Appendix 3.2 Carbon Calculator Input and Output

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Carbon Calculator v1.6.1
Cumberhead West Wind Farm Location: 55.586814 -3.983079
3R Energy & ScottishPower Renewables

Core input data

Input data	Expected value	Minimum value	Maximum value	Source of data
Windfarm characteristics				
Dimensions				
No. of turbines	21	21	21	EIA Chapter 3
Duration of consent (years)	30	30	30	EIA Chapter 3
Performance				
Power rating of 1 turbine (MW)	6	6	6	EIA Chapter 3
Capacity factor	35	31.5	38.5	Site specific
Backup				
Fraction of output to backup (%)	5	5	5	Standard value
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	EIA Chapter 7
Average annual air temperature at site (°C)	7.85	7.065	8.635	Annual met station data
Average depth of peat at site (m)	0.84	0.756	0.924	EIA Chapter 11
C Content of dry peat (% by weight)	32.4	19	58.9	Lab data from survey samples
Average extent of drainage around drainage features at site (m)	10	9	11	EIA Chapter 7
Average water table depth at site (m)	0.1	0.05	0.3	Observed during site survey
Dry soil bulk density (g cm^{-3})	0.3	0.29	0.3	Maximum value allowed as default
Characteristics of bog plants				
Time required for regeneration of bog plants after restoration (years)	10	5	15	Standard value
Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha^{-1} yr^{-1})	0.25	0.12	0.31	SNH guidance standard value
Forestry Plantation Characteristics				
Area of forestry plantation to be felled (ha)	63.08	56.772	69.388	EIA Chapter 16 & Appendix 3.3
Average rate of carbon sequestration in timber (tC ha^{-1} yr^{-1})	3.6	3.24	3.96	SNH guidance standard value
Counterfactual emission factors				

Input data	Expected value	Minimum value	Maximum value	Source of data
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	1	3	EIA Chapter 3
Average length of pits (m)	111.09	99.981	122.199	EIA Chapter 3 - based on total borrow pit search area and assumption max 50% exacavated
Average width of pits (m)	111.09	99.981	122.199	EIA Chapter 3 - based on total borrow pit search area and assumption max 50% exacavated
Average depth of peat removed from pit (m)	0.82	0.66	0.92	EIA Appendix 11.2
Access tracks				
Total length of access track (m)	37542	36488.1	38595.9	EIA Chapter 3
Existing track length (m)	27003	27003	27003	EIA Chapter 3
Length of access track that is floating road (m)	409	368.1	449.9	EIA Chapter 3
Floating road width (m)	5	5	5	EIA Chapter 3
Floating road depth (m)	0	0	0	EIA Chapter 3
Length of floating road that is drained (m)	0	0	0	N/A
Average depth of drains associated with floating roads (m)	0	0	0	N/A
Length of access track that is excavated road (m)	10130	9117	11143	EIA Chapters 3 & 11
Excavated road width (m)	5	5	5	EIA Chapter 3
Average depth of peat excavated for road (m)	0.58	0.522	0.638	EIA Appendix 11.2 plus data from Douglas West Extension EIAR
Length of access track that is rock filled road (m)	0	0	0	EIA Chapter 3 - no rock filled road
Rock filled road width (m)	5	5	5	N/A
Rock filled road depth (m)	0	0	0	N/A
Length of rock filled road that is drained (m)	0	0	0	N/A
Average depth of drains associated with rock filled roads (m)	0	0	0	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	EIA Chapter 3
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)	5099.7	4589.73	5609.67	"EIA Chapter 11 Includes substation and met mast hardstanding"

Input data	Expected value	Minimum value	Maximum value	Source of data
Area of additional peat excavated (m^2)	7250	6525	7975	"EIA Chapter 11 Includes substation and met mast hardstanding"
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)	24.66	3	74	EIA Appendix 7.5- HMP - third of the search areas
Water table depth in degraded bog before improvement (m)	0.1	0.05	0.3	Assumption based on site survey observations
Water table depth in degraded bog after improvement (m)	0.09	0.04	0.29	Assumption based on site survey observations
Time required for hydrology and habitat of bog to return to its previous state on improvement (years)	10	5	15	Standard Value
Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years)	30	30	30	EIA Chapter 3 - proposed development lifetime
Improvement of felled plantation land				
Area of felled plantation to be improved (ha)	63.08	56.772	69.388	EIA Chapter 16 & Appendix 3.3
Water table depth in felled area before improvement (m)	3	2.7	3	assumed value. max allowed
Water table depth in felled area after improvement (m)	1	0.9	1	assumed value. max allowed
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)	10	5	15	standard value
Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years)	30	30	30	EIA Chapter 3
Restoration of peat removed from borrow pits				
Area of borrow pits to be restored (ha)	3.7	3.33	4.07	EIA Chapter 3 - 50% total area of borrow pit search areas
Depth of water table in borrow pit before restoration with respect to the restored surface (m)	0.1	0.05	0.3	Assumption based on site survey observations
Depth of water table in borrow pit after restoration with respect to the restored surface (m)	0.09	0.04	0.29	Assumption based on site survey observations
Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years)	10	5	15	standard value
Period of time when effectiveness of the restoration of peat removed from borrow pits can be guaranteed (years)	30	30	30	EIA Chapter 3
Early removal of drainage from foundations and hardstanding				

Input data	Expected value	Minimum value	Maximum value	Source of data
Water table depth around foundations and hardstanding before restoration (m)	0	0	0	N/A - no early removal
Water table depth around foundations and hardstanding after restoration (m)	0	0	0	N/A
Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)	2	2	2	EIA Chapter 3
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	CEMP
Will you attempt to block all artificial ditches and facilitate rewetting?	Yes	Yes	Yes	CEMP
Will the habitat of the site be restored on decommissioning?	Yes	Yes	Yes	
Will you control grazing on degraded areas?	Yes	Yes	Yes	HMP
Will you manage areas to favour reintroduction of species	Yes	Yes	Yes	HMP
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
Site				
Number of turbines in this area	21	21	21	EIA Chapter 3
Turbine foundations				
Depth of hole dug when constructing foundations (m)	0.66	0.594	0.726	EIA Appendix 11.2
Aproximate geometric shape of whole dug when constructing foundations	Circular	Circular	Circular	EIA Chapter 3
Diameter at bottom	30	30	30	
Diameter at surface	30	30	30	
Hardstanding				
Depth of hole dug when constructing hardstanding (m)	0.69	0.621	0.759	EIA Appendix 11.2
Aproximate geometric shape of whole dug when constructing hardstanding	Rectangular	Rectangular	Rectangular	EIA Chapter 3
Length at surface	50	50	50	
Width at surface	30	30	30	
Length at bottom	50	50	50	
Width at bottom	30	30	30	
Piling				
Is piling used?	No	No	No	EIA Chapter 3
Volume of Concrete				
Volume of concrete used (m^3) in the entire area	49350	44415	54285	Calculated by engineers

Payback Time

Payback Time
Payback Time - ChartsInput Data

1. Windfarm CO2 emission saving over...	Exp.	Min.	Max.
...coal-fired electricity generation (t CO2 / yr)	355,411	319,870	390,952
...grid-mix of electricity generation (t CO2 / yr)	97,962	88,166	107,758
...fossil fuel-mix of electricity generation (t CO2 / yr)	173,842	156,458	191,226
Energy output from windfarm over lifetime (MWh)	11,589,480	10,430,532	12,748,428

Total CO2 losses due to wind farm (tCO2 eq.)	Exp.	Min.	Max.
2. Losses due to turbine life (eg. manufacture, construction, decomissioning)	123,504	121,945	125,064
3. Losses due to backup	74,504	74,504	74,504
4. Lossess due to reduced carbon fixing potential	1,570	521	2,534
5. Losses from soil organic matter	31,936	8,623	70,853
6. Losses due to DOC & POC leaching	1,788	0	4,862
7. Losses due to felling forestry	24,980	20,234	30,226
Total losses of carbon dioxide	258,282	225,826	308,042

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	501	0	-11,646
8b. Change in emissions due to improvement of felled forestry	-14,096	-9,228	-19,886
8c. Change in emissions due to restoration of peat from borrow pits	75	0	-641
8d. Change in emissions due to removal of drainage from foundations & hardstanding	0	0	0
Total change in emissions due to improvements	-13,520	-9,228	-32,173

RESULTS	Exp.	Min.	Max.
Net emissions of carbon dioxide (t CO2 eq.)	244,762	193,653	298,814
Carbon Payback Time			
...coal-fired electricity generation (years)	0.7	0.5	0.9
...grid-mix of electricity generation (years)	2.5	1.8	3.4
...fossil fuel-mix of electricity generation (years)	1.4	1.0	1.9
Ratio of soil carbon loss to gain by restoration (not used in Scottish applications)	2.49	0.27	8.21
Ratio of CO2 eq. emissions to power generation (g/kWh) (for info. only)	21.12	15.19	28.65