TECHNICAL APPENDIX 15.1:

CARBON CALCULATOR

Kirkton Energy Park

Prepared for: Kirkton Wind Farm Ltd

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Core input data

Input data	Expected value	Minimum value	Maximum value	Source of data
Windfarm characteristics				
Dimensions				
No. of turbines	11	11	11	ES
Duration of consent (years)	30	30	30	ES
Performance				
Power rating of 1 turbine (MW)	4.8	4.8	4.8	ES
Capacity factor	39.8	39.5	40.3	ES
Backup				
Fraction of output to backup (%)	5	5	5	ES
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	ES
Average annual air temperature at site (°C)	8	4	13	ES
Average depth of peat at site (m)	0.7	0.6	0.8	ES
C Content of dry peat (% by weight)	55	49	62	ES
Average extent of drainage around drainage features at site (m)	5	4	6	ES
Average water table depth at site (m)	0.2	0.1	0.3	ES
Dry soil bulk density ($g\ cm^{-3}$)	0.2	0.18	0.22	ES
Characteristics of bog plants				
Time required for regeneration of bog plants after restoration (years)	2	2	2	ES
Carbon accumulation due to C fixation by bog plants in undrained peats ($tC\ ha^{-1}\ yr^{-1}$)	0.25	0.12	0.31	ES
Forestry Plantation Characteristics				
Area of forestry plantation to be felled (ha)	91	90	92	ES
Average rate of carbon sequestration in timber ($tC\ ha^{-1}\ yr^{-1}$)	3.6	3.4	3.8	ES
Counterfactual emission factors				
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	2	2	2	ES
Average length of pits (m)	165	165	165	ES
Average width of pits (m)	105	105	105	ES
Average depth of peat removed from pit (m)	0.55	0.5	0.6	ES
Access tracks				
Total length of access track (m)	7517	7504	7524	ES
Existing track length (m)	2034	2034	2034	ES
Length of access track that is floating road (m)	447	440	450	ES
Floating road width (m)	7	7	7	ES
Floating road depth (m)	2.1	2	2.2	ES
Length of floating road that is drained (m)	447	440	450	ES
Average depth of drains associated with floating roads (m)	0.3	0.3	0.3	ES
Length of access track that is excavated road (m)	5036	5030	5040	ES

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Floating road width (m)	7	7	7	ES
Floating road depth (m)	2.1	2	2.2	ES
Length of floating road that is drained (m)	447	440	450	ES
Average depth of drains associated with floating roads (m)	0.3	0.3	0.3	ES
Length of access track that is excavated road (m)	5036	5030	5040	ES
Excavated road width (m)	5	5	5	ES
Average depth of peat excavated for road (m)	0.37	0.3	0.4	ES
Length of access track that is rock filled road (m)	0	0	0	
Rock filled road width (m)	0	0	0	
Rock filled road depth (m)	0	0	0	
Length of rock filled road that is drained (m)	0	0	0	
Average depth of drains associated with rock filled roads (m)	0	0	0	
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)	7500	7400	7600	ES
Average depth of peat cut for cable trenches (m)	0.5	0.3	0.7	ES
Additional peat excavated (not already accounted for above)				
Volume of additional peat excavated (m^3)	4576	4500	4600	ES
Area of additional peat excavated (m^2)	5409	5400	5410	ES
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)	88	87	89	ES
Water table depth in degraded bog before improvement (m)	0.3	0.29	0.31	ES
Water table depth in degraded bog after improvement (m)	0.1	0.09	0.11	ES
Time required for hydrology and habitat of bog to return to its previous state on improvement (years)	15	15	15	ES
Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years)	25	25	25	ES
Improvement of felled plantation land				
Area of felled plantation to be improved (ha)	0	0	0	ES
Water table depth in felled area before improvement (m)	0	0	0	ES
Water table depth in felled area after improvement (m)	0	0	0	ES
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)	2	2	2	ES
Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years)	2	2	2	ES
Restoration of peat removed from borrow pits				
Area of borrow pits to be restored (ha)	0.5	0.5	0.5	ES
Depth of water table in borrow pit before restoration with respect to the restored surface (m)	0.3	0.29	0.31	ES
Depth of water table in borrow pit after restoration with respect to the restored surface (m)	0.2	0.19	0.21	ES
Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years)	2	2	2	ES
Period of time when effectiveness of the restoration of peat removed from borrow pits can be guaranteed (years)	2	2	2	ES
Early removal of drainage from foundations and hardstanding				
Water table depth around foundations and hardstanding before restoration (m)	0.3	0.29	0.31	ES
Water table depth around foundations and hardstanding after restoration (m)	0.2	0.19	0.21	ES
Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)	2	2	2	ES
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	ES
Will you attempt to block all artificial ditches and facilitate rewetting?	Yes	Yes	Yes	ES
Will the habitat of the site be restored on decommissioning?	No	No	No	

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Water table depth in felled area before improvement (m)	0	0	0	ES
Water table depth in felled area after improvement (m)	0	0	0	ES
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)	2	2	2	ES
Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years)	2	2	2	ES
Restoration of peat removed from borrow pits				
Area of borrow pits to be restored (ha)	0.5	0.5	0.5	ES
Depth of water table in borrow pit before restoration with respect to the restored surface (m)	0.3	0.29	0.31	ES
Depth of water table in borrow pit after restoration with respect to the restored surface (m)	0.2	0.19	0.21	ES
Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years)	2	2	2	ES
Period of time when effectiveness of the restoration of peat removed from borrow pits can be guaranteed (years)	2	2	2	ES
Early removal of drainage from foundations and hardstanding				
Water table depth around foundations and hardstanding before restoration (m)	0.3	0.29	0.31	ES
Water table depth around foundations and hardstanding after restoration (m)	0.2	0.19	0.21	ES
Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)	2	2	2	ES
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	ES
Will you attempt to block all artificial ditches and facilitate rewetting?	Yes	Yes	Yes	ES
Will the habitat of the site be restored on decommissioning?	No	No	No	
Will you control grazing on degraded areas?	No	No	No	ES
Will you manage areas to favour reintroduction of species	Yes	Yes	Yes	ES
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	11	11	11	ES
Turbine foundations				
Depth of hole dug when constructing foundations (m)	0.5	0.4	0.6	ES
Aproximate geometric shape of whole dug when constructing foundations	Circular	Circular	Circular	ES
Diameter at bottom	28	28	28	
Diameter at surface	28	28	28	
Hardstanding				
Depth of hole dug when constructing hardstanding (m)	0.5	0.4	0.6	ES
Aproximate geometric shape of whole dug when constructing hardstanding	Rectangular	Rectangular	Rectangular	ES
Length at surface	75	75	75	
Width at surface	15	15	15	
Length at bottom	75	75	75	
Width at bottom	15	15	15	
Piling				
Is piling used?	No	No	No	ES
Volume of Concrete				
Volume of concrete used (m^3) in the entire area	7600	7600	7600	ES

Payback Time and CO_2 emissions • LKIV-O3H2-15KW v5

1. Windfarm CO2 emission saving over...	Exp.	Min.	Max.
...coal-fired electricity generation (t CO2 / yr)	169,359	168,083	171,487
...grid-mix of electricity generation (t CO2 / yr)	46,681	46,329	47,267
...fossil fuel-mix of electricity generation (t CO2 / yr)	82,839	82,214	83,879
Energy output from windfarm over lifetime (MWh)	5,522,584	5,480,957	5,591,964

Total CO2 losses due to wind farm (tCO2 eq.)	Exp.	Min.	Max.
2. Losses due to turbine life (eg. manufacture, construction, decomissioning)	46,592	46,592	46,592
3. Losses due to backup	31,221	31,221	31,221
4. Lossess due to reduced carbon fixing potential	715	298	1,005
5. Losses from soil organic matter	18,390	11,260	28,401
6. Losses due to DOC & POC leaching	56	14	106
7. Losses due to felling forestry	36,036	33,660	38,456
Total losses of carbon dioxide	133,011	123,046	145,781

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	-6,846	-6,177	-7,553
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	-334	-230	-460
Total change in emissions due to improvements	-7,179	-6,407	-8,014

RESULTS	Exp.	Min.	Max.
Net emissions of carbon dioxide (t CO2 eq.)	125,832	115,032	139,374
Carbon Payback Time			
...coal-fired electricity generation (years)	0.7	0.7	0.8
...grid-mix of electricity generation (years)	2.7	2.4	3.0
...fossil fuel-mix of electricity generation (years)	1.5	1.4	1.7
Ratio of soil carbon loss to gain by restoration (not used in Scottish applications)	2.57	1.41	4.45
Ratio of CO2 eq. emissions to power generation (g/kWh) (for info. only)	22.78	20.57	25.43

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