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Environmental Impact Assessment Report

Swarclett Wind Farm

Chapter 2: EIA Approach and Methodology

Swarclett Wind Energy Limited

wind2

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Introduction

This Technical Appendix presents the findings of the Carbon Calculations prepared for the Proposed Development and should be read in conjunction with Chapter 13 Climate Change and Carbon Balance.

Applicants are required to calculate potential carbon losses and savings from wind farms on Scottish peatlands as set out the ECU's online good practice guidance for applications under Section 36 and 37 of the Electricity Act 1989 (2022). The tool is typically used for applications for onshore wind farm development proposals of over 50MW installed capacity (which are subject to consent under Section 36 of the Electricity Act 1989) however this can also apply to the Proposed Development as it is located where peat is present.

Carbon Calculator Inputs and Outputs

The Scottish Government's Online Carbon Calculator v1.8.1 (updated in December 2023) was used to calculate the carbon cost and payback period of the Proposed Development.

The online Reference for the Carbon Calculator is KC8T-U38N-WFSA v1.

Table 13-1-1 and Table 13-1-2 presented below, summarise out the outputs and inputs respectively. These are presented with 'Expected' values – the best estimate of the anticipated value, based on the current understanding of the Proposed Development – along with 'minimum' and 'maximum' values to give a range of possible outputs, dependant on the variables within the model.

Table 13-1-1: Payback time and CO_2 emissions

	Expected	Minimum	Maximum
1: Wind farm CO_2 Emission Saving over (tonnes CO_2 eq.):			
Coal Fired electricity Generation	27,815	25,033	30,596
Grid mix of electricity generation	6,093	5,483	6,702
Fossil fuel mix of electricity generation	12,480	11,232	13,728
Energy output from windfarm over lifetime (30 years) (MWh)	883,008	794,707	971,309
Total CO2 emissions due to wind farm (tCO_2 eq.)			
2. emissions due to turbine life (e.g. manufacture, construction, decommissioning)	8,240	8,240	8,240
3. emissions due to backup	5,349	5,349	5,349
4. emissions due to reduced carbon fixing potential	264	70	1,518
5. emissions from soil organic matter	-308	-1,123	1,630
6. emissions due to DOC & POC leaching	1	0	22
7. emissions due to felling forestry	0	0	0
Total emissions of Carbon dioxide	13,546	12,536	16,759
Total CO_2 gain due to improvement of site (tCO_2 eq.)			
8a. gains due to improvement of degraded bogs	0	0	0

	Expected	Minimum	Maximum
8b. gains due to improvement of felled forestry	0	0	0
8c. gains due to restoration of peat form borrow pits	0	0	0
8 d. gains due to removal of drainage from foundations and hardstandings	-80	0	-604
Total gains	-80	0	-604
Results: Carbon Payback Time			
Net emissions of carbon dioxide (t CO_2 eq.)	13,467	11,933	16,759
Coal Fired electricity Generation (years)	0.5	0.4	0.7
Grid mix of electricity generation (years)	2.2	1.8	3.1
Fossil fuel mix of electricity generation (years)	1.1	0.9	1.5
Carbon Intensity (gCO_2e/kWh)	15.25	12.29	21.09

Table 13-1-2: Inputs into the Scottish Government Carbon Calculator

Input date	Expected value	Minimum value	Maximum value	Source of Data
Windfarm characteristics				
No. of turbines	2	2	2	Chapter 3 - Description of Development
Duration of consent (years)	30	30	30	Chapter 3 - Description of Development
Performance				
Power rating of 1 turbine (MW)	4.8	4.8	4.8	Chapter 3 - Description of Development
Capacity factor	35	31.5	38.5	Chapter 13 states that real time wind data and the energy yield assessment (EYA) are available for operational projects in the locality of the Proposed Development and have been applied for the purposes of this assessment. This data indicates that a capacity factor of 35% is expected to be a more realistic scenario for the Proposed Development than that which is estimated by DUKES (BEIS 2023). Expected, Min and Max values taken as +/-10%.
Backup				
Fraction of output to backup (%)	5	5	5	The extra electricity generation capacity required to maintain electricity supply during times of low wind generation. The extra capacity needed for backup power generation, backup is currently estimated to be 5% of the rated capacity of the wind plant if wind power contributes more than 20% to the national grid (Dale et al., 2004).
Additional emissions due to reduced thermal efficiency of the reserve generation (%)	10	10	10	Fixed
Total CO_2 emission from turbine life (tCO_2 MW^{-1}) (eg. manufacture, construction, decommissioning)	Calculate with installed capacity	Calculate with installed capacity	Calculate with installed capacity	Calculate with installed capacity
Characteristics of peatland before windfarm development				
Type of peatland	Acid Bog	Acid Bog	Acid Bog	Technical Appendix 8-1 Peat Survey Results
Average annual air temperature at site (°C)	8.21	5.39	11.03	Taken from nearest met office weather station Wick John O Groats Airport 1991 - 2000. (Met Office, 2023)
Average depth of peat at site (m)	0.24	0.22	0.26	Technical Appendix 8-1 Peat Survey Results. +/- 10% values used for maximum and minimum.
C Content of dry	55	49	62	Default value: An estimate of the range of %C in peat of between 49% and 62% is

Input date	Expected value	Minimum value	Maximum value	Source of Data
peat (% by weight)				provided by Birnie et al. (1991).
Average extent of drainage around drainage features at site (m)	10	5	50	Generic precautionary values have been entered into the carbon calculator as follows: expected = 10m; minimum = 5m; and maximum = 50m as per Windfarm Carbon Calculator Web Tool User Guidance (SEPA, n.d)
Average water table depth at site (m)	0.3	0.1	0.5	The Carbon Calculator notes that water table depth should be measured on site. However, where site-specific values are not available, for degraded peat, reasonable estimated minimum, expected and maximum values are: 0.1 m, 0.3 m and 0.5 m, respectively.
Dry soil bulk density (g cm^{-3})	0.132	0.072	0.293	The Windfarm Carbon Calculator Web Tool User Guidance (SEPA, n.d) notes that given the difficulty of collecting sufficient samples to derive a representative site-specific value for this parameter, Scottish generic values for peat may be used instead: expected = 0.132 g/cm^3; minimum = 0.072 g/cm^3; and maximum = 0.293 g/cm^3.
Characteristics of bog plants				
Time required for regeneration of bog plants after restoration (years)	10	5	15	Generic assumptions: "The physical and hydrological restoration of the site post construction, even if no wider site improvements and restoration are undertaken, should allow the vegetation to recover more rapidly than within 15 years. SEPA (n.d) Windfarm Carbon Calculator Web Tool User Guidance
Carbon accumulation due to C xation by bog plants in undrained peats (tC ha^{-1} yr^{-1})	0.25	0.12	0.31	Carbon Calculator default value: Apparent C accumulation rate in peatland is 0.12 to 0.31 tC ha-1 yr-1 (Turunen et al., 2001; Botch et al., 1995). The SNH guidance uses a value of 0.25 tC ha-1 yr-1 .
Forestry Plantation Characteristics				
Area of forestry plantation to be felled (ha)	0	0	0	As noted in Chapter 13 of the EIAR no forestry will be felled as a result of the Proposed Development Site.
Average rate of carbon sequestration in timber (tC ha^{-1} yr^{-1})	11	10.99	11	Values of 13.2 , 11.8, 14.5 for expected, minimum and maximum respectively taken from "Calculating potential carbon losses and savings from wind farms on Scottish peatlands Technical Note – Version 2.10.0" However the carbon calculator allowed values between 0 and 11 only.
Counterfactual emission factors				
Coal-red plant emission factor (t CO_2 MWh^{-1})	Fixed	Fixed	Fixed	Fixed
Grid-mix emission factor (t CO_2 MWh-1)	Fixed	Fixed	Fixed	Fixed
Fossil fuel-mix	Fixed	Fixed	Fixed	Fixed

Input date	Expected value	Minimum value	Maximum value	Source of Data
emission factor (t CO_2 MWh^{-1})				
Borrow pits				
Number of borrow pits	0	0	0	As noted in Chapter 3 of the EIAR borrow pits will not form part of this application.
Average length of pits (m)	0	0	0	As noted in Chapter 3 of the EIAR borrow pits will not form part of this application.
Average width of pits (m)	0	0	0	As noted in Chapter 3 of the EIAR borrow pits will not form part of this application.
Average depth of peat removed from pit (m)	0	0	0	As noted in Chapter 3 of the EIAR borrow pits will not form part of this application.
Foundations and hard-standing area associated with each turbine				
Average length of turbine foundations (m)	25	25	25	Chapter 3 - Description of Development
Average width of turbine foundations (m)	25	25	25	Chapter 3 - Description of Development
Average depth of peat removed from turbine foundations(m)	0.21	0.19	0.23	Technical Appendix 8-1 Peat Survey Results and Chapter 8 Hydrology and Hydrogeology, Max and Min +/-10%
Average length of hard-standing (m)	66	66	66	Chapter 3 - Description of Development, Figure 3-5
Average width of hard-standing (m)	22	22	22	Chapter 3 - Description of Development, Figure 3-5
Average depth of peat removed from hard-standing (m)	0.16	0.14	0.17	Technical Appendix 8-1 Peat Survey Results and Chapter 8 Hydrology and Hydrogeology, Max and Min +/-10%
Volume of concrete used in construction of the ENTIRE windfarm				
Volume of concrete (m^3)	650	650	650	Chapter 3 - Description of Development
Access tracks				
Existing track length (m)	640	640	640	Chapter 3 - Description of Development
Total length of access track (m)	2440	2260	2620	Chapter 3 Description of Development. Sum of all tracks
Length of access track that is floating road (m)	0	0	0	Floating road is not required due to peat depths on the Proposed Development Site as detailed in Technical Appendix 8-1 Peat Survey Results.
Floating road width (m)	5	5	5	Carbon calculator requires a value of greater than 5 therefore 5 was used. Floating road is not required due to peat depths on the Proposed Development Site as detailed in Technical Appendix 8-1 Peat Survey Results.

Input date	Expected value	Minimum value	Maximum value	Source of Data
Floating road depth (m)	0	0	0	Floating road is not required due to peat depths on the Proposed Development Site as detailed in Technical Appendix 8-1 Peat Survey Results.
Length of floating road that is drained (m)	0	0	0	Floating road is not required due to peat depths on the Proposed Development Site as detailed in Technical Appendix 8-1 Peat Survey Results.
Average depth of drains associated with floating roads (m)	0	0	0	Floating road is not required due to peat depths on the Proposed Development Site as detailed in Technical Appendix 8-1 Peat Survey Results.
Length of access track that is excavated road (m)	1800	1620	1980	Chapter 3 Description of Development: 1.8 km new access track. Carbon Calculator requires that minimum is less than expected and maximum is more that expected therefore +/-10% used.
Excavated road width (m)	8	8	8	Chapter 3 Description of Development, Figure 3-7. Tracks will have a total width of up to 8m (including verges), the width of the road itself will be 6m.
Average depth of peat excavated for road (m)	0.16	0.14	0.18	Technical Appendix 8-1 Peat Survey Results and Chapter 8 Hydrology and Hydrogeology, Max and Min +/-10%
Length of access track that is rock filled road (m)	0	0	0	n/a All roads have been accounted for in previous sections
Rock filled road width (m)	5	5	5	Carbon calculator requires a value of greater than 5 therefore 5 was used.
Rock filled road depth (m)	0	0	0	n/a All roads have been accounted for in previous sections
Length of rock filled road that is drained (m)	0	0	0	n/a All roads have been accounted for in previous sections
Average depth of drains associated with rock filled roads (m)	0	0	0	n/a All roads have been accounted for in previous sections
Cable Trench				
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	Chapter 3 Description of Development. It is anticipated these cables will be sited within the footprint of the existing and proposed access track and will be suitably marked on the surface.
Average depth of peat cut for cable trenches (m)	0.24	0.22	0.26	Technical Appendix 8-1 Peat Survey Results and Chapter 8 Hydrology and Hydrogeology, Max and Min +/-10%

Input date	Expected value	Minimum value	Maximum value	Source of Data
Additional peat excavated (not already accounted above)				
Volume of additional peat excavated (m^3)	264.2	264.2	264.2	Technical Appendix 8-1 Peat Survey Results and Chapter 8 Hydrology and Hydrogeology, Max and Min +/-10%
Area of additional peat excavated (m^2)	7770	7770	7770	Chapter 3 Description of Development, Table 3-3, substatioin, BESS, construction compound area, hardstandings
Peat Landslide Hazard and Risk Assessments	Fixed	Fixed	Fixed	Fixed
Improvement of C sequestration at site by blocking drains, restoration of habitat, etc				
Area of degraded bog to be improved (ha)	0	0	0	Technical Appendix 8-1 Peat Survey Results and Chapter 8 Hydrology and Hydrogeology, Max and Min +/-10%
Water table depth in degraded bog before improvement (m)	0.3	0.1	0.5	The Carbon Calculator notes that water table depth should be measured on site. However, where site-specific values are not available, for degraded peat, reasonable estimated minimum, expected and maximum values are: 0.1 m, 0.3 m and 0.5 m, respectively. As noted in Appendix 13.2, section 6.3.1, several areas of partly degraded but still high quality peatland comprising would benefit from restoration.
Water table depth in degraded bog after improvement (m)	0.1	0.05	0.3	The Carbon Calculator notes that water table depth should be measured on site. However, where site-specific values are not available, for intact peat, reasonable estimated minimum, expected and maximum values are: 0.05m, 0.1m, 0.3m respectively.
Time required for hydrology and habitat of bog to return to its previous state on improvement (years)	15	5	30	Carbon Calculator requires that a value between 2 and 30 is input. Values of 5, 15 and 30 used for min, max and expected to show worst case scenario
Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years)	30	30	30	Due to uncertainty this value has been set the maximum that the carbon calculator requires a value between 2 and 30 years. 30 years chosen for worst case.
Area of felled plantation to be improved (ha)	0	0	0	As noted in Chapter 13 of the EIAR no forestry will be felled as a result of the Proposed Development Site.
Water table depth in felled area before improvement (m)	0.3	0.1	0.5	The Carbon Calculator requires a value and notes that water table depth should be measured on site. However, where site-specific values are not available, for degraded peat, reasonable estimated

Input date	Expected value	Minimum value	Maximum value	Source of Data
				minimum, expected and maximum values are: 0.1 m, 0.3 m and 0.5 m, respectively. As noted in Appendix 13.2, section 6.3.1, several areas of partly degraded but still high quality peatland comprising would benefit from restoration.
Water table depth in felled area after improvement (m)	0.1	0.05	0.3	The Carbon Calculator requires a value and notes that water table depth should be measured on site. However, where site-specific values are not available, for intact peat, reasonable estimated minimum, expected and maximum values are: 0.05m, 0.1m, 0.3m respectively.
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)	30	30	30	Carbon calculator requires a value between 2 and 30 years. 30 years chosen for worst case.
Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years)	30	30	30	Carbon calculator requires a value between 2 and 30 years. 30 years chosen for worst case.
Area of borrow pits to be restored (ha)	0	0	0	As noted in Chapter 3 of the EIAR borrow pits will not form part of this application.
Depth of water table in borrow pit before restoration with respect to the restored surface (m)	0	0	0	As noted in Chapter 3 of the EIAR borrow pits will not form part of this application.
Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years)	30	30	30	Carbon calculator requires a value between 1 and 30 years. 30 years chosen for worst case scenario.
Period of time when effectiveness of the restoration of peat removed from borrow pits can be guaranteed (years)	30	30	30	Carbon calculator requires a value between 1 and 30 years. 30 years chosen for worst case scenario.
Water table depth around foundations and hardstanding	0.3	0.1	0.5	The Carbon Calculator notes that water table depth should be measured on site. However, where site-specific values are not available, for degraded peat,

Input date	Expected value	Minimum value	Maximum value	Source of Data
before restoration (m)				reasonable estimated minimum, expected and maximum values are: 0.1 m, 0.3 m and 0.5 m, respectively.
Water table depth around foundations and hardstanding after restoration (m)	0.1	0.05	0.3	The Carbon Calculator notes that water table depth should be measured on site. However, where site-specific values are not available, for intact peat, reasonable estimated minimum, expected and maximum values are: 0.05 m, 0.1 m and 0.3 m, respectively.
Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)	*5*	*5*	*5*	Carbon calculator requires a value between 0.1 and 5 years. 5 years chosen for worst case.
Restoration of site after decommissioning				
Will you attempt to block any gullies that have formed due to the windfarm?	No	No	No	Chapter 8 Hydrology and Hydrogeology. No turbines are sited on deep (>1m) peat and all other infrastructure elements (compound, substation and borrow pit search areas) are sited on areas with peat depth less than 1.0 m.
Will you attempt to block all artificial ditches and facilitate rewetting?	No	No	No	Chapter 8 Hydrology and Hydrogeology. No turbines are sited on deep (>1m) peat and all other infrastructure elements (compound, substation and borrow pit search areas) are sited on areas with peat depth less than 1.0 m.
Will you control grazing on degraded areas?	No	No	No	Technical Appendix 6-4 Outline Habitat Management Plan.
Will you manage areas to favour reintroduction of species?	Yes	Yes	Yes	Technical Appendix 6-4 Outline Habitat Management Plan.