Technical Appendix 17.1 Carbon Calculator

Carbon Calculator v1.8.1
Oliver Forest Wind Farm Location: 55.506176 -3.453175
Oliver Forest Wind Farm Limited

Core input data

Input data	Expected value	Minimum value	Maximum value	Source of data
Windfarm characteristics				
Dimensions				
No. of turbines	7	7	7	Volume 2 Chapter 3 Description of the Development
Duration of consent (years)	50	50	50	Volume 2 Chapter 3 Description of the Development
Performance				
Power rating of 1 turbine (MW)	7.2	7.2	7.2	Volume 2 Chapter 3 Description of the Development
Capacity factor	37.3	37	38	Data provided by Client
Backup				
Fraction of output to backup (%)	5	0	5	Calculating Potential Carbon Losses & Savings from Wind Farms on Scottish Peatlands, Technical Note, Version 2.10.0, Para 19.
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	Volume 2 Chapter 3 Description of the Development
Average annual air temperature at site (°C)	11	5	15	Nearest met office station: Eskdalemuir https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/gcvdxj13y
Average depth of peat at site (m)	0.3	0	7	Volume 4 TA 10.1 PLHRA: Peat data
C Content of dry peat (% by weight)	55.5	49	62	Birnie et al. 1991
Average extent of drainage around drainage features at site (m)	10	5	25	Site specific values are not available. Standard values are from "Windfarm Carbon Calculator Web Tool, User Guidance".
Average water table depth at site (m)	0.1	0.05	0.2	Site specific values are not available. Standard values are from "Windfarm Carbon Calculator Web Tool, User Guidance". Values for 'intact peat' have been used.

Input data	Expected value	Minimum value	Maximum value	Source of data
Dry soil bulk density (g cm^{-3})	0.2	0.18	0.22	Lilly et al. 2010
Characteristics of bog plants				
Time required for regeneration of bog plants after restoration (years)	5	2	15	Site specific values are not available. Conservative estimates have been used.
Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha^{-1} yr^{-1})	0.25	0.12	0.31	Calculating Potential Carbon Losses & Savings from Wind Farms on Scottish Peatlands, Technical Note, Version 2.10.0, para 25.
Forestry Plantation Characteristics				
Area of forestry plantation to be felled (ha)	50.42	50	51	Volume 2 Chapter 3 Description of the Development
Average rate of carbon sequestration in timber (tC ha^{-1} yr^{-1})	3	2.4	3.6	Cannel, 1999, Growing trees in the UK to sequester carbon. Sitka spruce, YC 16, 3.6 tC ha-1 yr-1 over 55 years Beech, YC 6, about 2.4 tC ha-1 yr-1 over 92 years
Counterfactual emission factors				
Coal-fired plant emission factor (t CO2 MWh^{-1})	0.945	0.945	0.945	
Grid-mix emission factor (t CO2 MWh^{-1})	0.207	0.207	0.207	
Fossil fuel-mix emission factor (t CO2 MWh^{-1})	0.424	0.424	0.424	
Borrow pits				
Number of borrow pits	3	3	3	Volume 2 Chapter 3 Description of the Development
Average length of pits (m)	100	100	100	Volume 2 Chapter 3 Description of the Development
Average width of pits (m)	60	60	60	Volume 2 Chapter 3 Description of the Development
Average depth of peat removed from pit (m)	0.17	0.11	0.29	Volume 4 TA 10.1 PLHRA: Peat data
Foundations and hard-standing area associated with each turbine				
Average length of turbine foundations (m)	0	0	0	
Average width of turbine foundations (m)	0	0	0	

Input data	Expected value	Minimum value	Maximum value	Source of data
Average depth of peat removed from turbine foundations(m)	0	0	0	
Average length of hard-standing (m)	0	0	0	
Average width of hard-standing (m)	0	0	0	
Average depth of peat removed from hard-standing (m)	0	0	0	
Volume of concrete used in construction of the ENTIRE windfarm				
Volume of concrete (m^3)	0	0	0	
Access tracks				
Total length of access track (m)	4947	4946	4948	Volume 3 Chapter 2 Description of the Development
Existing track length (m)	3452	3452	3452	Volume 3 Chapter 2 Description of the Development
Length of access track that is floating road (m)	0	0	0	Volume 3 Chapter 2 Description of the Development
Floating road width (m)	5	5	5	Volume 3 Chapter 2 Description of the Development
Floating road depth (m)	0	0	0	Volume 3 Chapter 2 Description of the Development
Length of floating road that is drained (m)	0	0	0	Volume 3 Chapter 2 Description of the Development
Average depth of drains associated with floating roads (m)	0	0	0	Volume 3 Chapter 2 Description of the Development
Length of access track that is excavated road (m)	1495	1494	1496	Volume 3 Chapter 2 Description of the Development
Excavated road width (m)	5	5	5	Volume 3 Chapter 2 Description of the Development
Average depth of peat excavated for road (m)	0.25	0.25	0.25	Volume 4 TA 10.1 PLHRA: Peat data
Length of access track that is rock filled road (m)	0	0	0	Volume 3 Chapter 2 Description of the Development
Rock filled road width (m)	5	5	5	Volume 3 Chapter 2 Description of the Development
Rock filled road depth (m)	0	0	0	Volume 3 Chapter 2 Description of the Development
Length of rock filled road that is drained (m)	0	0	0	Volume 3 Chapter 2 Description of the Development

Input data	Expected value	Minimum value	Maximum value	Source of data
Average depth of drains associated with rock filled roads (m)	0	0	0	Volume 3 Chapter 2 Description of the Development
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
Average depth of peat cut for cable trenches (m)	0	0	0	n/a
Additional peat excavated (not already accounted for above)				
Volume of additional peat excavated (m^3)	4235	4235	4235	Volume 4 TA 10.2 PMP: Annex A
Area of additional peat excavated (m^2)	4581	4581	4581	Volume 4 TA 10.2 PMP: Annex 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)	57.35	57.35	57.35	Volume 4 TA 8.5 ONEMP
Water table depth in degraded bog before improvement (m)	0.3	0.1	0.5	Site specific values are not available. Standard values are from “Windfarm Carbon Calculator Web Tool, User Guidance”. Values for 'degraded peat' have been used.
Water table depth in degraded bog after improvement (m)	0.1	0.05	0.3	Site specific values are not available. Standard values from "Windfarm Carbon Calculator Web Tool, User Guidance" and values for 'intact peat' have been used to make an estimate of water table depth.
Time required for hydrology and habitat of bog to return to its previous state on	10	5	15	Site specific values are not available. Standard values from "Windfarm Carbon Calculator Web Tool, User Guidance" and values for 'intact peat' have been used to make an estimate.

Input data	Expected value	Minimum value	Maximum value	Source of data
improvement (years)				
Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years)	50	50	50	The duration of consent for this development is 50 years.
Improvement of felled plantation land				
Area of felled plantation to be improved (ha)	20.4	20.4	20.4	Volume 4 TA 8.5 ONEMP
Water table depth in felled area before improvement (m)	0.3	0.1	0.5	Site specific values are not available. Standard values are from “Windfarm Carbon Calculator Web Tool, User Guidance”. Values for 'degraded peat' have been used.
Water table depth in felled area after improvement (m)	0.1	0.05	0.3	Site specific values are not available. Standard values from "Windfarm Carbon Calculator Web Tool, User Guidance" and values for 'intact peat' have been used to make an estimate of water table depth.
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)	10	5	15	Site specific values are not available. Standard values from "Windfarm Carbon Calculator Web Tool, User Guidance" and values for 'intact peat' have been used to make an estimate.
Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years)	50	50	50	The duration of consent for this development is 50 years.
Restoration of peat removed from borrow pits				
Area of borrow pits to be restored (ha)	1.8	1.8	1.8	Volume 4 TA 8.5 ONEMP
Depth of water table in borrow pit before restoration with respect to the restored surface (m)	0.3	0.1	0.5	Site specific values are not available. Standard values are
Depth of water table in borrow pit after restoration with respect to the	0.1	0.05	0.3	Site specific values are not available. Standard values from "Windfarm Carbon Calculator Web

Input data	Expected value	Minimum value	Maximum value	Source of data
restored surface (m)				
Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years)	10	5	15	Site specific values are not available. Standard values from "Windfarm Carbon Calculator Web
Period of time when effectiveness of the restoration of peat removed from borrow pits can be guaranteed (years)	50	50	50	The duration of consent for this development is 50 years.
Early removal of drainage from foundations and hardstanding				
Water table depth around foundations and hardstanding before restoration (m)	0.3	0.1	0.5	Site specific values are not available. Standard values are from “Windfarm Carbon Calculator Web Tool, User Guidance”. Values for 'degraded peat' have been used.
Water table depth around foundations and hardstanding after restoration (m)	0.1	0.05	0.3	Site specific values are not available. Standard values are from “Windfarm Carbon Calculator Web Tool, User Guidance”. Values for 'intact peat' have been used.
Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)	0.25	0.1	3	These parameters are estimated values which refer to the removal of drainage around foundations and hardstandings after construction, not the removal of hardstandings and turbine foundations after decommissioning.
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	This will form part of a decommissioning and restoration plan for the site in the future.
Will you attempt to block all artificial ditches and facilitate rewetting?	Yes	Yes	Yes	This will form part of a decommissioning and restoration plan for the site in the future.

Input data	Expected value	Minimum value	Maximum value	Source of data
Will the habitat of the site be restored on decommissioning?	Yes	Yes	Yes	
Will you control grazing on degraded areas?	Yes	Yes	Yes	This will form part of a decommissioning and restoration plan for the site in the future.
Will you manage areas to favour reintroduction of species	Yes	Yes	Yes	This will form part of a decommissioning and restoration plan for the site in the future.
Methodology				
Choice of methodology for calculating emission factors	Site specific (required for planning applications)			

Forestry input data

N/A

Construction input data

Input data	Expected value	Minimum value	Maximum value	Source of data
1				
Number of turbines in this area	7	7	7	Volume 3 Chapter 2 Description of the Development
Turbine foundations				
Depth of hole dug when constructing foundations (m)	0.2	0.1	0.4	Volume 4 TA 10.1 PLHRA: Peat data
Aproximate geometric shape of whole dug when constructing foundations	Circular	Circular	Circular	Volume 3 Chapter 2 Description of the Development
Diameter at bottom	30	30	30	
Diameter at surface	30	30	30	
Hardstanding				
Depth of hole dug when constructing hardstanding (m)	0.2	0.1	0.4	Volume 4 TA 10.1 PLHRA: Peat data
Aproximate geometric shape of whole dug when constructing hardstanding	Rectangular	Rectangular	Rectangular	Volume 3 Chapter 2 Description of the Development
Length at surface	60	60	60	
Width at surface	40	40	40	
Length at bottom	60	60	60	
Width at bottom	40	40	40	
Piling				

Input data	Expected value	Minimum value	Maximum value	Source of data
1				
Is piling used?	No	No	No	Volume 3 Chapter 2 Description of the Development
Volume of Concrete				
Volume of concrete used (m^3) in the entire area	5600	5600	5600	Volume 3 Chapter 2 Description of the Development

Payback Time and CO_2 emissions • NP06-BZ2F-C2J5 v2

1. Windfarm CO2 emission saving over...	Exp.	Min.	Max.
...coal-fired electricity generation (t CO2 / yr)	155,624	154,372	158,544
...grid-mix of electricity generation (t CO2 / yr)	34,089	33,815	34,729
...fossil fuel-mix of electricity generation (t CO2 / yr)	69,825	69,263	71,135
Energy output from windfarm over lifetime (MWh)	8,234,050	8,167,824	8,388,576

Total CO2 losses due to wind farm (tCO2 eq.)	Exp.	Min.	Max.
2. Losses due to turbine life (eg. manufacture, construction, decomissioning)	45,588	45,588	45,588
3. Losses due to backup	46,799	0	46,799
4. Lossess due to reduced carbon fixing potential	602	193	1,752
5. Losses from soil organic matter	3,292	596	6,409
6. Losses due to DOC & POC leaching	318	0	2,259
7. Losses due to felling forestry	27,731	22,000	33,660
Total losses of carbon dioxide	124,331	68,378	136,468

8. Total CO2 gains due to improvement of site (t CO2 eq.)	Exp.	Min.	Max.
8a. Change in emissions due to improvement of degraded bogs	-18,375	0	-36,855
8b. Change in emissions due to improvement of felled forestry	-6,536	0	-13,110
8c. Change in emissions due to restoration of peat from borrow pits	-149	0	-547
8d. Change in emissions due to removal of drainage from foundations & hardstanding	-966	0	-5,067
Total change in emissions due to improvements	-26,027	0	-55,578

RESULTS	Exp.	Min.	Max.
Net emissions of carbon dioxide (t CO2 eq.)	98,304	12,800	136,468
Carbon Payback Time			
...coal-fired electricity generation (years)	0.6	0.1	0.9
...grid-mix of electricity generation (years)	2.9	0.4	4.0
...fossil fuel-mix of electricity generation (years)	1.4	0.2	2.0
Ratio of soil carbon loss to gain by restoration (not used in Scottish applications)	0.14	0.01	No gains!
Ratio of CO2 eq. emissions to power generation (g/kWh) (for info. only)	11.94	1.53	16.71

References

Scottish Government (2022). Carbon Calculator Tool v1.8.1. Available at: https://informatics.sepa.org.uk/CarbonCalculator/. Accessed on: 22 May 2024.