voltalia

CRUACH CLENAMACRIE WIND FARM

APPENDIX 17.1 CARBON CALCULATOR INPUTS AND RESULTS

Appendix 17.1: Carbon Calculator Inputs and Results

Cruach Clenamacrie Wind Farm

Client: Voltalia UK Ltd
Reference: C5676-1404
Version 1.0

November 2024

Report Prepared for:
Voltalia UK Ltd

Author:
Green Cat Renewables Ltd

Version	Reviewed by (Date)	Approved by (Date)	Date of Issue	Details
V1.0	Isla Ferguson (01/11/2024)	Corey Simpson (07/11/2024)	08/11/2024	Client and Legal Issue
V2.0	Corey Simpson (15/11/2024)	Corey Simpson (15/11/2024)	15/11/2024	Second Draft Issue

Table of Contents

Appendix 17.1 Carbon Calculator Inputs and Results

1.1 Excel Carbon Calculator Results

	Exp.	*Min.*	*Max.*
1. Windfarm CO_2 emission saving over…			
…coal-fired electricity generation (tCO_2 yr^{-1})	143763	129458	158067
…grid-mix of electricity generation (tCO_2 yr^{-1})	31491	28357	34624
…fossil fuel - mix of electricity generation (tCO_2 yr^{-1})	64503	58085	70921
Energy output from windfarm over lifetime (MWh)	7606483	6849619	8363347
Total CO_2 losses due to wind farm (t CO_2 eq.)			
2. Losses due to turbine life (eg. manufacture, construction, decomissioning)	42695	42181	43208
3. Losses due to backup	40114	0	40114
4. Losses due to reduced carbon fixing potential	1118	276	2234
5. Losses from soil organic matter	1544	-2320	12532
6. Losses due to DOC & POC leaching	1	0	3235
7. Losses due to felling forestry	43806	35564	52906
Total losses of carbon dioxide	129278	75701	154229
8. Total CO_2 gains due to improvement of site (t CO_2 eq.)			
8a. Change in emissions due to improvement of degraded bogs	-178	0	-1395
8b. Change in emissions due to improvement of felled forestry	0	0	0
8c. Change in emissions due to restoration of peat from borrow pits	0	0	0
8d. Change in emissions due to removal of drainage from foundations & hardstanding	0	0	0
Total change in emissions due to improvements	-178	0	-1395
RESULTS			
	Exp.	*Min.*	*Max.*
Net emissions of carbon dioxide (t $CO_{2\ eq.}$)	**129100**	**74306**	**154229**
Carbon Payback Time			
…coal-fired electricity generation (years)	0.9	0.5	1.2
…grid-mix of electricity generation (years)	4.1	2.1	5.4

…fossil fuel - mix of electricity generation (years)	2.0	1.0	2.7
Ratio of soil carbon loss to gain by restoration (TARGET ratio (Natural Resources Wales) < 1.0)	No gains!	No gains!	No gains!
Ratio of CO_2 eq. emissions to power generation (g / kWh) (TARGET ratio by 2030 (electricity generation) < 50 g /kWh)	17	9	23

1.2 Carbon Calculator Inputs

Different data sources have been used to collect the data required for the Scottish Government Carbon Calculator tool. Wind farm and site-specific data has been utilised wherever appropriate however where data was not available, default data or estimates have been applied. Inputs and their sources are noted in Table 1. For uncertainty a range of +/- 10% has been applied to some categories.

Table 1 – Carbon Calculator Inputs

Input data	Expected value	Minimum value	Maximum value	Source of data
Windfarm characteristics				
Dimensions				
No. of turbines	6	6	6	**EIA Report Chapter 5: Project Description**
Duration of consent (years)	50	50	50	**EIA Report Chapter 5: Project Description**
Performance				
Power rating of 1 turbine (MW)	7.2	7.2	7.2	**EIA Report Chapter 5: Project Description**
Capacity factor	40.2	36.2	44.2	Voltalia UK, Preliminary Energy Yield Estimate study.
Backup				
Fraction of output to backup (%)	5	0	5	Guidance in Scottish Carbon Calculator results tab - conservative – Dale et al. (2004)
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	Scottish Government Carbon Calculator
Characteristics of peatland before windfarm development				
Type of peatland	Acid bog	Acid bog	Acid bog	**Appendix 9.2: Outline Peat Management Plan**
Average annual air temperature at site (°C)	9.6	8.6	10.6	Met Office. Dunstaffnage Climate Station (1991-2020)

Input data	Expected value	Minimum value	Maximum value	Source of data
Average depth of peat at site (m)	0.51	0.46	0.56	Raw Data from Peat Probing datasets. **Appendix 9.1: Peat Slide Risk Assessment**
C Content of dry peat (% by weight)	41.2	37.1	45.3	Map of topsoil organic carbon concentration. Scottish Government.
Average extent of drainage around drainage features at site (m)	10	5	15	Smith et al (2011) Worst case Scenario
Average water table depth at site (m)	0.3	0.1	0.5	Guidance from 'Calculating Potential Carbon Losses & Savings from Wind Farms on Scottish Peatlands'
Dry soil bulk density (g cm^{-3})	0.132	0.072	0.293	Assumed decomposed peat value, National Soil Inventory of Scotland
Characteristics of bog plants				
Time required for regeneration of bog plants after restoration (years)	7.5	5	10	**EIA Report Chapter 10: Ecology**
Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha^{-1} yr^{-1})	0.25	0.12	0.31	NatureScot recommended value, Calculating carbon savings from wind farms on Scottish peat lands: a new approach
Forestry Plantation Characteristics				
Area of forestry plantation to be felled (ha)	18.1	16.3	19.9	**EIA Report Chapter 13: Forestry**
Average rate of carbon sequestration in timber (tC ha^{-1} yr^{-1})	13.2	11.9	14.5	Cannell (1999)[1] and **EIA Report Chapter 13: Forestry**
Counterfactual emission factors				
Coal-fired plant emission factor (t CO2 MWh^{-1})	0.945	0.945	0.945	Fixed
Grid-mix emission factor (t CO2 MWh^{-1})	0.207	0.207	0.207	Fixed
Fossil fuel-mix emission factor (t CO2 MWh^{-1})	0.424	0.424	0.424	Fixed
Borrow pits				

[1] Compensatory planting will be undertaken to compensate the permanent lost area due to infrastructure on Site. Due to the setup of the Carbon Calculator, the compensatory planting is not able to be accounted for in these calculations.

Input data	Expected value	Minimum value	Maximum value	Source of data
Number of borrow pits	2	2	2	Appendix 9.5: Borrow Pit Assessment
Average length of pits (m)	80	72	88	Appendix 9.5: Borrow Pit Assessment
Average width of pits (m)	80	72	88	Appendix 9.5: Borrow Pit Assessment
Average depth of peat removed from pit (m)	0.28	0.25	0.31	Appendix 9.5: Borrow Pit Assessment
Access tracks				
Total length of access track (m)	10,205	9,185	11,226	EIA Report Chapter 5: Project Description
Existing track length (m)	2,562	2,306	2,818	EIA Report Chapter 5: Project Description
Length of access track that is floating road (m)	200	180	220	EIA Report Chapter 5: Project Description
Floating road width (m)	5	4.5	5.5	EIA Report Chapter 5: Project Description
Floating road depth (m)	1	0.9	1.1	EIA Report Chapter 5: Project Description
Length of floating road that is drained (m)	200	180	220	EIA Report Chapter 5: Project Description
Average depth of drains associated with floating roads (m)	0.42	0.38	0.46	EIA Report Chapter 5: Project Description
Length of access track that is excavated road (m)	7,443	6,699	8,187	EIA Report Chapter 5: Project Description
Excavated road width (m)	5	4.5	5.5	EIA Report Chapter 5: Project Description
Average depth of peat excavated for road (m)	0.55	0.50	0.60	EIA Report Chapter 5: Project Description
Length of access track that is rock filled road (m)	N/A			N/A
Rock filled road width (m)	N/A			N/A
Rock filled road depth (m)	N/A			N/A
Length of rock filled road that is drained (m)	N/A			N/A
Average depth of drains associated with rock filled roads (m)	N/A			N/A
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	N/A – Cables follow access tracks
Average depth of peat cut for cable trenches (m)	0	0	0	N/A
Additional peat excavated (not already accounted for above)				

Input data	Expected value	Minimum value	Maximum value	Source of data
Volume of additional peat excavated (m^3)	0	0	0	Borrow Pits, Substation are located on mineral soils.
Area of additional peat excavated (m^2)	0	0	0	N/A
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)	9	8	10	**Appendix 10.5: Outline Habitat Management Plan.**
Water table depth in degraded bog before improvement (m)	0.3	0.1	0.5	Windfarm Carbon Calculator Web Tool, User Guidance
Water table depth in degraded bog after improvement (m)	0.1	0.05	0.3	Windfarm Carbon Calculator Web Tool, User Guidance
Time required for hydrology and habitat of bog to return to its previous state on improvement (years)	7.5	5	10	**Appendix 10.5: Outline Habitat Management Plan.**
Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years)	10	5	15	**Appendix 10.5: Outline Habitat Management Plan.**
Improvement of felled plantation land				
Area of felled plantation to be improved (ha)	N/A			
Water table depth in felled area before improvement (m)	N/A			
Water table depth in felled area after improvement (m)	N/A			
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)	N/A			
Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years)	N/A			
Restoration of peat removed from borrow pits				

Input data	Expected value	Minimum value	Maximum value	Source of data
Area of borrow pits to be restored (ha)	N/A			There is effectively no peat in the borrow pit areas, so there is no restoration of this peat – borrow pits are not being used for peatland restoration (WRC Group).
Depth of water table in borrow pit before restoration with respect to the restored surface (m)	N/A			
Depth of water table in borrow pit after restoration with respect to the restored surface (m)	N/A			
Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years)	N/A			
Period of time when effectiveness of the restoration of peat removed from borrow pits can be guaranteed (years)	N/A			
Early removal of drainage from foundations and hardstanding				
Water table depth around foundations and hardstanding before restoration (m)	0	0	0	N/A
Water table depth around foundations and hardstanding after restoration (m)	0	0	0	
Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)	0	0	0	
Restoration of site after decommissioning				
Will the hydrology of the site be restored on decommissioning?				
Will you attempt to block any gullies that have formed due to the windfarm?	Yes	Yes	Yes	**EIA Report Chapter 9: Geology, Hydrogeology, Hydrology and Soils** and **Appendix 10.5 - Outline Habitat Management Plan.**
Will you attempt to block all artificial ditches and facilitate rewetting?	Yes	Yes	Yes	Details to be confirmed, if tracks are left in situ, then drainage will be required.
Will you control grazing on degraded areas?	Yes	Yes	Yes	**EIA Report Chapter 10: Ecology**
Will you manage areas to favour reintroduction of species	Yes	Yes	Yes	**EIA Report Chapter 10: Ecology**

Construction Input Data	Expected Value	Maximum	Minimum	Source of Data
Development Infrastructure				
Number of turbines in this area	6	6	6	EIA Report Chapter 5: Project Description
Turbine foundations				
Average Peat depth excavated when constructing foundations (m)	0.53	0.48	0.58	Appendix 9.1: Peat Slide Risk Assessment
Approximate geometric shape of whole dug when constructing foundations	Circular	Circular	Circular	EIA Report Chapter 5: Project Description Figure 5.4
Diameter at bottom	22.65	20.39	24.92	EIA Report Chapter 5: Project Description Figure 5.4
Diameter at surface	7	6.3	7.7	EIA Report Chapter 5: Project Description Figure 5.4
Hardstanding				
Average Peat depth excavated when constructing foundations (m)	0.53	0.48	0.58	Appendix 9.1: Peat Slide Risk Assessment
Approximate geometric shape of whole dug when constructing hardstanding	Rectangular	Rectangular	Rectangular	EIA Report Chapter 5: Project Description Figure 5.10
Length at surface	107	96	118	EIA Report Chapter 5: Project Description Figure 5.10
Width at surface	63	57	69	EIA Report Chapter 5: Project Description Figure 5.10
Length at bottom	107	96	118	EIA Report Chapter 5: Project Description Figure 5.10
Width at bottom	63	57	69	EIA Report Chapter 5: Project Description Figure 5.10
Piling				
Is piling used?	No	No	No	Post-consent decision
Volume of Concrete				
Volume of concrete used (m^3) in the entire area	16,254	14,628	17,879	EIA Report Chapter 5: Project Description

Registered Office
Green Cat Renewables
Stobo House
Roslin
Midlothian
EH25 9RE

+44 (0) 131 541 0060

info@greencatrenewables.co.uk
www.greencatrenewables.co.uk