Technical Appendix 15.5

Carbon Calculator

Table 15.1.1: Carbon Calculator Input

Input data	Expected value	Minimum value	Maximum value	Source of data
Windfarm Characteristics				
Dimensions				
No. of turbines	10	10	10	**Chapter 3: Proposed Development**
Duration of consent (years)	40	40	40	**Chapter 15: Other Issues**
Performance				
Power rating of 1 turbine (MW)	5	5	5	**Chapter 3: Proposed Development**
Capacity factor	26.7	15	35	Department for Business, Energy and Industrial Strategy (2020) Renewable electricity in Scotland, Wales, Northern Ireland and the regions of England in 2020.
Back Up				
Fraction of output to backup (%)	5	0	5	Per Nayak et al (2008)
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 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	The calculator offers two options for this item: Fen or Acid Bog. Peatland present on this site is consistent with the Acid Bog option.
Average annual air temperature at site (°C)	7	5.1	10.8	Met Office (2020).
Average depth of peat at Site (m)	1.27	0	8.1	**Chapter 10: Hydrology, Hydrogeology, Geology and Soils**

Input data	Expected value	Minimum value	Maximum value	Source of data
Content of dry peat (% by weight)	55	49	61	**Technical Appendix 10.1: Peat Slide Risk Assessment**
Average extent of drainage around drainage features at site (m)	0.75	0.5	1	**Chapter 10: Hydrology, Hydrogeology, Geology and Soils**
Average water table depth at site (m)	0.1	0	0.3	The 'Calculating Potential Carbon Losses & Savings from Wind Farms on Scottish Peatlands (Scottish Government, 2016) guidance indicates that on intact sites, the depth to water table may be <100mm (0.10m), with up to 300mm (0.3m) to water table on eroded sites.
Dry soil bulk density (g cm^{-3})	0.14	0.1	0.19	**Technical Appendix 10.1: Peat Slide Risk Assessment**
Characteristics of Bog Plants				
Time required for regeneration of bog plants after restoration (years)	6	2	10	The expected value used here is 6 years. This is a judgement made by Avian and SPR based on their experience of other windfarms and knowledge of the existing environment. This figure assumes the use of best practice during restoration.
Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha^{-1} yr^{-1})	0.25	0.24	0.26	Wind Farms and Carbon Savings (SNH, 2003)
Forestry Plantation Characteristics				
Area of forestry plantation to be felled (ha)	111.8	100.62	122.98	**Chapter 15: Other Issues**
Average rate of carbon sequestration in timber (tC ha^{-1} yr^{-1})	3.6	2.4	4.4	Growing trees to sequester carbon in the UK: answer to some common questions (Cannell, 1999)
Counterfactual Emissions Factors				
Coal-fired plant emission factor (t CO_2 MWh^{-1})	0.92	0.92	0.92	Scottish Government Carbon Calculator
Grid-mix emission factor (t CO_2 MWh^{-1})	0.25358	0.25358	0.25358	Scottish Government Carbon Calculator
Fossil fuel-mix emission factor (t CO_2 MWh^{-1})	0.45	0.45	0.45	Scottish Government Carbon Calculator

Input data	Expected value	Minimum value	Maximum value	Source of data
Borrow Pits				
Number of borrow pits	3	3	3	**Technical Appendix 10.3: Borrow Pit Assessment**
Average length of pits (m)	158	90	260	**Technical Appendix 10.3: Borrow Pit Assessment**
Average width of pits (m)	50	35	60	**Technical Appendix 10.3: Borrow Pit Assessment**
Average depth of peat removed from pit (m)	0.38	0	0.6	**Technical Appendix 10.3: Borrow Pit Assessment**
Foundations and Hard-Standing Area Associated with Each Turbine				
Average length of turbine foundations (m)	22	22	22	**Chapter 3: Proposed Development**
Average width of turbine foundations (m)	22	22	22	**Chapter 3: Proposed Development**
Average depth of peat removed from turbine foundations(m)	0.56	0.2	1.0	**Chapter 10: Hydrology, Hydrogeology, Geology and Soils**
Average length of hard-standing (m)	314.55	283.1	346	**Chapter 3: Proposed Development**
Average width of hard-standing (m)	10	8	12	**Chapter 3: Proposed Development**
Average depth of peat removed from hard-standing (m)	0.65	0.05	2.2	**Technical appendix 10.4: Peat Management Plan**
Volume of Concrete Used in Construction of the ENTIRE Windfarm				
Volume of concrete (m^3)	80473	59259	101687	Infrastructure design and aggregate estimates
Access Tracks				
Total length of access track (m)	12010	10809	13211	**Chapter 3: Proposed Development**
Existing track length (m)	3080	2772	3388	**Chapter 3: Proposed Development**
Length of access track that is floating road (m)	2750	2475	3025	**Chapter 3: Proposed Development**
Floating road width (m)	5	5	6	**Chapter 3: Proposed Development**
Floating road depth (m)	0.8	0.6	1	**Chapter 3: Proposed Development**
Length of floating road that is drained (m)	135.5	121.95	149.05	**Technical Appendix 10.2: Peat Management Plan**
Average depth of drains associated with floating roads (m)	0.5	0.45	0.55	**Chapter 10: Hydrology, Hydrogeology, Geology and Soils**

Input data	Expected value	Minimum value	Maximum value	Source of data
Length of access track that is excavated road (m)	0	0	0	**Chapter 3: Proposed Development**
Excavated road width (m)	0	0	0	**Chapter 3: Proposed Development**
Average depth of peat excavated for road (m)	0	0	0	**Technical Appendix 10.2: Peat Management Plan**
Length of access track that is rock filled road (m)	6180	5562	6798	**Chapter 3: Proposed Development**
Rock filled road width (m)	5	5	5	**Chapter 3: Proposed Development**
Rock filled road depth (m)	0.6	0.4	0.8	**Chapter 3: Proposed Development**
Length of rock filled road that is drained (m)	1254	1128.6	1379.4	**Technical Appendix 10.2: Peat Management Plan**
Average depth of drains associated with rock filled roads (m)	0.5	0.5	0.5	**Chapter 10: Hydrology, Hydrogeology, Geology and Soils**
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	It is intended that all cable trenches will follow the route of both existing and proposed new tracks and that there will be negligible impact for the purpose of the calculator. The value used is therefore zero.
Average depth of peat cut for cable trenches (m)	0	0	0	It is intended that all cable trenches will follow the route of both existing and proposed new tracks and that there will be negligible impact for the purpose of the calculator. The value used is therefore zero.
Additional Peat Excavated (not already accounted for above)				
Volume of additional peat excavated (m^3)	1373	1235	1510	**Technical Appendix 10.2: Peat Management Plan**
Area of additional peat excavated (m^2)	26497	23847	29147	**Technical Appendix 10.2: Peat Management Plan**
Peat Landslide Hazard				
Peat Landslide Hazard and Risk Assessments: Best Practice Guide for	negligible	negligible	negligible	Fixed

Input data	Expected value	Minimum value	Maximum value	Source of data
Proposed Electricity Generation Developments				
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)	168.3	151.47	185.13	**Technical Appendix 8.6: Draft Habitat Management Plan**
Water table depth in degraded bog before improvement (m)	0.3	0	0.5	Wind Farms and Carbon Savings (SNH, 2003)
Water table depth in degraded bog after improvement (m)	0.1	0	0.3	Wind Farms and Carbon Savings (SNH, 2003)
Time required for hydrology and habitat of bog to return to its previous state on improvement (years)	10	5	15	Professional judgement of ecologist and hydrologist. Estimated as hydrology recovery is dependent on habitat.
Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years)	20	15	25	Professional judgement of ecologist and hydrologist. Estimated as hydrology recovery is dependent on habitat.
Improvement of Felled Plantation				
Area of felled plantation to be improved (ha)	24.3	21.06	25.74	**Chapter 15: Other Issues**
Water table depth in felled area before improvement (m)	0.5	0.4	0.6	Wind Farms and Carbon Savings (SNH, 2003)
Water table depth in felled area after improvement (m)	0.2	0.1	0.3	Wind Farms and Carbon Savings (SNH, 2003)
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)	8	5	12	Professional judgement of ecologist and hydrologist. Estimated as hydrology recovery is dependent on habitat.
Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years)	22	15	27	Professional judgement of ecologist, hydrologist and forester. Estimated as hydrology recovery is dependent on habitat.

Input data	Expected value	Minimum value	Maximum value	Source of data
Restoration of Peat Removed from Borrow Pits				
Area of borrow pits to be restored (ha)	0.5722	0.51498	0.62942	**Chapter 10: Hydrology, Hydrogeology, Geology and Soils**
Depth of water table in borrow pit before restoration with respect to the restored surface (m)	0.1	0	0.3	Wind Farms and Carbon Savings (SNH, 2003)
Depth of water table in borrow pit after restoration with respect to the restored surface (m)	-0.1	-0.3	0	For calculation purposes, it has been assumed that restoration of the borrow pits will be carried out using good practice and that the post restoration water table in the borrow pits will be similar to the water table across the Site, which was estimated to be 0.3m. The calculator states that the values inputted for this field must be less than 0.1.
Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years)	10	5	15	Professional judgement of ecologist and hydrologist. Estimated as hydrology recovery is dependent on habitat.
Period of time when effectiveness of the restoration of peat removed from borrow pits can be guaranteed (years)	20	15	25	Professional judgement of ecologist and hydrologist. Estimated as hydrology recovery is dependent on habitat.
Early removal of drainage from foundations and hardstanding				
Water table depth around foundations and hard standing before restoration (m)	0.2	0.1	0.4	Professional judgement of hydrologist.
Water table depth around foundation and hard standing after restoration (m)	0.05	0	0.1	Professional judgement of hydrologist.
Time to completion of backfilling, removal of any surface drains, and full restoration of hydrology (years)	5	2	5	Professional judgement of hydrologist.
Restoration of Site after Decommissioning				
Will the hydrology of the site be restored on decommissioning?	Yes	Yes	Yes	Consent is being sought 'in perpetuity', i.e. with no time limit. However, for the purpose of calculation, it has been

Input data	Expected value	Minimum value	Maximum value	Source of data
				assumed that the Site will be restored on decommissioning.
Will you attempt to block any gullies that have formed due to the windfarm?	Yes	Yes	Yes	Consent is being sought 'in perpetuity', i.e. with no time limit. However, for the purpose of calculation, it has been assumed that the Site will be restored on decommissioning.
Will you attempt to block all artificial ditches and facilitate rewetting?	Yes	Yes	Yes	Consent is being sought 'in perpetuity', i.e. with no time limit. However, for the purpose of calculation, it has been assumed that the Site will be restored on decommissioning.
Will the habitat of the site be restored on decommissioning?	No	No	No	Much of the Site is currently used for forestry operations. It has been assumed that during the operational phase and post decommissioning of the windfarm, such activities will continue.
Will you control grazing on degraded areas?	No	No	No	Areas of the Site are currently used for woodland grazing. It has been assumed that during the operational phase and post decommissioning of the windfarm, such activities will continue.
Will you manage areas to favour reintroduction of species	Yes	Yes	Yes	**Chapter 8: Ecology and Biodiversity**
Methodology				
Choice of methodology for calculating emission factors	Site specific (required for planning applications)			

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