Payback Time and CO_2 emissions • OSOY-L878-7N4J v9

1. Windfarm CO2 emission saving over...	Exp.	Min.	Max.
...coal-fired electricity generation (t CO2 / yr)	389,936	324,367	417,789
...grid-mix of electricity generation (t CO2 / yr)	107,478	89,405	115,155
...fossil fuel-mix of electricity generation (t CO2 / yr)	190,730	158,658	204,353
Energy output from windfarm over lifetime (MWh)	21,192,192	17,628,624	22,705,920

Total CO2 losses due to wind farm (tCO2 eq.)	Exp.	Min.	Max.
2. Losses due to turbine life (eg. manufacture, construction, decomissioning)	153,156	136,338	153,156
3. Losses due to backup	170,294	152,555	170,294
4. Lossess due to reduced carbon fixing potential	5,357	1,394	8,376
5. Losses from soil organic matter	74,920	-20,082	622,278
6. Losses due to DOC & POC leaching	20	0	179
7. Losses due to felling forestry	0	0	0
Total losses of carbon dioxide	403,747	270,205	954,282

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	0	0	-3,037
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	-240	0	-1,204
8d. Change in emissions due to removal of drainage from foundations & hardstanding	-956	0	-1,451
Total change in emissions due to improvements	-1,197	0	-5,692

RESULTS	Exp.	Min.	Max.
Net emissions of carbon dioxide (t CO2 eq.)	402,550	264,512	954,282
Carbon Payback Time			
...coal-fired electricity generation (years)	1.0	0.6	2.9
...grid-mix of electricity generation (years)	3.7	2.3	10.7
...fossil fuel-mix of electricity generation (years)	2.1	1.3	6.0
Ratio of soil carbon loss to gain by restoration (not used in Scottish applications)	62.61	-3.53	No gains!
Ratio of CO2 eq. emissions to power generation (g/kWh) (for info. only)	19.00	11.65	54.13

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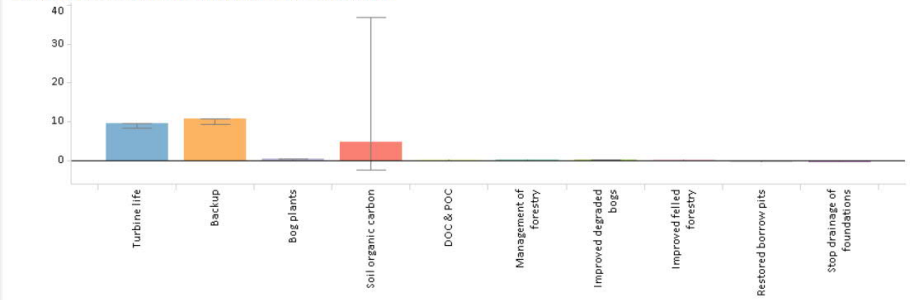
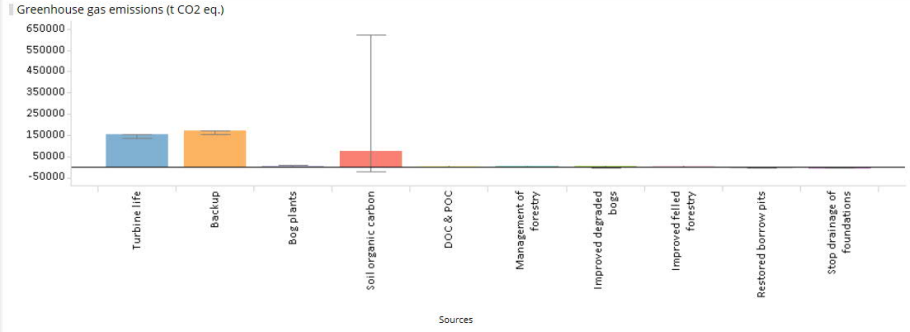
MENU

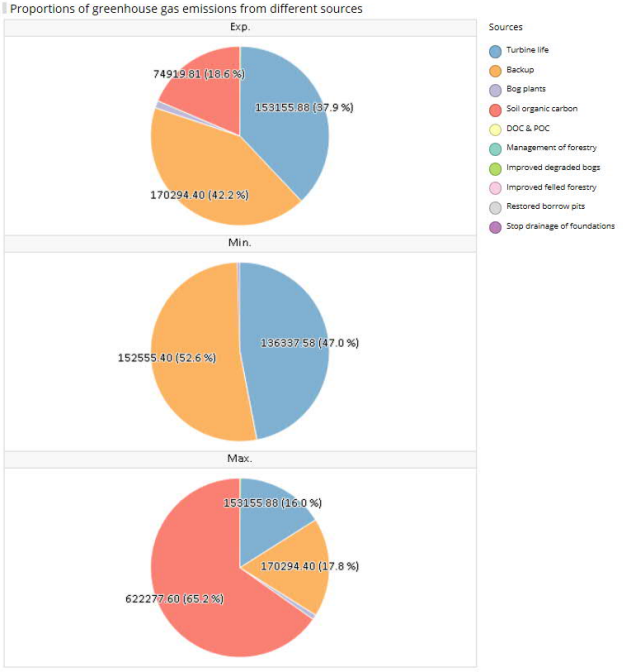
Carbon payback time (months) using fossil-fuel mix as conterfactual



Greenhouse gas emissions (t CO2 eq.)



Proportions of greenhouse gas emissions from different sources



Carbon Calculator v1.6.0
Cloiche Wind Farm Location: 57.094678 -4.468139
SSE

Core input data

Input data	Expected value	Minimum value	Maximum value	Source of data
Windfarm characteristics				
Dimensions				
No. of turbines	36	36	36	Volume 2, Chapter 3, Section 3.3
Duration of consent (years)	50	50	50	Volume 2, Chapter 3, Section 3.6.
Performance				
Power rating of 1 turbine (MW)	4.8	4.3	4.8	Volume 2, Chapter 3, Section 3.3
Capacity factor	28	26	30	raw data
Backup				
Fraction of output to backup (%)	5	5	5	Guidance in results tab-conservative
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 8, Section 8.6
Average annual air temperature at site (°C)	7.5	3.9	11	Raw data
Average depth of peat at site (m)	0.79	0	3	Volume 4, Appendix 11.2, Figure A.2
C Content of dry peat (% by weight)	53.23	19.57	64.28	Assumed Blanket Peat value, Scottish Soil Knowledge and Information Base
Average extent of drainage around drainage features at site (m)	5	2	6	Raw data
Average water table depth at site (m)	0.2	0.1	0.3	Raw data
Dry soil bulk density (g cm^{-3})	0.132	0.072	0.293	Assumed decomposed peat value, National Soil Inventory of Scotland
Characteristics of bog plants				
Time required for regeneration of bog plants after restoration (years)	15	10	20	Raw data
Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha^{-1} yr^{-1})	0.25	0.12	0.31	SNH recommended value, Calculating carbon savings from wind farms on Scottish peat lands: a new approach
Forestry Plantation Characteristics				

Input data	Expected value	Minimum value	Maximum value	Source of data
Area of forestry plantation to be felled (ha)	0	0	0	Volume 2, Chapter 5, Section 5.7
Average rate of carbon sequestration in timber (tC ha^{-1} yr^{-1})	0	0	0	Raw data
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	9	9	9	Volume 4, Appendix 11.1, Section 1
Average length of pits (m)	150	100	150	Volume 4, Appendix 11.1, Figures
Average width of pits (m)	150	100	150	Volume 4, Appendix 11.1, Figures
Average depth of peat removed from pit (m)	0.944	0.5	1.5	Volume 4, Appendix 11.1, Section 3
Access tracks				
Total length of access track (m)	55353.71	53995	58495.03	Volume 2, Chapter 3, Section 3.1
Existing track length (m)	29495	29495	29495.03	Volume 2, Chapter 3, Section 3.1
Length of access track that is floating road (m)	2217.2	1500	4000	Volume 2, Chapter 3, Section 3.3
Floating road width (m)	6.5	5	7	Volume 3, Figure 3.4
Floating road depth (m)	0.8	0.2	1	Volume 3, Figure 3.4
Length of floating road that is drained (m)	1670	0	2000	estimate
Average depth of drains associated with floating roads (m)	0.5	0.5	0.5	estimate
Length of access track that is excavated road (m)	23641.51	23000	25000	Volume 2, Chapter 3, Section 3.1
Excavated road width (m)	5.5	5	7	Volume 3, Figure 3.4
Average depth of peat excavated for road (m)	0.3	0	0.5	Volume 4, Appendix 11.2
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)	0	0	0	

Input data	Expected value	Minimum value	Maximum value	Source of data
Average depth of peat cut for cable trenches (m)	0	0	0	
Additional peat excavated (not already accounted for above)				
Volume of additional peat excavated (m^3)	41296	0	156819	Raw data
Area of additional peat excavated (m^2)	52273	52273	52273	Raw data
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)	13.92	13.92	20.28	Volume 2, Chapter 8, Section 8.8
Water table depth in degraded bog before improvement (m)	0.3	0.1	0.5	Based on The Hydrology of Peat, Uni. Birmingham 2016
Water table depth in degraded bog after improvement (m)	0.25	0.09	0.4	Based on The Hydrology of Peat, Uni. Birmingham 2016
Time required for hydrology and habitat of bog to return to its previous state on improvement (years)	10	5	15	Raw data
Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years)	10	5	15	Raw data
Improvement of felled plantation land				
Area of felled plantation to be improved (ha)	0	0	0	Volume 2, Chapter 5, Section 5.7
Water table depth in felled area before improvement (m)	0	0	0	
Water table depth in felled area after improvement (m)	0	0	0	
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)	0	0	0	
Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years)	0	0	0	
Restoration of peat removed from borrow pits				
Area of borrow pits to be restored (ha)	8.74	0.6	8.74	Volume 4, Appendix 11.1
Depth of water table in borrow pit before restoration with respect to the restored surface (m)	0.2	0.1	0.3	Raw data

Input data	Expected value	Minimum value	Maximum value	Source of data
Depth of water table in borrow pit after restoration with respect to the restored surface (m)	0.19	0.05	0.25	Raw data
Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years)	10	5	20	estimate
Period of time when effectiveness of the restoration of peat removed from borrow pits can be guaranteed (years)	20	15	25	estimate
Early removal of drainage from foundations and hardstanding				
Water table depth around foundations and hardstanding before restoration (m)	0.2	0.1	0.3	Raw data
Water table depth around foundations and hardstanding after restoration (m)	0.1	0	0.2	Raw data
Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)	5	5	5	estimate
Restoration of site after decomissioning				
Will the hydrology of the site be restored on decommissioning?	No	No	No	
Will you attempt to block any gullies that have formed due to the windfarm?	Yes	Yes	Yes	Volume 4, Appendix 8.6
Will you attempt to block all artificial ditches and facilitate rewetting?	No	No	No	Volume 4, Appendix 8.6
Will the habitat of the site be restored on decommissioning?	No	No	No	
Will you control grazing on degraded areas?	No	No	No	Volume 2, Chapter 3, Section 3.6
Will you manage areas to favour reintroduction of species	No	No	No	Volume 2, Chapter 3, Section 3.6
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
Development Area				
Number of turbines in this area	36	36	36	Voume 2, Chapter 3, Section 3.3
Turbine foundations				
Depth of hole dug when constructing foundations (m)	0.8	0.1	2.5	Volume 4, Appendix 11.3, Section 3.3
Aproximate geometric shape of whole dug when constructing foundations	Circular	Circular	Circular	Volume 3, Figure 3.3
Diameter at bottom	22.5	22.5	22.5	
Diameter at surface	6	6	6	
Hardstanding				
Depth of hole dug when constructing hardstanding (m)	0.8	0.1	2.5	Volume 4, Appendix 11.3, Section 3.3
Aproximate geometric shape of whole dug when constructing hardstanding	Rectangular	Rectangular	Rectangular	Volume 3, Figure 3.6
Length at surface	103	103	103	
Width at surface	35	35	35	
Length at bottom	103	103	103	
Width at bottom	35	35	35	
Piling				
Is piling used?	No	No	No	Voume 2, Chapter 3, Section 3.3
Volume of Concrete				
Volume of concrete used (m^3) in the entire area	27000	27000	27000	Voume 2, Chapter 3, Section 3.3