Appendix 8.A Carbon Calculator - Justification for Values Used

Input data	Limekiln Wind Farm S36C Variation (Revised Consented Development)			Comments/Assumptions
	Expected	Minimum	Maximum	
Wind Farm Characteristics				
Dimensions				
No. of turbines	21	21	21	Chapter 4 - Project Description
Lifetime of wind farm	40	40	40	Chapter 4 - Project Description
Power rating of turbines	4.2	4.2	4.2	Chapter 4 - Project Description
Capacity factor	36.0%	27.0%	37.0%	Site capacity factor of approximately 36%. Minimum figure 27% (average for Scotland), maximum figure of 37%, just above expected figure.
Extra capacity required for back up	5%	0%	5%	Following the guidance provided by Nayak et al, UK Energy in brief 2013 confirms that wind energy accounts for less than 20% of total national electricity generation therefore 0% could be used however 5% has been used to reflect a worst case scenario 0% is entered as a minimum value.
Additional emissions due to thermal inefficiency of back up generation (%)	10%	10%	10%	Extra emissions due to reduced thermal efficiency of the reserve power generation ≈ 10% (Dale et al 2004).
Carbon dioxide emissions from turbines' life	Calculate w.r.t installed capacity			
Peatland Characteristics before wind development				
Average annual air temperature at site (°C)	8.0	4.9	11.1	Average annual temperature taken for Strathy East Met Office station, 1981-2010. Expected value calculated using average of minimum and maximum average temperatures. Maximum and minimum chosen as a range.
Average peat depth at site	0.81	0.65	0.97	Expected value calculated as average value of all 1,780 peat depth measurements taken at site. Minimum and maximum values chosen as a 20% range.
Content of dry peat % by weight	55	49	62	Calculated using typical values provided in carbon calculator tool
Average extent of drainage around	7.5	5	10	No site-specific measurements available, precautionary values used

drainage features at site (m)				
Average water table depth at site (m)	0.3	0.2	0.4	No site specific values available. Values taken from a similar upland site with underlying peat.
Dry soil bulk density (gcm^{-3})	0.25	0.2	0.3	Due to lack of site specific information, indicative figures from National Soil Inventory of Scotland have been used.
Characteristics of bog plants				
Time required for regeneration of bog plants after restoration (years)	3	2	5	Estimated values, based on condition of the current vegetation.
Carbon accumulation due to C fixation by bog plants in undrained peat ($tC\ ha^{-1}\ yr^{-1}$)	0.25	0.12	0.31	Default values provided by Turunen et al., 2001; Botch et al., 1995
Forestry Plantation Characteristics				
Enter simple data				
Area of forestry plantation to be felled (ha)	222.11	199.90	244.32	Minimum and maximum entered as a range.
Average rate of carbon sequestration in timber	3.6	3.4	3.8	Figures from Cannell, 1999. min and max entered as a range.
Counterfactual emission factors				
Coal-fired plant emission factor tCO_2MWh^{-1}	0.920	0.920	0.920	Figure provided in carbon payback calculator
Grid mix emission factor tCO_2MWh^{-1}	0.254	0.254	0.254	Figure provided in carbon payback calculator
Fossil fuel mix emission factor tCO_2MWh^{-1}	0.450	0.450	0.450	Figure provided in carbon payback calculator
Borrow Pits				
Number of Areas	1	1	1	EIA Report - Chapter 4. Project description
Average length of area (m)	147.00	132.30	161.70	EIA Report - Peat Management Plan (Assumed footprint)
Average width of areas (m)	147.0	132.3	161.7	EIA Report - Peat Management Plan (Assumed footprint)
Average depth of peat removed from area (m)	0.62	0.56	0.68	peat depth survey. Maximum and minimum calculated as 10% range
Access tracks				
Total length of access tracks (m)	12100	11040	12160	EIA Report - Peat Management Plan
Existing tracks length (m)	0	0	0	EIA Report - Peat Management Plan
Length of access tracks that is floating road (m)	1900	1870	1930	EIA Report - Peat Management Plan
Floating road width (m)	10	10	10	The minimum track width which has been adopted is 5.5m running width with 0.25m shoulders. There is then

				a verge allowance of 2m either side for drainage / cable trench.
Floating road depth (m)	0	0	0	0 as no sinking expected.
Length of floating road that is drained (m)	0	0	0	Assume no drains required alongside floating roads.
Average depth of drains associated with floating roads (m)	0	0	0.5	Assume no drains required alongside floating roads. Maximum drain depth of 0.5m required for worst case scenario.
Length of access track that is excavated road (m)	10200	9170	10230	EIA Report - Peat Management Plan
Excavated road width (m)	10	10	10	The minimum track width which has been adopted is 5.5m running width with 0.25m shoulders. There is then a verge allowance of 2m either side for drainage / cable trench.
Average depth of peat excavated from road (m)	0.57	0.46	0.68	EIA Report - Peat Management Plan
Length of access track that is rock filled road (m)	0	0	0	EIA Report - Chapter 4. Project description. Assumed that road on peat depth <1m is peat excavated and hence there is no rock filled road.
Rock filled road width (m)	5	5	5	NA. Minimum value that Carbon Calculator allows is 5m
Rock filled road depth (m)	0	0	0	NA
Length of rock filled road that is drained (m)	n/a	0	0	NA
Average depth of drains associated with rock filled roads (m)	n/a	0	0	NA
Cable Trenches				
Length of any cable trench on peat that does not follow access track and is lined with a permeable material (m)	0	0	0	Assume full length of cable route to follow access track.
Depth of cable trench	n/a	n/a	n/a	Appendix A - Excavated Materials Calculation
Additional peat excavated (not accounted for above)				
Volume of additional peat excavated (m^3)	3,600	2,880	4,320	Total volume of excavated peat for construction compound. Substation platform already constructed
Area of additional peat excavated (m^2)	15,000	12,000	18,000	Area of infrastructure as per site layout (minimum and maximum figures are a range to allow for minor adjustments to compound size). See PMP for calculations
Peat Landslide hazard				

Peat landslide hazard risk assessment	Negligible	Negligible	Negligible	Fixed value.
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)	-	-	-	No bog restoration works proposed other than those in the borrow pit – see below.
Water table depth in degraded bog before improvement (m)	n/a	n/a	n/a	n/a
Water table depth in degraded bog after improvement (m)	n/a	n/a	n/a	n/a
Time required for hydrology and habitat of bog to return to its previous state on restoration (years)	n/a	n/a	n/a	n/a
Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years)	n/a	n/a	n/a	n/a
Improvement of felled plantation				
Area of felled plantation to be improved (ha)	149	134	164	Phase 1 (2018-2022) - Temporary fell/replant
Water table depth in felled area before improvement (m)	0.3	0.24	0.36	No site-specific values available. Forested site, so water table depth is likely to be suppressed. Maximum and minimum values plus/ minus 20%.
Water table depth in felled area after improvement (m)	0.2	0.16	0.24	Assumed small improvement following removal of trees and restoration. Maximum and minimum values plus/ minus 20%.
Time required for hydrology and habitat of felled plantation to return to its previous state on restoration (years)	5	4	6	Expected case based upon professional judgement. Maximum and minimum values plus/ minus 20%.
Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years)	25	24	26	Expected case based upon professional judgement. Maximum and minimum values plus/ minus 20%.
Restoration of peat removed from borrow pits				
Area of borrow pits to be restored (ha)	2.2	2.0	2.4	EIA Report - PMP. Maximum and minimum values plus/ minus 10%
Depth of water table in borrow pit before restoration with respect	0.3	0.24	0.36	No site-specific values available. Forested site, so water table depth is likely to be suppressed. Maximum and

to the restored surface (m)				minimum values plus/ minus 20%.
Depth of water table in borrow pit after restoration with respect to the restored surface (m)	0.2	0.16	0.24	Assumed small improvement following removal of trees and restoration. Maximum and minimum values plus/ minus 20%.
Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years)	5	4	6	Expected case based upon professional judgement. Maximum and minimum values plus/ minus 20%.
Period of time when effectiveness of the restoration of peat removed from borrow pits can be guaranteed (years)	25	24	26	Expected case based upon professional judgement. Maximum and minimum values plus/ minus 20%.
Removal of drainage from foundations and hardstanding				
Water table depth around foundations and hardstanding before restoration	0	0	0	Assume no removal of drainage.
Water table depth around foundations and hardstanding after restoration	0	0	0	Assume no removal of drainage.
Time to completion of backfilling, removal of any surface drains and full restoration of the hydrology (years)	0	0	0	Assume no removal of drainage.
Will you attempt to block any gullies that have formed due to the wind farm?	Yes	Yes	No	Assumes that any gullies caused by construction of the wind farm would be blocked to maintain habitats except worst case scenario (maximum column).
Will you attempt to block all artificial ditches and facilitate rewetting?	No	No	No	No
Will the habitat of the site be restored on decommissioning				
Will you control grazing on degraded areas?	Yes	Yes	Yes	If required.
Will you manage areas to favour reintroduction of species	No	No	No	No
Construction Input Data				
Area 1 - Construction Input Data for turbines in organic matter <0.5m deep				
Number of turbines in this area	8	8	8	EIA Report - Peat Management Plan
Turbine foundations				

Depth of hole dug when constructing foundations	0.38	0.34	0.41	EIA Report - Peat Management Plan: Average peat depth across turbines in this area
Approximate geometric shape of hole dug when constructing foundations	circular	circular	circular	
Length at surface (m)	6	6	6	EIA Report - Peat Management Plan
Width at surface (m)	6	6	6	EIA Report - Peat Management Plan
Length at bottom (m)	20	20	20	EIA Report - Peat Management Plan
Width at bottom (m)	20	20	20	EIA Report - Peat Management Plan
Volume of concrete used in the entire area (m3)	16,360	13,088	19,632	Total volume of concrete per turbine (foundations) is 645m^3, hardstanding area is 40x35m
Hardstanding				
Depth of hole dug when constructing hardstanding	0.38	0.34	0.41	EIA Report - Peat Management Plan: Average peat depth across turbines in this area
Approximate geometric shape of hole dug when constructing hardstanding	Rectangular	Rectangular	Rectangular	
Length at surface (m	40	40	40	EIA Report - Peat Management Plan
Width at surface (m)	35	35	35	EIA Report - Peat Management Plan
Length at bottom (m)	40	40	40	EIA Report - Peat Management Plan
Width at bottom (m)	35	35	35	EIA Report - Peat Management Plan
Is piling used?	No	No	No	Piling not likely to be used.
Area 2 - Construction Input Data – Turbines in peat between 0.5m and 1m				
Number of turbines in this area	8	8	8	EIA Report - Peat Management Plan
Turbine foundations				
Depth of hole dug when constructing foundations	0.74	0.67	0.82	EIA Report - Peat Management Plan: Average peat depth across turbines in this area
Approximate geometric shape of hole dug when constructing foundations	circular	circular	circular	EIA Report - Peat Management Plan

Length at surface (m)	6	6	6	EIA Report - Peat Management Plan
Width at surface (m)	6	6	6	EIA Report - Peat Management Plan
Length at bottom (m)	20	20	20	EIA Report - Peat Management Plan
Width at bottom (m)	20	20	20	EIA Report - Peat Management Plan
Volume of concrete used in the entire area (m3)	16360	13088	19632	Total volume of concrete per turbine (foundations) is 645m^3
Hardstanding				
Depth of hole dug when constructing hardstanding	0.74	0.67	0.82	EIA Report - Peat Management Plan: Average peat depth across turbines in this area
Approximate geometric shape of hole dug when constructing hardstanding	Rectangular	Rectangular	Rectangular	EIA Report - Peat Management Plan
Length at surface (m	40	40	40	EIA Report - Peat Management Plan
Width at surface (m)	35	35	35	EIA Report - Peat Management Plan
Length at bottom (m)	40	40	40	EIA Report - Peat Management Plan
Width at bottom (m)	35	35	35	EIA Report - Peat Management Plan
Is piling used?	No	No	No	Piling not likely to be used.
Area 3 - Construction Input Data – Turbines in peat > 1m				
Number of turbines in this area	5	5	5	EIA Report - Peat Management Plan
Turbine foundations				
Depth of hole dug when constructing foundations	1.20	1.08	1.32	EIA Report - Peat Management Plan: Average peat depth across turbines in this area
Approximate geometric shape of hole dug when constructing foundations	circular	circular	circular	
Length at surface (m)	6	6	6	EIA Report - Peat Management Plan
Width at surface (m)	6	6	6	EIA Report - Peat Management Plan
Length at bottom (m)	20	20	20	EIA Report - Peat Management Plan
Width at bottom (m)	20	20	20	EIA Report - Peat Management Plan

Volume of concrete used in the entire area (m3)	10225	8180	12270	Total volume of concrete per turbine (foundations) is 645m3
Hardstanding				
Depth of hole dug when constructing hardstanding	1.20	1.08	1.32	EIA Report - Peat Management Plan: Average peat depth across turbines in this area
Approximate geometric shape of hole dug when constructing hardstanding	Rectangular	Rectangular	Rectangular	
Length at surface (m	40	40	40	EIA Report - Peat Management Plan
Width at surface (m)	35	35	35	EIA Report - Peat Management Plan
Length at bottom (m)	40	40	40	EIA Report - Peat Management Plan
Width at bottom (m)	35	35	35	EIA Report - Peat Management Plan
Is piling used?	No	No	No	Piling not likely to be used.