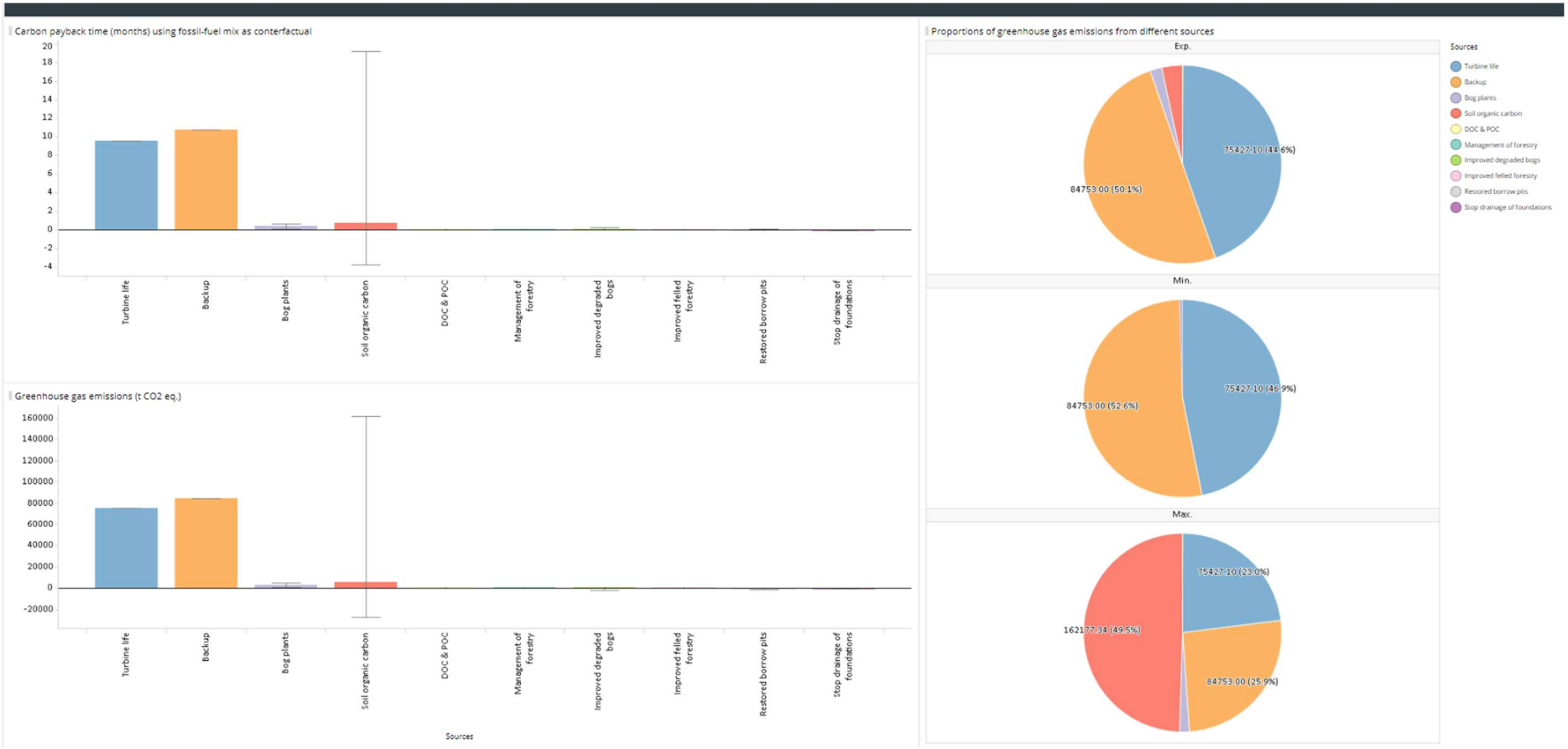
Payback Time and CO_2 emissions • UIRC-LUK8-7CN3 v2

1. Windfarm CO2 emission saving over...	Exp.	Min.	Max.
...coal-fired electricity generation (t CO2 / yr)	194,066	180,204	207,927
...grid-mix of electricity generation (t CO2 / yr)	53,490	49,670	57,311
...fossil fuel-mix of electricity generation (t CO2 / yr)	94,923	88,143	101,704
Energy output from windfarm over lifetime (MWh)	10,547,040	9,793,680	11,300,400

Total CO2 losses due to wind farm (tCO2 eq.)	Exp.	Min.	Max.
2. Losses due to turbine life (eg. manufacture, construction, decomissioning)	75,427	75,427	75,427
3. Losses due to backup	84,753	84,753	84,753
4. Lossess due to reduced carbon fixing potential	3,252	814	5,258
5. Losses from soil organic matter	5,714	-27,372	162,177
6. Losses due to DOC & POC leaching	10	0	100
7. Losses due to felling forestry	0	0	0
Total losses of carbon dioxide	169,156	133,622	327,715

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	-1,746
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	-154	0	-1,094
8d. Change in emissions due to removal of drainage from foundations & hardstanding	-453	0	-684
Total change in emissions due to improvements	-607	0	-3,524

RESULTS	Exp.	Min.	Max.
Net emissions of carbon dioxide (t CO2 eq.)	168,549	130,097	327,715
Carbon Payback Time			
...coal-fired electricity generation (years)	0.9	0.6	1.8
...grid-mix of electricity generation (years)	3.2	2.3	6.6
...fossil fuel-mix of electricity generation (years)	1.8	1.3	3.7
Ratio of soil carbon loss to gain by restoration (not used in Scottish applications)	9.43	-7.77	No gains!
Ratio of CO2 eq. emissions to power generation (g/kWh) (for info. only)	15.98	11.51	33.46


Carbon payback time (months) using fossil-fuel mix as conterfactual
20
18
16
14
12
10
8
6
4
2
0
-2
-4
Turbine life
Backup
Bog plants
Soil organic carbon
DOC & POC
Management of forestry
Improved degraded bogs
Improved felled forestry
Restored borrow pits
Stop drainage of foundations
Greenhouse gas emissions (t CO2 eq.)
160000
140000
120000
100000
80000
60000
40000
20000
0
-20000
Turbine life
Backup
Bog plants
Soil organic carbon
DOC & POC
Management of forestry
Improved degraded bogs
Improved felled forestry
Restored borrow pits
Stop drainage of foundations
Sources
Proportions of greenhouse gas emissions from different sources
Exp.
75427.10 (44.6%)
84753.00 (50.1%)
Min.
75427.10 (46.9%)
84753.00 (52.6%)
Max.
75427.10 (23.0%)
162177.34 (49.5%)
84753.00 (25.9%)
Sources
Turbine life
Backup
Bog plants
Soil organic carbon
DOC & POC
Management of forestry
Improved degraded bogs
Improved felled forestry
Restored borrow pits
Stop drainage of foundations

Carbon Calculator v1.6.1

Achany Extension Wind Farm Location: 58.045629 -4.624451

SSEN

Core input data

Input data	Expected value	Minimum value	Maximum value	Source of data
Windfarm characteristics				
Dimensions				
No. of turbines	20	20	20	Chapter 3: Description of Development. Section 3.3
Duration of consent (years)	50	50	50	Chapter 3: Description of Development. Section 3.6.
Performance				
Power rating of 1 turbine (MW)	4.3	4.3	4.3	Chapter 3: Description of Development. Section 3.3.
Capacity factor	28	26	30	raw data
Backup				
Fraction of output to backup (%)	5	5	5	Conservative factor based on guidance
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)	10	8	12	Raw Data
Average depth of peat at site (m)	0.67	0	5.8	Volume 4, Appendix 11.2
C Content of dry peat (% by weight)	53	19	65	Assumed Blanket Peat value
Average extent of drainage around drainage features at site (m)	5	2	6	Raw Data
Average water table depth at site (m)	0.5	0.1	1	Raw Data
Dry soil bulk density (g cm^{-3})	0.15	0.09	0.25	Based on past experience
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				
Area of forestry plantation to be felled (ha)	0	0	0	No Trees Felled

Input data	Expected value	Minimum value	Maximum value	Source of data
Average rate of carbon sequestration in timber (tC ha^{-1} yr^{-1})	0	0	0	No Trees Felled
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	1	2	Volume 4, Appendix 11.1
Average length of pits (m)	255	191	330	Raw Data
Average width of pits (m)	205	175	238	Raw Data
Average depth of peat removed from pit (m)	0.62	0.41	0.94	Volume 4, Appendix 11.2
Foundations and hard-standing area associated with each turbine				
Average length of turbine foundations (m)	0	0	0	
Average width of turbine foundations (m)	0	0	0	
Average depth of peat removed from turbine foundations(m)	0	0	0	
Average length of hard-standing (m)	0	0	0	
Average width of hard-standing (m)	0	0	0	
Average depth of peat removed from hard-standing (m)	0	0	0	
Volume of concrete used in construction of the ENTIRE windfarm				
Volume of concrete (m^3)	0	0	0	
Access tracks				
Total length of access track (m)	23832	23821	23843	Raw data
Existing track length (m)	6600	6600	6600	Volume 2, Chapter 3, Section 3.1
Length of access track that is floating road (m)	2002	2001	2003	Volume 2, Chapter 3, Section 3.1
Floating road width (m)	7	5.5	7	Volume 3, Figure 3.4
Floating road depth (m)	0.6	0.59	0.7	Volume 3, Figure 3.4
Length of floating road that is drained (m)	1000	0	1500	estimate
Average depth of drains associated with floating roads (m)	0.5	0.5	1	estimate
Length of access track that is excavated road (m)	15230	15220	15240	Volume 2, Chapter 3, Section 3.1
Excavated road width (m)	7	5.5	7	Volume 3, Figure 3.4
Average depth of peat excavated for road (m)	0.37	0.37	0.37	Raw Data
Length of access track that is rock filled road (m)	0	0	0	-
Rock filled road width (m)	5	5	5	Input required but not used

Input data	Expected value	Minimum value	Maximum value	Source of data
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	-
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)	20400	20300	20500	Raw Data (Welfare, construction compounds, batch plants, temp hardstands and turning heads)
Area of additional peat excavated (m^2)	64000	63000	65000	Raw Data (Welfare, construction compounds, batch plants, temp hardstands and turning heads)
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)	11.6	11.6	11.6	Volume 2, Chapter 3, Section 8.13
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	Not required
Water table depth in felled area before improvement (m)	0	0	0	Not required
Water table depth in felled area after improvement (m)	0	0	0	Not required
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)	2	2	2	Input required but not considered

Input data	Expected value	Minimum value	Maximum value	Source of data
Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years)	2	2	2	Input required but not considered
Restoration of peat removed from borrow pits				
Area of borrow pits to be restored (ha)	5.2275	3.3425	7.854	Raw data
Depth of water table in borrow pit before restoration with respect to the restored surface (m)	0.2	0.1	0.3	Raw 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)	3	3	3	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
Will you manage areas to favour reintroduction of species	No	No	No	Volume 2, Chapter 3
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
Achany Extension Wind FArm				
Number of turbines in this area	20	20	20	Volume 2, Chapter 3, Section 3.3
Turbine foundations				
Depth of hole dug when constructing foundations (m)	0.57	0.13	1.73	Raw Data
Aproximate geometric shape of whole dug when constructing foundations	Circular	Circular	Circular	Volume 2, Chapter 3, Section 3.3
Diameter at bottom	25	25	25	
Diameter at surface	30	26	38.8	
Hardstanding				
Depth of hole dug when constructing hardstanding (m)	0.57	0.13	1.73	Raw Data
Aproximate geometric shape of whole dug when constructing hardstanding	Rectangular	Rectangular	Rectangular	Volume 2, Chapter 3, Section 3.3
Length at surface	63	63	63	
Width at surface	25	25	25	
Length at bottom	64.14	63.26	66.46	
Width at bottom	26.14	25.26	28.46	
Piling				
Is piling used?	No	No	No	Not required
Volume of Concrete				
Volume of concrete used (m^3) in the entire area	14000	14000	14000	Volume 2, Chapter 3, Section 3.3