favour the reintroduction of species.

Methodology for Calculating Emission Factors

Site-specific values have been used as required for a planning or Section 36 application.

3.0 Carbon Calculator Output

The output from the Carbon Calculator indicates the expected total carbon dioxide loss for the Proposed Development (from manufacture of turbines, construction, decommissioning, and carbon sink losses, also taking account of gains due to restoration of borrow pits) is 281,677 tonnes of carbon dioxide (tCO_2 eq).

Scottish Government guidance on wind farm carbon savings (Scottish Government, 2018), states: “carbon emission savings from wind farms should be calculated using the fossil fuel sourced grid mix as the counterfactual, rather than the grid mix.” Taking account of the expected total CO_2 loss from the Carbon Calculator result, the Proposed Development would be expected to result in a saving of approximately 124,883 tonnes of carbon dioxide (tCO_2) per annum, meaning a total of almost 5 million tonnes over the 40-year operational lifetime of the Proposed Development, through displacement of carbon-emitting generation.

The carbon payback time of the wind element of the Proposed Development is between 0.7 and 3.9 years, with an expected payback period of 1.9 years (approximately 23 months). This is the period of time for which a wind farm needs to be in operation before it has, by displacing generation from fossil-fuelled power stations, avoided as much carbon dioxide as was released in its lifecycle.

As recommended in current guidance estimated savings are for replacement of fossil fuel electricity generation but, while this could be the case in the short term, it is not the most probable scenario in the longer-term. The 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. Based on the grid-mix results, the Proposed Development is expected to result in a saving of approximately 55,902 tCO_2 per annum with an expected carbon payback time of 4.3 years.

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