Appendix 6.1

Carbon Calculator Vestas / Siemens & Input Data

Coolglass Wind Farm EIAR Volume 3

Coolglass Wind Farm Limited

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Publication - Factsheet

Carbon calculator for wind farms on Scottish peatlands: factsheet

Last updated: **8 February 2022 -** see all updates

Directorate: Energy and Climate Change Directorate

Part of: Energy, Environment and climate change

Information on the carbon calculator we developed for determining the carbon impact of wind farm developments in Scotland.

Access the carbon calculator tool

Background to the tool

The carbon calculator is our tool to support the process of determining wind farm developments in Scotland. The tool's purpose is to assess, in a comprehensive and consistent way, the carbon impact of wind farm developments. This is done by comparing the carbon costs of wind farm developments with the carbon savings attributable to the wind farm. The tool and supporting guidance material remain the property of the Scottish Government.

The online carbon calculator

This latest version of the carbon calculator is a web-based application and central database, where all the data entered in the carbon calculator is stored in a structured manner. This web-based

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all earlier versions of the Excel-based carbon calculator. We commissioned it in response to feedback from stakeholders concerning previous versions of the tool, under the guidance of a steering group with membership including Scottish Government, Scottish Environment Protection Agency (SEPA), Scottish Natural Heritage (SNH) and Forestry Research. Stakeholder engagement and feedback via workshops, in the final stages of the tool's development, helped to further inform the final design. Any queries regarding its use and functionality should be directed in the first instance to the Energy Consents Unit.

The web tool incorporates high-level automated checking, detailed user guidance (within the tool), cells for identification of data sources and relevant data calculations and modifications required to the calculation method, at this time.

The improved ease of use will reduce the burden on developers as a consequence of the increased user-friendliness and the more sophisticated entry checking and guidance. The expectation is that this will reduce the number of resubmissions. The improved quality of submissions will reduce the validation work required. It will allow developers to submit carbon assessments and conduct initial carbon assessment screening tests on their proposed developments online in a self-service manner. It will allow an aggregated picture to be made of assessments (initial applications and re-applications) across Scotland.

Development of the carbon calculator

Originally published in 2008 with research report, Calculating carbon savings from wind farms on Scottish peat lands: a new approach (Nayak et al, 2008), the calculator has been refined on the basis of feedback and further research (Nayak et al., 2010 and Smith et al., 2011) to be an even more effective tool. Version 2 of the calculator launched in June 2011. The calculator was subsequently revised to include multiple regions for forestry and construction. The last version of the Excel spreadsheet tool was 2.9.0.

Deployment and protocols for use

The web-based version of the carbon calculator has been available since 29 June 2016 to support the carbon assessment of wind farm developments. The initial release was referenced as C-CalcWebV1.0 and will continue to be referred to as the 'carbon calculator'. This web–based version of the carbon calculator superseded all previous Excel based versions of the tool, and should be used for all appropriate applications which previously would have used the Excel based tool. Any major updates and revisions of the tool (V2.0, V3.0 etc) will be undertaken on an annual basis, with only absolutely necessary interim 'minor' patches (V1.1, V1.2 etc) being undertaken otherwise.

All new applications to the Energy Consents Unit should use the web-based tool or may be subject to rejection. All applications submitted and received using the carbon calculator may be subject to audit by the Scottish Environment Protection Agency. This is to ensure, as far as possible, that the carbon calculator continues to be used appropriately. If an audit highlights any issues, these will be raised with the applicant by SEPA such that they may be addressed.

The web-based version of the carbon calculator provides significant enhancements over the previous Excel tool, including some automatic validation of data entry. However, an Excel based tool is also being maintained for the purposes of development of new functionality, testing and trialling. This can be made available upon request. However, it must be recognised that this may not replicate exactly the functionality and results of the web based tool and its use and any decisions based thereon will be at the users own discretion.

We have produced technical guidance for using the carbon calculator.

Further peat guidance

SEPA and Scottish Renewables have produced guidance on the assessment of peat volumes, the reuse of excavated peat, and the minimisation of waste, which was published in February 2014.

The guidance on peatland site surveys was updated in April 2017.

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Core input data

Input data	Expected value	Minimum value	Maximum value	Source of data
Windfarm characteristics				
Dimensions				
No. of turbines	13	13	13	number
Duration of consent (years)	35	35	35	years
Performance				
Power rating of 1 turbine (MW)	6.6	6.5	6.7	MW
Capacity factor	33	32	34	%
Backup				
Fraction of output to backup (%)	5	5	5	%
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	no
Average annual air temperature at site (°C)	9.82	1	15	C
Average depth of peat at site (m)	0	0	0	m
C Content of dry peat (% by weight)	19	19	20	%
Average extent of drainage around drainage features at site (m)	0.5	0.45	0.55	m
Average water table depth at site (m)	0	0	0	m
Dry soil bulk density (g cm^{-3})	0.05	0.05	0.06	g cm-3
Characteristics of bog plants				
Time required for regeneration of bog plants after restoration (years)	2	2	2	yr
Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha^{-1} yr^{-1})	0.1	0.1	0.2	tC ha-1 yr-1
Forestry Plantation Characteristics				
Area of forestry plantation to be felled (ha)	54.36	54.35	54.37	ha
Average rate of carbon sequestration in timber (tC ha^{-1} yr^{-1})	3.6	3.59	3.61	tC ha-1 yr-1
Counterfactual emission factors				
Coal-fired plant emission factor (t CO2 MWh^{-1})	1.002	1.002	1.002	
Grid-mix emission factor (t CO2 MWh^{-1})	0.19338	0.19338	0.19338	
Fossil fuel-mix emission factor (t CO2 MWh^{-1})	0.432	0.432	0.432	
Borrow pits				

Input data	Expected value	Minimum value	Maximum value	Source of data
Number of borrow pits	1	1	1	number
Average length of pits (m)	145	140	145	m
Average width of pits (m)	45	45	60	m
Average depth of peat removed from pit (m)	1e-9	1e-9	1e-9	m
Foundations and hard-standing area associated with each turbine				
Average length of turbine foundations (m)	0	0	0	m
Average width of turbine foundations (m)	0	0	0	m
Average depth of peat removed from turbine foundations(m)	0	0	0	m
Average length of hard-standing (m)	0	0	0	m
Average width of hard-standing (m)	0	0	0	m
Average depth of peat removed from hard-standing (m)	0	0	0	m
Volume of concrete used in construction of the ENTIRE windfarm				
Volume of concrete (m^3)	0	0	0	m3
Access tracks				
Total length of access track (m)	15507	15505	15509	m
Existing track length (m)	5264	5263	5265	m
Length of access track that is floating road (m)	0	0	0	m
Floating road width (m)	5	5	5	m
Floating road depth (m)	0.1	0.09	0.11	m
Length of floating road that is drained (m)	0	0	0	m
Average depth of drains associated with floating roads (m)	0	0	0	m
Length of access track that is excavated road (m)	10243	10242	10244	m
Excavated road width (m)	5.5	5	5.6	m
Average depth of peat excavated for road (m)	0	0	0	m
Length of access track that is rock filled road (m)	0	0	0	m
Rock filled road width (m)	5	5	5	m
Rock filled road depth (m)	300	299	301	m
Length of rock filled road that is drained (m)	10243	10242	10244	m
Average depth of drains associated with rock filled roads (m)	500	499	501	m
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)	0	0	0	
Area of additional peat excavated (m^2)	0	0	0	
Peat Landslide Hazard				
Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity	negligible	negligible	negligible	Fixed

Input data	Expected value	Minimum value	Maximum value	Source of data
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)	0	0	0	ha
Water table depth in degraded bog before improvement (m)	0	0	0	m
Water table depth in degraded bog after improvement (m)	0	0	0	m
Time required for hydrology and habitat of bog to return to its previous state on improvement (years)	2	2	2	years
Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years)	2	2	2	years
Improvement of felled plantation land				
Area of felled plantation to be improved (ha)	23	22	23	ha
Water table depth in felled area before improvement (m)	0	0	0	m
Water table depth in felled area after improvement (m)	0	0	0	m
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)	2	2	2	years
Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years)	15	15	15	years
Restoration of peat removed from borrow pits				
Area of borrow pits to be restored (ha)	1	1	1	ha
Depth of water table in borrow pit before restoration with respect to the restored surface (m)	0	0	0	m
Depth of water table in borrow pit after restoration with respect to the restored surface (m)	0	0	0	m
Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years)	15	15	15	yr
Period of time when effectiveness of the restoration of peat removed from borrow pits can be guaranteed (years)	2	2	2	yr
Early removal of drainage from foundations and hardstanding				
Water table depth around foundations and hardstanding before restoration (m)	0	0	0	m
Water table depth around foundations and hardstanding after restoration (m)	0	0	0	
Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)	0	0	0	
Restoration of site after decomissioning				

Input data	Expected value	Minimum value	Maximum value	Source of data
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?	No	No	No	na
Will you attempt to block all artificial ditches and facilitate rewetting?	No	No	No	na
Will the habitat of the site be restored on decommissioning?	Yes	Yes	Yes	
Will you control grazing on degraded areas?	Yes	Yes	Yes	Y
Will you manage areas to favour reintroduction of species	Yes	Yes	Yes	Y
Methodology				
Choice of methodology for calculating emission factors	IPCC default			

Forestry input data

N/A

Construction input data

Input data	Expected value	Minimum value	Maximum value	Source of data
Fossy				
Number of turbines in this area	13	13	13	units
Turbine foundations				
Depth of hole dug when constructing foundations (m)	1e-8	1e-8	1e-8	m
Aproximate geometric shape of whole dug when constructing foundations	Circular	Circular	Circular	m
Diameter at bottom	30	30	30	
Diameter at surface	30	30	30	
Hardstanding				
Depth of hole dug when constructing hardstanding (m)	1e-8	1e-8	1e-8	m
Aproximate geometric shape of whole dug when constructing hardstanding	Rectangular	Rectangular	Rectangular	m
Length at surface	80	80	80	
Width at surface	30	30	30	
Length at bottom	80	80	80	
Width at bottom	30	30	30	
Piling				
Is piling used?	No	No	No	No
Volume of Concrete				
Volume of concrete used (m^3) in the entire area	6000	6000	6000	m^3

Payback Time

1. Windfarm CO2 emission saving over...	Exp.	Min.	Max.
...coal-fired electricity generation (t CO2 / yr)	248,527	237,344	259,937
...grid-mix of electricity generation (t CO2 / yr)	47,964	45,806	50,166
...fossil fuel-mix of electricity generation (t CO2 / yr)	107,149	102,328	112,069
Energy output from windfarm over lifetime (MWh)	8,681,072	8,290,464	9,079,652

Total CO2 losses due to wind farm (tCO2 eq.)	Exp.	Min.	Max.
2. Losses due to turbine life (eg. manufacture, construction, decomissioning)	75,985	74,770	77,200
3. Losses due to backup	56,822	55,961	57,682
4. Lossess due to reduced carbon fixing potential	171	161	357
5. Losses from soil organic matter	34,860	30,952	51,111
6. Losses due to DOC & POC leaching	0	0	0
7. Losses due to felling forestry	25,115	25,040	25,189
Total losses of carbon dioxide	192,952	186,884	211,539

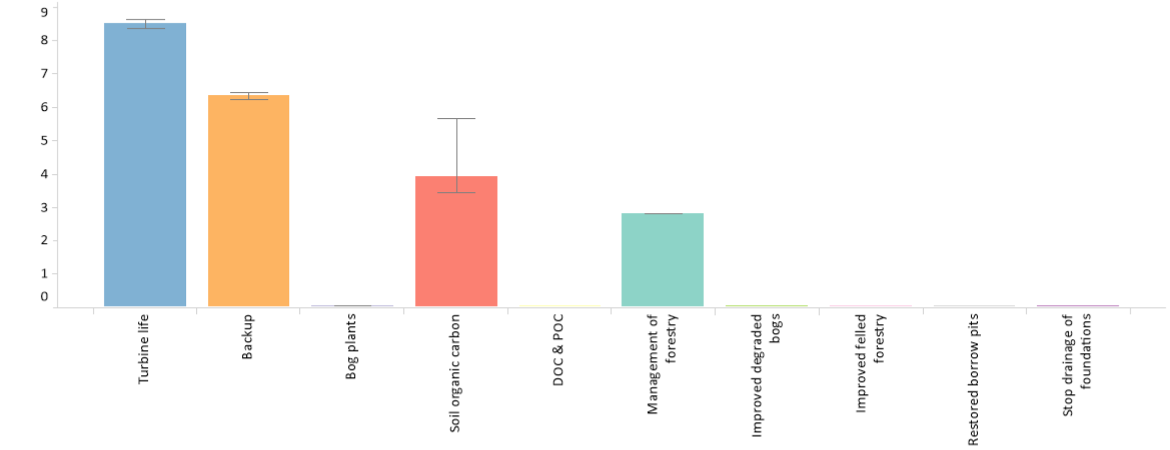
8. Total CO2 gains due to improvement of site (t CO2 eq.)	Exp.	Min.	Max.
8a. Change in emissions due to improvement of degraded bogs	0	0	0
8b. Change in emissions due to improvement of felled forestry	0	0	0
8c. Change in emissions due to restoration of peat from borrow pits	0	0	0
8d. Change in emissions due to removal of drainage from foundations & hardstanding	0	0	0
Total change in emissions due to improvements	0	0	0

RESULTS	Exp.	Min.	Max.
Net emissions of carbon dioxide (t CO2 eq.)	192,952	186,884	211,539
Carbon Payback Time			
...coal-fired electricity generation (years)	0.8	0.7	0.9
...grid-mix of electricity generation (years)	4.0	3.7	4.6
...fossil fuel-mix of electricity generation (years)	1.8	1.7	2.1
Ratio of soil carbon loss to gain by restoration (not used in Scottish applications)	No gains!	No gains!	No gains!
Ratio of CO2 eq. emissions to power generation (g/kWh) (for info. only)	22.23	20.58	25.52

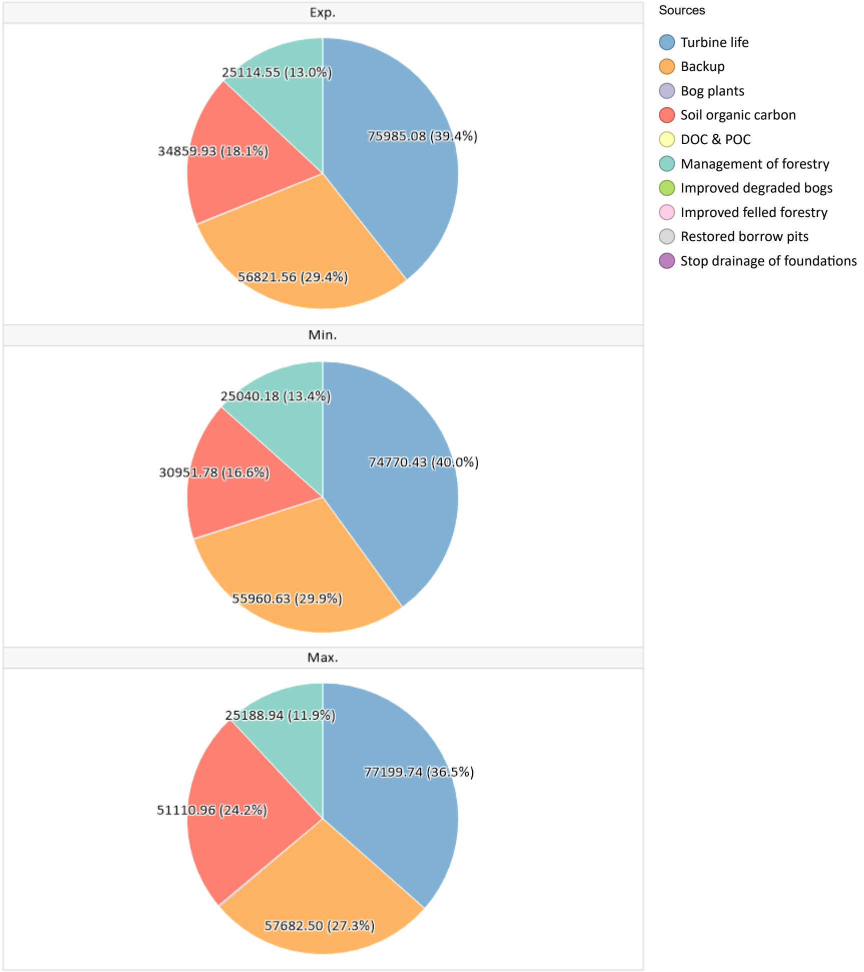
Payback Time - Charts

Payback Time
Payback Time - ChartsInput Data
1. Windfarm CO2 emission saving 2. CO2 loss due to turbine life 3. CO2 loss due to backup 4. Loss of CO2 fixing potential 5. Loss of soil CO2 (a,b) 5. Loss of soil CO2 (c,d,e) 6. CO2 loss by DOC & POC loss 7. Forestry CO2 loss 8. CO2 gain - site improvement

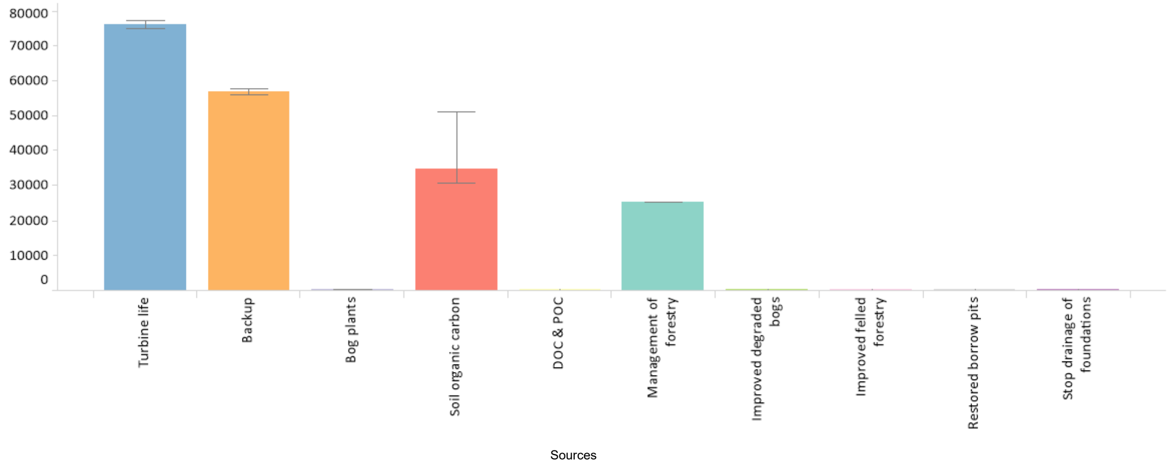
Carbon payback time (months) using fossil-fuel mix as conterfactual



Proportions of greenhouse gas emissions from different sources



Greenhouse gas emissions (t CO2 eq.)



5. Loss of soil CO2 (a, b)

Emissions due to loss of soil organic carbon
Loss of C stored in peatland is estimated from % site lost by peat removal (table 5a), CO2 loss from removed peat (table 5b), % site affected by drainage (table 5c), and the CO2 loss from drained peat (table 5d).

5. Loss of soil C02

	Exp.	Min.	Max.
CO2 loss from removed peat (t CO2 equiv.)	-7118.86	-6749.89	-7339.83
CO2 loss from drained peat (t CO2 equiv.)	41978.8	37701.67	58450.79
RESULTS			
Total CO2 loss from peat (removed + drained) (t CO2 equiv.)	34859.93	30951.78	51110.96
Additional CO2 payback time of windfarm due to loss of soil C...			
...coal-fired electricity generation (months)	1.68	1.56	2.36
...grid-mix of electricity generation (months)	8.72	8.11	12.23
...fossil fuel - mix of electricity generation (months)	3.9	3.63	5.47

CO_2 loss from removed peats
If peat is treated in such a way that it is permanently restored, so that less than 100% of the C is lost to the atmosphere, a lower percentage can be entered in cell C10.

5b. CO2 loss from removed peat

	Exp.	Min.	Max.
CO2 loss from removed peat (t CO2)	0.00	0.00	0.00
CO2 loss from undrained peat left in situ (t CO2)	7118.86	6749.89	7339.83
RESULTS			
CO2 loss atributable to peat removal only (t CO2)	-7118.86	-6749.89	-7339.83

Volume of Peat Removed
% site lost by peat removal is estimated from peat removed in borrow pits, turbine foundations, hard-standing and access tracks. If peat is removed for any other reason, this must be added in as additional peat excavated in the core input data entry.

5a. Volume of peat removed

	Exp.	Min.	Max.
Peat removed from borrow pits			
Area of land lost in borrow pits (m2)	6525	6300	8700
Volume of peat removed from borrow pits (m3)	0	0	0
Peat removed from turbine foundations			
Area of land lost in foundation (m2)	9189.16	9189.16	9189.16
Volume of peat removed from foundation area (m3)	0	0	0
Peat removed from hard-standing			
Area of land lost in hard-standing (m2)	31200	31200	31200
Volume of peat removed from hard-standing area (m3)	0	0	0
Peat removed from access tracks			
Area of land lost in floating roads (m2)	0	0	0
Volume of peat removed from floating roads (m3)	0	0	0
Area of land lost in excavated roads (m2)	56336.5	51210	57366.4
Volume of peat removed from excavated roads (m3)	0	0	0
Area of land lost in rock-filled roads (m2)	0	0	0
Volume of peat removed from rock-filled roads (m3)	0	0	0
Total area of land lost in access tracks (m2)	56336.5	51210	57366.4
Total volume of peat removed due to access tracks (m3)	0	0	0
RESULTS			
Total area of land lost due to windfarm construction (m2)	103250.66	97899.16	106455.56
Total volume of peat removed due to windfarm construction (m3)	0	0	0

5. Loss of soil CO2 (c,d,e)

Volume of peat drained
Extent of site affected by drainage is calculated assuming an average extent of drainage around each drainage feature as given in the input data.

CO_2 loss due to drainage
Note, CO2 losses are calculated using two approaches: IPCC default methodology and more site specific equations derived for this project. The IPCC methodology is included because it is the established approach, although it contains no site detail. The new equations have been derived directly from experimental data for acid bogs and fens (see Nayak et al, 2008 - Final report).

5c. Volume of peat drained

	Exp.	Min.	Max.
Total area affected by drainage around borrow pits (m2)	191	167.31	226.71
Total volume affected by drainage around borrow pits (m3)	0	0	0
Peat affected by drainage around turbine foundation and hardstanding			
Total area affected by drainage of foundation and hardstanding area (m2)	2134.26	1919.66	2349.11
Total volume affected by drainage of foundation and hardstanding area (m3)	0	0	0
Peat affected by drainage of access tracks			
Total area affected by drainage of access track(m2)	20486	18435.6	22536.8
Total volume affected by drainage of access track(m3)	2560750	2299841.1	2822734.2
Peat affected by drainage of cable trenches			
Total area affected by drainage of cable trenches(m2)	0	0	0
Total volume affected by drainage of cable trneches(m3)	0	0	0
Drainage around additional peat excavated			
Total area affected by drainage (m2)	0	0	0
Total volume affected by drainage (m3)	0	0	0
RESULTS			
Total area affected by drainage due to windfarm (m2)	22811.26	20522.57	25112.62
Total volume affected by drainage due to windfarm (m3)	2560750	2299841.1	2822734.2

5d. CO2 loss from drained peat

	Exp.	Min.	Max.
Calculations of C Loss from Drained Land if Site is NOT Restored after Decomissioning			
Total GHG emissions from Drained Land (t CO2 equiv.)	89200.27	80111.86	124201.43
Total GHG emissions from Undrained Land (t CO2 equiv.)	47221.47	42410.19	65750.64
Calculations of C Loss from Drained Land if Site IS Restored after Decomissioning			
Losses if Land is Drained			
CH4 emissions from drained land (t CO2 equiv.)	0	0	0
CO2 emissions from drained land (t CO2)	2970.94	2672.86	3270.67
Total GHG emissions from Drained Land (t CO2 equiv.)	89200.27	80111.86	124201.43
Losses if Land is Undrained			
CH4 emissions from undrained land (t CO2 equiv.)	50.68	45.59	55.79
CO2 emissions from undrained land (t CO2)	1522.1	1369.38	1675.66
Total GHG emissions from Undrained Land (t CO2 equiv.)	47221.47	42410.19	65750.64
RESULTS			
Total GHG emissions due to drainage (t CO2 equiv.)	41978.8	37701.67	58450.79

Emission rates from soils
Note, CO2 losses are calculated using two approaches: IPCC default methodology and more site specific equations derived for this project. The IPCC methodology is included because it is the established approach, although it contains no site detail. The new equations have been thoroughly tested against experimental data (see Nayak et al, 2008 - Final report).

5e. Emission rates from soils

	Exp.	Min.	Max.
Calculations following IPCC default methodology			
Flooded period (days/year)	178	178	178
Annual rate of methane emission (t CH4-C/ha year)	0.04	0.04	0.04
Annual rate of carbon dioxide emission (t CO2/ha year)	35.2	35.2	35.2
Calculations following ECOSSE based methodology			
Total area affected by drainage due to wind farm construction (ha)	2.28	2.05	2.51

7. Forestry CO2 loss

CO_2 loss from forests - calculation using detailed management information
Forest carbon calculator (Perks et al, 2009)

Total potential carbon squestration loss due to felling of forestry for the wind farm (t CO2)	
Total emissions due to cleared land (t CO2)	
Emissions due to harvesting operations (t CO2)	
Fossil fuel equivalent saving from use of felled forestry as biofuel (t CO2)	
Fossil fuel equivalent saving from use of replanted forestry as biofuel (t CO2)	
RESULTS	
Total carbon loss associated with forest management(t CO2)	

Emissions due to forest felling - calculation using simple management data
Emissions due to forestry felling are calculated from the reduced carbon sequestered per crop rotation. If the forestry was due to be removed before the planned development, this C loss is not attributable to the wind farm and so the area of forestry to be felled should be entered as zero.

	Exp.	**Min.**	**Max.**
Area of forestry plantation to be felled (ha)	54.36	54.35	54.37
Carbon sequestered (t C ha-1 yr-1)	3.6	3.59	3.61
Lifetime of windfarm (years)	35	35	35
Carbon sequestered over the lifetime of the windfarm (t C ha-1)	126	125.65	126.35
RESULTS			
Total carbon loss due to felling of forestry (t CO2)	25114.55	25040.18	25188.94
Additional CO2 payback time of windfarm due to management of forestry			
...coal-fired electricity generation (months)	1.21	1.27	1.16
...grid-mix of electricity generation (months)	6.28	6.56	6.03
...fossil fuel - mix of electricity generation (months)	2.81	2.94	2.7

8. CO2 gain - site improvement

Gains due to site improvement
Note, CO2 losses are calculated using two approaches: IPCC default methodology and more site specific equations derived for this project. The IPCC methodology is included because it is the established approach, although it contains no site detail. The new equations have been thoroughly tested against experimental data (see Nayak et al, 2008 - Final report).

Degraded Bog

	Exp.	Min.	Max.
1. Description of site			
Area to be improved (ha)	0	0	0
Depth of peat above water table before improvement (m)	0	0	0
Depth of peat above water table after improvement (m)	0	0	0
2. Losses with improvement			
Improved period (years)	0	0	0
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.04	0.04	0.04
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	0	0	0
CO2 emissions from improved land (t CO2 equiv.)	0	0	0
Total GHG emissions from improved land (t CO2 eqiv.)	0	0	0
3. Losses without improvement			
Improved period (years)	0	0	0
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0	0	0
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	35.2	35.2	35.2
CO2 emissions from unimproved land (t CO2 equiv.)	0	0	0

Felled Forestry

	Exp.	Min.	Max.
1. Description of site			
Area to be improved (ha)	0	0	0
Depth of peat above water table before improvement (m)	0	0	0
Depth of peat above water table after improvement (m)	0	0	0
2. Losses with improvement			
Improved period (years)	13	13	13
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.04	0.04	0.04
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	0	0	0
CO2 emissions from improved land (t CO2 equiv.)	0	0	0
Total GHG emissions from improved land (t CO2 eqiv.)	0	0	0
3. Losses without improvement			
Improved period (years)	13	13	13
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0	0	0
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	35.2	35.2	35.2
CO2 emissions from unimproved land (t CO2 equiv.)	0	0	0

Borrow Pits

	Exp.	Min.	Max.
1. Description of site			
Area to be improved (ha)	0	0	0
Depth of peat above water table before improvement (m)	0	0	0
Depth of peat above water table after improvement (m)	0	0	0
2. Losses with improvement			
Improved period (years)	0	0	0
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.04	0.04	0.04
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	0	0	0
CO2 emissions from improved land (t CO2 equiv.)	0	0	0
Total GHG emissions from improved land (t CO2 eqiv.)	0	0	0
3. Losses without improvement			
Improved period (years)	0	0	0
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0	0	0
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	35.2	35.2	35.2
CO2 emissions from unimproved land (t CO2 equiv.)	0	0	0

Foundations & Hardstanding

	Exp.	Min.	Max.
1. Description of site			
Area to be improved (ha)	0	0	0
Depth of peat above water table before improvement (m)	0	0	0
Depth of peat above water table after improvement (m)	0	0	0
2. Losses with improvement			
Improved period (years)	35	35	35
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.04	0.04	0.04
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	0	0	0
CO2 emissions from improved land (t CO2 equiv.)	0	0	0
Total GHG emissions from improved land (t CO2 eqiv.)	0	0	0
3. Losses without improvement			
Improved period (years)	35	35	35
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0	0	0
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	35.2	35.2	35.2
CO2 emissions from unimproved land (t CO2 equiv.)	0	0	0

3. CO2 loss backup

Emissions due to backup power generation
CO2 loss due to back up is calculated from the extra capacity required for backup of the windfarm given in the input data.

Wind generated electricity is inherently variable, providing unique challenges to the electricity generating industry for provision of a supply to meet consumer demand (Netz, 2004). Backup power is required to accompany wind generation to stabilise the supply to the consumer. This backup power will usually be obtained from a fossil fuel source. At a high level of wind power penetration in the overall generating mix, and with current grid management techniques, the capacity for fossil fuel backup may become strained because it is being used to balance the fluctuating consumer demand with a variable and highly unpredictable output from wind turbines (White, 2007). The Carbon Trust (Carbon Trust/DTI, 2004) concluded that increasing levels of intermittent generation do not present major technical issues at the percentages of renewables expected by 2010 and 2020, but the UK renewables target at the time of that report was only 20%. When national reliance on wind power is low (less than ~20%), the additional fossil fuel generated power requirement can be considered to be insignificant and may be obtained from within the spare generating capacity of other power sectors (Dale et al, 2004). However, as the national supply from wind power increases above 20%, without improvements in grid management techniques, emissions due to backup power generation may become more significant. The extra capacity needed for backup power generation is currently estimated to be 5% of the rated capacity of the wind plant if wind power contributes more than 20% to the national grid (Dale et al 2004). Moving towards the SG target of 50% electricity generation from renewable sources, more short-term capacity may be required in terms of pumped-storage hydro-generated power, or a better mix of offshore and onshore wind generating capacity. Grid management techniques are anticipated to reduce this extra capacity, with improved demand side management, smart meters, grid reinforcement and other developments. However, given current grid management techniques, it is suggested that 5% extra capacity should be assumed for backup power generation if wind power contributes more than 20% to the national grid. At lower contributions, the extra capacity required for backup should be assumed to be zero. These assumptions should be revisited as technology improves.

Assumption: Backup assumed to be by fossil-fuel-mix of electricity generation. Note that hydroelectricity may also be used for backup, so this assumption may make the value for backup generation too high. These assumptions should be revisited as technology develops.

	Exp.	Min.	Max.
Reserve energy (MWh/yr)	37,580	37,011	38,150
Annual emissions due to backup from fossil fuel-mix of electricity generation (tCO2/yr)	1,623	1,599	1,648
RESULTS			
Total emissions due to backup from fossil fuel-mix of electricity generation (tCO2)	56,822	55,961	57,682

1. CO2 emission saving

Emissions due to turbine life
The carbon payback time of the windfarm due to turbine life (eg. manufacture, construction, decomissioning) is calculated by comparing the emissions due to turbine life with carbon-savings achieved by the windfarm while displacing electricity generated from coal-fired capacity or grid-mix.

Capacity factor calculated from forestry data

Area name	Value type	Capacity factor (%)	Wind speed ratio	Average site windspeed (m/s)	Annual theoretical energy output (MW / turbine yr)

Capacity factor - Direct input

	Exp.	Min.	Max.
Capacity factor (%)	33.0	32.0	34.0

	Exp.	Min.	Max.
Annual energy output from windfarm (MW/yr)			
RESULTS			
Emissions saving over coal-fired electricity generatio...	248,527	237,344	259,937
Emissions saving over grid-mix of electricity generati...	47,964	45,806	50,166
Emissions saving over fossil fuel - mix of electricity g...	107,149	102,328	112,069

2. CO2 loss turbine life

Emissions due to turbine life
The carbon payback time of the windfarm due to turbine life (eg. manufacture, construction, decomissioning) is calculated by comparing the emissions due to turbine life with carbon-savings achieved by the windfarm while displacing electricity generated from coal-fired capacity or grid-mix.

Calculation of emissions with relation to installed capacity

	Exp.	Min.	Max.
Emissions due to turbine frome energy output (t CO2)	5699	5606	5793
Emissions due to cement used in construction (t CO2)	1896	1896	1896

Direct input of emissions due to turbine life

	Exp.	Min.	Max.
Emissions due to turbine life (tCO2/windfarm)			

RESULTS

	Exp.	Min.	Max.
Losses due to turbine life (manufacture, construction, etc.) (t CO2)	75985	74770	77200
Additional CO2 payback time of windfarm due to turbine life			
...coal-fired electricity generation (months)	4	4	4
...grid-mix of electricity generation (months)	19	20	18
...fossil fuel - mix of electricity generation (months)	9	9	8

4. Loss CO2 fixing pot.

Payback Time
Payback Time - ChartsInput Data
1. Windfarm CO2 emission saving 2. CO2 loss due to turbine life 3. CO2 loss due to backup 4. Loss of CO2 fixing potential 5. Loss of soil CO2 (a,b) 5. Loss of soil CO2 (c,d,e) 6. CO2 loss by DOC & POC loss 7. Forestry CO2 loss 8. CO2 gain - site improvement

Emissions due to loss of bog plants
Annual C fixation by the site is calculated by multiplying area of the windfarm by the annual C accumulation due to bog plant fixation.

	Exp.	Min.	Max.
Area where carbon accumulation by bog plants is lost (ha)	12.61	11.84	13.16
Total loss of carbon accumulation up to time of restoration (tCO2 eq./ha)	14	14	27
RESULTS			
Total loss of carbon fixation by plants at the site (t CO2)	171	161	357
Additional CO2 payback time of windfarm due to loss of CO2 fixing potential			
...coal-fired electricity generation (months)	0	0	0
...grid-mix of electricity generation (months)	0	0	0
...fossil fuel - mix of electricity generation (months)	0	0	0

6. CO2 loss DOC & POC

Emissions due to loss of DOC and POC
Note, CO_2 losses from DOC and POC are calculated using a simple approach derived from generic estimates of the percentage of the total CO_2 loss that is due to DOC or POC leaching.

No POC losses for bare soil included yet. If extensive areas of bare soil is present at site need modified calculation (Birnie et al, 1991)

	Exp.	Min.	Max.
Gross CO2 loss from restored drained land (t CO2)	0.00	0.00	0.00
Gross CH4 loss from restored drained land (t CO2 equiv.)	0.00	0.00	0.00
Gross CO2 loss from improved land (t CO2)	0.00	0.00	0.00
Gross CH4 loss from improved land (t CO2 equiv.)	0.00	0.00	0.00
Total gaseous loss of C (t C)	0.00	0.00	0.00
Total C loss as DOC (t C)	0.00	0.00	0.00
Total C loss as POC (t C)	0.00	0.00	0.00
RESULTS			
Total CO2 loss due to DOC leaching (t CO2)	0.00	0.00	0.00
Total CO2 loss due to POC leaching (t CO2)	0.00	0.00	0.00
Total CO2 loss due to DOC & POC leaching (t CO2)	0.00	0.00	0.00
Additional CO2 payback time of windfarm due to DOC & POC			
...coal-fired electricity generation (months)	0	0	0
...grid-mix of electricity generation (months)	0	0	0
...fossil fuel - mix of electricity generation (months)	0	0	0

Core input data

Input data	Expected value	Minimum value	Maximum value	Source of data
Windfarm characteristics				
Dimensions				
No. of turbines	13	13	13	number
Duration of consent (years)	35	35	35	years
Performance				
Power rating of 1 turbine (MW)	6.6	6.5	6.7	MW
Capacity factor	33	32	34	%
Backup				
Fraction of output to backup (%)	5	5	5	%
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	no
Average annual air temperature at site (°C)	9.82	1	15	C
Average depth of peat at site (m)	0	0	0	m
C Content of dry peat (% by weight)	19	19	20	%
Average extent of drainage around drainage features at site (m)	0.5	0.45	0.55	m
Average water table depth at site (m)	0	0	0	m
Dry soil bulk density (g cm^{-3})	0.05	0.05	0.06	g cm-3
Characteristics of bog plants				
Time required for regeneration of bog plants after restoration (years)	2	2	2	yr
Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha^{-1} yr^{-1})	0.1	0.1	0.2	tC ha-1 yr-1
Forestry Plantation Characteristics				
Area of forestry plantation to be felled (ha)	54.36	54.35	54.37	ha
Average rate of carbon sequestration in timber (tC ha^{-1} yr^{-1})	3.6	3.59	3.61	tC ha-1 yr-1
Counterfactual emission factors				
Coal-fired plant emission factor (t CO2 MWh^{-1})	1.002	1.002	1.002	
Grid-mix emission factor (t CO2 MWh^{-1})	0.19338	0.19338	0.19338	
Fossil fuel-mix emission factor (t CO2 MWh^{-1})	0.432	0.432	0.432	
Borrow pits				

Input data	Expected value	Minimum value	Maximum value	Source of data
Number of borrow pits	1	1	1	number
Average length of pits (m)	145	140	145	m
Average width of pits (m)	45	45	60	m
Average depth of peat removed from pit (m)	1e-9	1e-9	1e-9	m
Foundations and hard-standing area associated with each turbine				
Average length of turbine foundations (m)	0	0	0	m
Average width of turbine foundations (m)	0	0	0	m
Average depth of peat removed from turbine foundations(m)	0	0	0	m
Average length of hard-standing (m)	0	0	0	m
Average width of hard-standing (m)	0	0	0	m
Average depth of peat removed from hard-standing (m)	0	0	0	m
Volume of concrete used in construction of the ENTIRE windfarm				
Volume of concrete (m^3)	0	0	0	m3
Access tracks				
Total length of access track (m)	15507	15505	15509	m
Existing track length (m)	5264	5263	5265	m
Length of access track that is floating road (m)	0	0	0	m
Floating road width (m)	5	5	5	m
Floating road depth (m)	0.1	0.09	0.11	m
Length of floating road that is drained (m)	0	0	0	m
Average depth of drains associated with floating roads (m)	0	0	0	m
Length of access track that is excavated road (m)	10243	10242	10244	m
Excavated road width (m)	5.5	5	5.6	m
Average depth of peat excavated for road (m)	0	0	0	m
Length of access track that is rock filled road (m)	0	0	0	m
Rock filled road width (m)	5	5	5	m
Rock filled road depth (m)	300	299	301	m
Length of rock filled road that is drained (m)	10243	10242	10244	m
Average depth of drains associated with rock filled roads (m)	500	499	501	m
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)	0	0	0	
Area of additional peat excavated (m^2)	0	0	0	
Peat Landslide Hazard				
Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity	negligible	negligible	negligible	Fixed

Input data	Expected value	Minimum value	Maximum value	Source of data
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)	0	0	0	ha
Water table depth in degraded bog before improvement (m)	0	0	0	m
Water table depth in degraded bog after improvement (m)	0	0	0	m
Time required for hydrology and habitat of bog to return to its previous state on improvement (years)	2	2	2	years
Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years)	2	2	2	years
Improvement of felled plantation land				
Area of felled plantation to be improved (ha)	23	22	23	ha
Water table depth in felled area before improvement (m)	0	0	0	m
Water table depth in felled area after improvement (m)	0	0	0	m
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)	2	2	2	years
Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years)	15	15	15	years
Restoration of peat removed from borrow pits				
Area of borrow pits to be restored (ha)	1	1	1	ha
Depth of water table in borrow pit before restoration with respect to the restored surface (m)	0	0	0	m
Depth of water table in borrow pit after restoration with respect to the restored surface (m)	0	0	0	m
Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years)	15	15	15	yr
Period of time when effectiveness of the restoration of peat removed from borrow pits can be guaranteed (years)	2	2	2	yr
Early removal of drainage from foundations and hardstanding				
Water table depth around foundations and hardstanding before restoration (m)	0	0	0	m
Water table depth around foundations and hardstanding after restoration (m)	0	0	0	
Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)	0	0	0	
Restoration of site after decomissioning				

Input data	Expected value	Minimum value	Maximum value	Source of data
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?	No	No	No	na
Will you attempt to block all artificial ditches and facilitate rewetting?	No	No	No	na
Will the habitat of the site be restored on decommissioning?	Yes	Yes	Yes	
Will you control grazing on degraded areas?	Yes	Yes	Yes	Y
Will you manage areas to favour reintroduction of species	Yes	Yes	Yes	Y
Methodology				
Choice of methodology for calculating emission factors	IPCC default			

Forestry input data

N/A

Construction input data

Input data	Expected value	Minimum value	Maximum value	Source of data
Fossy				
Number of turbines in this area	13	13	13	units
Turbine foundations				
Depth of hole dug when constructing foundations (m)	1e-8	1e-8	1e-8	m
Aproximate geometric shape of whole dug when constructing foundations	Circular	Circular	Circular	m
Diameter at bottom	30	30	30	
Diameter at surface	30	30	30	
Hardstanding				
Depth of hole dug when constructing hardstanding (m)	1e-8	1e-8	1e-8	m
Aproximate geometric shape of whole dug when constructing hardstanding	Rectangular	Rectangular	Rectangular	m
Length at surface	80	80	80	
Width at surface	30	30	30	
Length at bottom	80	80	80	
Width at bottom	30	30	30	
Piling				
Is piling used?	No	No	No	No
Volume of Concrete				
Volume of concrete used (m^3) in the entire area	6000	6000	6000	m^3

Publication - Factsheet

Carbon calculator for wind farms on Scottish peatlands: factsheet

Last updated: **8 February 2022 -** see all updates
Directorate: Energy and Climate Change Directorate
Part of: Energy, Environment and climate change

Information on the carbon calculator we developed for determining the carbon impact of wind farm developments in Scotland.

Access the carbon calculator tool

Background to the tool

The carbon calculator is our tool to support the process of determining wind farm developments in Scotland. The tool's purpose is to assess, in a comprehensive and consistent way, the carbon impact of wind farm developments. This is done by comparing the carbon costs of wind farm developments with the carbon savings attributable to the wind farm. The tool and supporting guidance material remain the property of the Scottish Government.

The online carbon calculator

This latest version of the carbon calculator is a web-based application and central database, where all the data entered in the carbon calculator is stored in a structured manner. This web-based

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all earlier versions of the Excel-based carbon calculator. We commissioned it in response to feedback from stakeholders concerning previous versions of the tool, under the guidance of a steering group with membership including Scottish Government, Scottish Environment Protection Agency (SEPA), Scottish Natural Heritage (SNH) and Forestry Research. Stakeholder engagement and feedback via workshops, in the final stages of the tool's development, helped to further inform the final design. Any queries regarding its use and functionality should be directed in the first instance to the Energy Consents Unit.

The web tool incorporates high-level automated checking, detailed user guidance (within the tool), cells for identification of data sources and relevant data calculations and modifications required to the calculation method, at this time.

The improved ease of use will reduce the burden on developers as a consequence of the increased user-friendliness and the more sophisticated entry checking and guidance. The expectation is that this will reduce the number of resubmissions. The improved quality of submissions will reduce the validation work required. It will allow developers to submit carbon assessments and conduct initial carbon assessment screening tests on their proposed developments online in a self-service manner. It will allow an aggregated picture to be made of assessments (initial applications and re-applications) across Scotland.

Development of the carbon calculator

Originally published in 2008 with research report, Calculating carbon savings from wind farms on Scottish peat lands: a new approach (Nayak et al, 2008), the calculator has been refined on the basis of feedback and further research (Nayak et al., 2010 and Smith et al., 2011) to be an even more effective tool. Version 2 of the calculator launched in June 2011. The calculator was subsequently revised to include multiple regions for forestry and construction. The last version of the Excel spreadsheet tool was 2.9.0.

Deployment and protocols for use

The web-based version of the carbon calculator has been available since 29 June 2016 to support the carbon assessment of wind farm developments. The initial release was referenced as C-CalcWebV1.0 and will continue to be referred to as the 'carbon calculator'. This web–based version of the carbon calculator superseded all previous Excel based versions of the tool, and should be used for all appropriate applications which previously would have used the Excel based tool. Any major updates and revisions of the tool (V2.0, V3.0 etc) will be undertaken on an annual basis, with only absolutely necessary interim 'minor' patches (V1.1, V1.2 etc) being undertaken otherwise.

All new applications to the Energy Consents Unit should use the web-based tool or may be subject to rejection. All applications submitted and received using the carbon calculator may be subject to audit by the Scottish Environment Protection Agency. This is to ensure, as far as possible, that the carbon calculator continues to be used appropriately. If an audit highlights any issues, these will be raised with the applicant by SEPA such that they may be addressed.

The web-based version of the carbon calculator provides significant enhancements over the previous Excel tool, including some automatic validation of data entry. However, an Excel based tool is also being maintained for the purposes of development of new functionality, testing and trialling. This can be made available upon request. However, it must be recognised that this may not replicate exactly the functionality and results of the web based tool and its use and any decisions based thereon will be at the users own discretion.

We have produced technical guidance for using the carbon calculator.

Further peat guidance

SEPA and Scottish Renewables have produced guidance on the assessment of peat volumes, the reuse of excavated peat, and the minimisation of waste, which was published in February 2014.

The guidance on peatland site surveys was updated in April 2017.

Contact

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First published: **20 November 2018**
Last updated: **8 February 2022 -** show all updates

Core input data

Input data	Expected value	Minimum value	Maximum value	Source of data
Windfarm characteristics				
Dimensions				
No. of turbines	13	13	13	number
Duration of consent (years)	35	35	35	years
Performance				
Power rating of 1 turbine (MW)	7.2	7.1	7.3	MW
Capacity factor	33	32	34	%
Backup				
Fraction of output to backup (%)	5	5	5	%
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	no
Average annual air temperature at site (°C)	9.82	1	15	C
Average depth of peat at site (m)	0	0	0	m
C Content of dry peat (% by weight)	19	19	20	%
Average extent of drainage around drainage features at site (m)	0.5	0.45	0.55	m
Average water table depth at site (m)	0	0	0	m
Dry soil bulk density (g cm^{-3})	0.05	0.05	0.06	g cm-3
Characteristics of bog plants				
Time required for regeneration of bog plants after restoration (years)	2	2	2	yr
Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha^{-1} yr^{-1})	0.1	0.1	0.2	tC ha-1 yr-1
Forestry Plantation Characteristics				
Area of forestry plantation to be felled (ha)	54.36	54.35	54.37	ha
Average rate of carbon sequestration in timber (tC ha^{-1} yr^{-1})	3.6	3.59	3.61	tC ha-1 yr-1
Counterfactual emission factors				
Coal-fired plant emission factor (t CO2 MWh^{-1})	1.002	1.002	1.002	
Grid-mix emission factor (t CO2 MWh^{-1})	0.19338	0.19338	0.19338	
Fossil fuel-mix emission factor (t CO2 MWh^{-1})	0.432	0.432	0.432	
Borrow pits				

Input data	Expected value	Minimum value	Maximum value	Source of data
Number of borrow pits	1	1	1	number
Average length of pits (m)	145	140	145	m
Average width of pits (m)	45	45	60	m
Average depth of peat removed from pit (m)	1e-9	1e-9	1e-9	m
Foundations and hard-standing area associated with each turbine				
Average length of turbine foundations (m)	0	0	0	m
Average width of turbine foundations (m)	0	0	0	m
Average depth of peat removed from turbine foundations(m)	0	0	0	m
Average length of hard-standing (m)	0	0	0	m
Average width of hard-standing (m)	0	0	0	m
Average depth of peat removed from hard-standing (m)	0	0	0	m
Volume of concrete used in construction of the ENTIRE windfarm				
Volume of concrete (m^3)	0	0	0	m3
Access tracks				
Total length of access track (m)	15507	15505	15509	m
Existing track length (m)	5264	5263	5265	m
Length of access track that is floating road (m)	0	0	0	m
Floating road width (m)	5	5	5	m
Floating road depth (m)	0.1	0.09	0.11	m
Length of floating road that is drained (m)	0	0	0	m
Average depth of drains associated with floating roads (m)	0	0	0	m
Length of access track that is excavated road (m)	10243	10242	10244	m
Excavated road width (m)	5.5	5	5.6	m
Average depth of peat excavated for road (m)	0	0	0	m
Length of access track that is rock filled road (m)	0	0	0	m
Rock filled road width (m)	5	5	5	m
Rock filled road depth (m)	300	299	301	m
Length of rock filled road that is drained (m)	10243	10242	10244	m
Average depth of drains associated with rock filled roads (m)	500	499	501	m
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)	0	0	0	
Area of additional peat excavated (m^2)	0	0	0	
Peat Landslide Hazard				
Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity	negligible	negligible	negligible	Fixed

Input data	Expected value	Minimum value	Maximum value	Source of data
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)	0	0	0	ha
Water table depth in degraded bog before improvement (m)	0	0	0	m
Water table depth in degraded bog after improvement (m)	0	0	0	m
Time required for hydrology and habitat of bog to return to its previous state on improvement (years)	2	2	2	years
Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years)	2	2	2	years
Improvement of felled plantation land				
Area of felled plantation to be improved (ha)	23	22	23	ha
Water table depth in felled area before improvement (m)	0	0	0	m
Water table depth in felled area after improvement (m)	0	0	0	m
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)	2	2	2	years
Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years)	15	15	15	years
Restoration of peat removed from borrow pits				
Area of borrow pits to be restored (ha)	1	1	1	ha
Depth of water table in borrow pit before restoration with respect to the restored surface (m)	0	0	0	m
Depth of water table in borrow pit after restoration with respect to the restored surface (m)	0	0	0	m
Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years)	15	15	15	yr
Period of time when effectiveness of the restoration of peat removed from borrow pits can be guaranteed (years)	2	2	2	yr
Early removal of drainage from foundations and hardstanding				
Water table depth around foundations and hardstanding before restoration (m)	0	0	0	m
Water table depth around foundations and hardstanding after restoration (m)	0	0	0	
Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)	0	0	0	
Restoration of site after decomissioning				

Input data	Expected value	Minimum value	Maximum value	Source of data
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?	No	No	No	na
Will you attempt to block all artificial ditches and facilitate rewetting?	No	No	No	na
Will the habitat of the site be restored on decommissioning?	Yes	Yes	Yes	
Will you control grazing on degraded areas?	Yes	Yes	Yes	Y
Will you manage areas to favour reintroduction of species	Yes	Yes	Yes	Y
Methodology				
Choice of methodology for calculating emission factors	IPCC default			

Forestry input data

N/A

Construction input data

Input data	Expected value	Minimum value	Maximum value	Source of data
Fossy				
Number of turbines in this area	13	13	13	units
Turbine foundations				
Depth of hole dug when constructing foundations (m)	1e-8	1e-8	1e-8	m
Aproximate geometric shape of whole dug when constructing foundations	Circular	Circular	Circular	m
Diameter at bottom	30	30	30	
Diameter at surface	30	30	30	
Hardstanding				
Depth of hole dug when constructing hardstanding (m)	1e-8	1e-8	1e-8	m
Aproximate geometric shape of whole dug when constructing hardstanding	Rectangular	Rectangular	Rectangular	m
Length at surface	80	80	80	
Width at surface	30	30	30	
Length at bottom	80	80	80	
Width at bottom	30	30	30	
Piling				
Is piling used?	No	No	No	No
Volume of Concrete				
Volume of concrete used (m^3) in the entire area	6000	6000	6000	m^3

Payback Time

1. Windfarm CO2 emission saving over...	Exp.	Min.	Max.
...coal-fired electricity generation (t CO2 / yr)	271,120	259,253	283,215
...grid-mix of electricity generation (t CO2 / yr)	52,325	50,034	54,659
...fossil fuel-mix of electricity generation (t CO2 / yr)	116,890	111,774	122,105
Energy output from windfarm over lifetime (MWh)	9,470,261	9,055,738	9,892,756

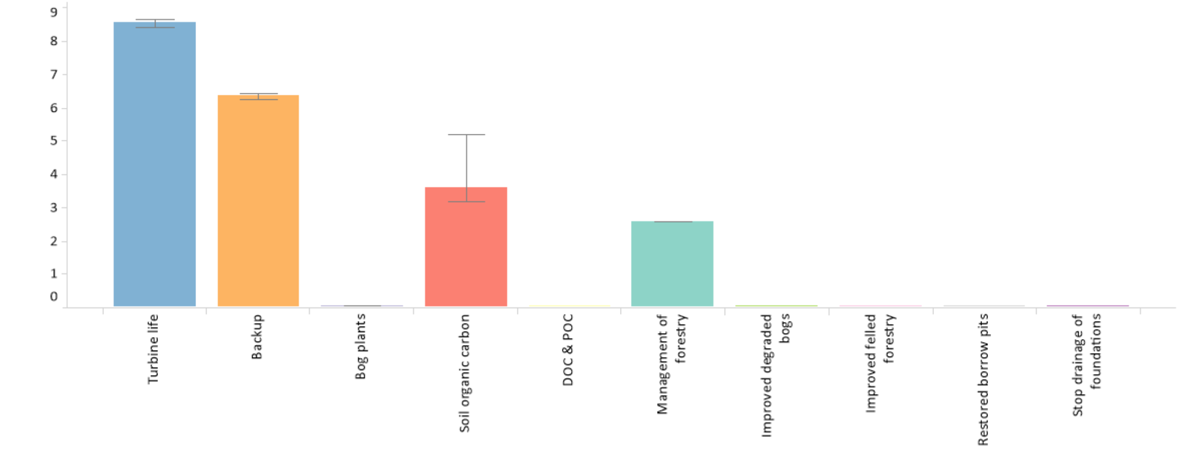
Total CO2 losses due to wind farm (tCO2 eq.)	Exp.	Min.	Max.
2. Losses due to turbine life (eg. manufacture, construction, decomissioning)	83,273	82,058	84,488
3. Losses due to backup	61,987	61,126	62,848
4. Lossess due to reduced carbon fixing potential	171	161	357
5. Losses from soil organic matter	34,860	30,952	51,111
6. Losses due to DOC & POC leaching	0	0	0
7. Losses due to felling forestry	25,115	25,040	25,189
Total losses of carbon dioxide	205,406	199,337	223,993

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	0
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	0	0	0
Total change in emissions due to improvements	0	0	0

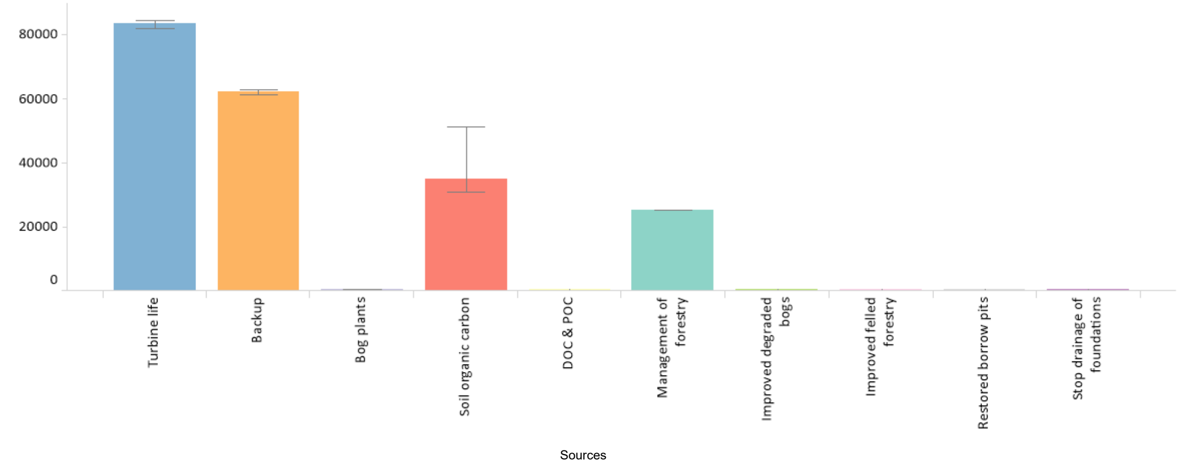
RESULTS	Exp.	Min.	Max.
Net emissions of carbon dioxide (t CO2 eq.)	205,406	199,337	223,993
Carbon Payback Time			
...coal-fired electricity generation (years)	0.8	0.7	0.9
...grid-mix of electricity generation (years)	3.9	3.6	4.5
...fossil fuel-mix of electricity generation (years)	1.8	1.6	2.0
Ratio of soil carbon loss to gain by restoration (not used in Scottish applications)	No gains!	No gains!	No gains!
Ratio of CO2 eq. emissions to power generation (g/kWh) (for info. only)	21.69	20.15	24.73

Payback Time - Charts

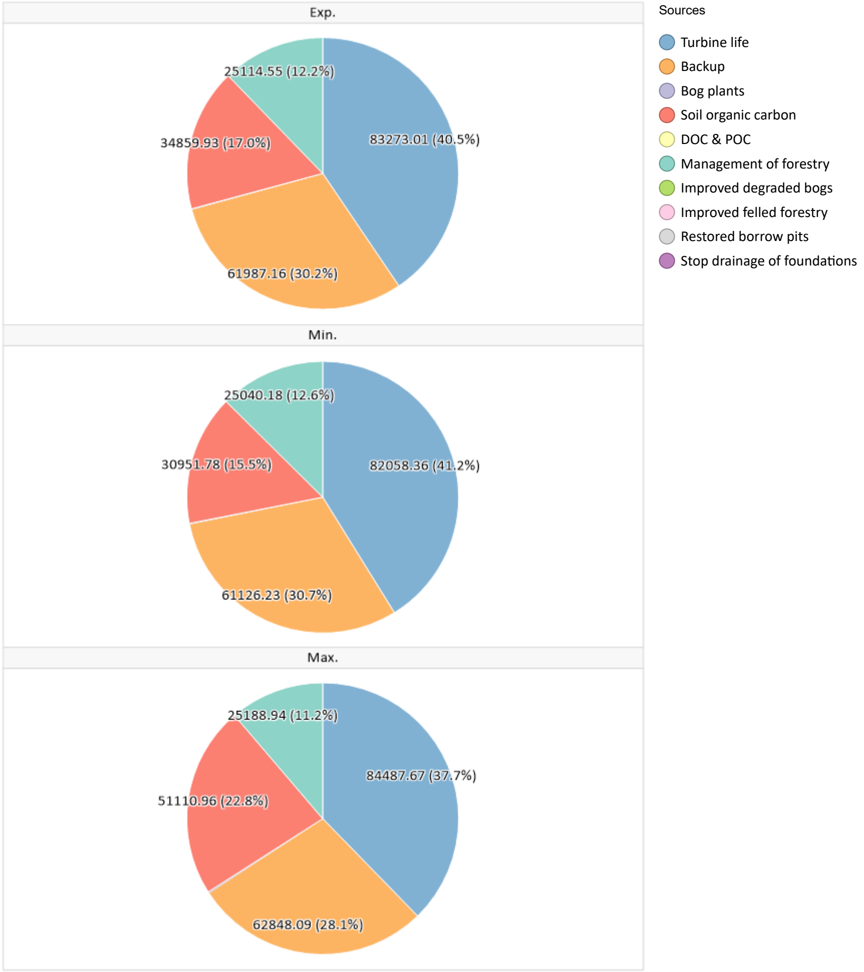
Carbon payback time (months) using fossil-fuel mix as conterfactual



Greenhouse gas emissions (t CO2 eq.)



Proportions of greenhouse gas emissions from different sources



5. Loss of soil CO2 (a, b)

Emissions due to loss of soil organic carbon
Loss of C stored in peatland is estimated from % site lost by peat removal (table 5a), CO2 loss from removed peat (table 5b), % site affected by drainage (table 5c), and the CO2 loss from drained peat (table 5d).

5. Loss of soil C02

	Exp.	Min.	Max.
CO2 loss from removed peat (t CO2 equiv.)	-7118.86	-6749.89	-7339.83
CO2 loss from drained peat (t CO2 equiv.)	41978.8	37701.67	58450.79
RESULTS			
Total CO2 loss from peat (removed + drained) (t CO2 equiv.)	34859.93	30951.78	51110.96
Additional CO2 payback time of windfarm due to loss of soil C...			
...coal-fired electricity generation (months)	1.54	1.43	2.17
...grid-mix of electricity generation (months)	7.99	7.42	11.22
...fossil fuel - mix of electricity generation (months)	3.58	3.32	5.02

CO_2 loss from removed peats
If peat is treated in such a way that it is permanently restored, so that less than 100% of the C is lost to the atmosphere, a lower percentage can be entered in cell C10.

5b. CO2 loss from removed peat

	Exp.	Min.	Max.
CO2 loss from removed peat (t CO2)	0.00	0.00	0.00
CO2 loss from undrained peat left in situ (t CO2)	7118.86	6749.89	7339.83
RESULTS			
CO2 loss atributable to peat removal only (t CO2)	-7118.86	-6749.89	-7339.83

Volume of Peat Removed
% site lost by peat removal is estimated from peat removed in borrow pits, turbine foundations, hard-standing and access tracks. If peat is removed for any other reason, this must be added in as additional peat excavated in the core input data entry.

5a. Volume of peat removed

	Exp.	Min.	Max.
Peat removed from borrow pits			
Area of land lost in borrow pits (m2)	6525	6300	8700
Volume of peat removed from borrow pits (m3)	0	0	0
Peat removed from turbine foundations			
Area of land lost in foundation (m2)	9189.16	9189.16	9189.16
Volume of peat removed from foundation area (m3)	0	0	0
Peat removed from hard-standing			
Area of land lost in hard-standing (m2)	31200	31200	31200
Volume of peat removed from hard-standing area (m3)	0	0	0
Peat removed from access tracks			
Area of land lost in floating roads (m2)	0	0	0
Volume of peat removed from floating roads (m3)	0	0	0
Area of land lost in excavated roads (m2)	56336.5	51210	57366.4
Volume of peat removed from excavated roads (m3)	0	0	0
Area of land lost in rock-filled roads (m2)	0	0	0
Volume of peat removed from rock-filled roads (m3)	0	0	0
Total area of land lost in access tracks (m2)	56336.5	51210	57366.4
Total volume of peat removed due to access tracks (m3)	0	0	0
RESULTS			
Total area of land lost due to windfarm construction (m2)	103250.66	97899.16	106455.56
Total volume of peat removed due to windfarm construction (m3)	0	0	0

5. Loss of soil CO2 (c,d,e)

Volume of peat drained
Extent of site affected by drainage is calculated assuming an average extent of drainage around each drainage feature as given in the input data.

CO_2 loss due to drainage
Note, CO2 losses are calculated using two approaches: IPCC default methodology and more site specific equations derived for this project. The IPCC methodology is included because it is the established approach, although it contains no site detail. The new equations have been derived directly from experimental data for acid bogs and fens (see Nayak et al, 2008 - Final report).

5c. Volume of peat drained

	Exp.	Min.	Max.
Total area affected by drainage around borrow pits (m2)	191	167.31	226.71
Total volume affected by drainage around borrow pits (m3)	0	0	0
Peat affected by drainage around turbine foundation and hardstanding			
Total area affected by drainage of foundation and hardstanding area (m2)	2134.26	1919.66	2349.11
Total volume affected by drainage of foundation and hardstanding area (m3)	0	0	0
Peat affected by drainage of access tracks			
Total area affected by drainage of access track(m2)	20486	18435.6	22536.8
Total volume affected by drainage of access track(m3)	2560750	2299841.1	2822734.2
Peat affected by drainage of cable trenches			
Total area affected by drainage of cable trenches(m2)	0	0	0
Total volume affected by drainage of cable trneches(m3)	0	0	0
Drainage around additional peat excavated			
Total area affected by drainage (m2)	0	0	0
Total volume affected by drainage (m3)	0	0	0
RESULTS			
Total area affected by drainage due to windfarm (m2)	22811.26	20522.57	25112.62
Total volume affected by drainage due to windfarm (m3)	2560750	2299841.1	2822734.2

5d. CO2 loss from drained peat

	Exp.	Min.	Max.
Calculations of C Loss from Drained Land if Site is NOT Restored after Decomissioning			
Total GHG emissions from Drained Land (t CO2 equiv.)	89200.27	80111.86	124201.43
Total GHG emissions from Undrained Land (t CO2 equiv.)	47221.47	42410.19	65750.64
Calculations of C Loss from Drained Land if Site IS Restored after Decomissioning			
Losses if Land is Drained			
CH4 emissions from drained land (t CO2 equiv.)	0	0	0
CO2 emissions from drained land (t CO2)	2970.94	2672.86	3270.67
Total GHG emissions from Drained Land (t CO2 equiv.)	89200.27	80111.86	124201.43
Losses if Land is Undrained			
CH4 emissions from undrained land (t CO2 equiv.)	50.68	45.59	55.79
CO2 emissions from undrained land (t CO2)	1522.1	1369.38	1675.66
Total GHG emissions from Undrained Land (t CO2 equiv.)	47221.47	42410.19	65750.64
RESULTS			
Total GHG emissions due to drainage (t CO2 equiv.)	41978.8	37701.67	58450.79

Emission rates from soils
Note, CO2 losses are calculated using two approaches: IPCC default methodology and more site specific equations derived for this project. The IPCC methodology is included because it is the established approach, although it contains no site detail. The new equations have been thoroughly tested against experimental data (see Nayak et al, 2008 - Final report).

5e. Emission rates from soils

	Exp.	Min.	Max.
Calculations following IPCC default methodology			
Flooded period (days/year)	178	178	178
Annual rate of methane emission (t CH4-C/ha year)	0.04	0.04	0.04
Annual rate of carbon dioxide emission (t CO2/ha year)	35.2	35.2	35.2
Calculations following ECOSSE based methodology			
Total area affected by drainage due to wind farm construction (ha)	2.28	2.05	2.51

7. Forestry CO2 loss

CO_2 loss from forests - calculation using detailed management information
Forest carbon calculator (Perks et al, 2009)

Total potential carbon squestration loss due to felling of forestry for the wind farm (t CO2)
Total emissions due to cleared land (t CO2)
Emissions due to harvesting operations (t CO2)
Fossil fuel equivalent saving from use of felled forestry as biofuel (t CO2)
Fossil fuel equivalent saving from use of replanted forestry as biofuel (t CO2)
RESULTS
Total carbon loss associated with forest management(t CO2)

Emissions due to forest felling - calculation using simple management data
Emissions due to forestry felling are calculated from the reduced carbon sequestered per crop rotation. If the forestry was due to be removed before the planned development, this C loss is not attributable to the wind farm and so the area of forestry to be felled should be entered as zero.

	Exp.	Min.	Max.
Area of forestry plantation to be felled (ha)	54.36	54.35	54.37
Carbon sequestered (t C ha-1 yr-1)	3.6	3.59	3.61
Lifetime of windfarm (years)	35	35	35
Carbon sequestered over the lifetime of the windfarm (t C ha-1)	126	125.65	126.35
RESULTS			
Total carbon loss due to felling of forestry (t CO2)	25114.55	25040.18	25188.94
Additional CO2 payback time of windfarm due to management of forestry			
...coal-fired electricity generation (months)	1.11	1.16	1.07
...grid-mix of electricity generation (months)	5.76	6.01	5.53
...fossil fuel - mix of electricity generation (months)	2.58	2.69	2.48

8. CO2 gain - site improvement

Gains due to site improvement
Note, CO2 losses are calculated using two approaches: IPCC default methodology and more site specific equations derived for this project. The IPCC methodology is included because it is the established approach, although it contains no site detail. The new equations have been thoroughly tested against experimental data (see Nayak et al, 2008 - Final report).

Degraded Bog

	Exp.	Min.	Max.
1. Description of site			
Area to be improved (ha)	0	0	0
Depth of peat above water table before improvement (m)	0	0	0
Depth of peat above water table after improvement (m)	0	0	0
2. Losses with improvement			
Improved period (years)	0	0	0
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.04	0.04	0.04
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	0	0	0
CO2 emissions from improved land (t CO2 equiv.)	0	0	0
Total GHG emissions from improved land (t CO2 eqiv.)	0	0	0
3. Losses without improvement			
Improved period (years)	0	0	0
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0	0	0
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	35.2	35.2	35.2
CO2 emissions from unimproved land (t CO2 equiv.)	0	0	0

Felled Forestry

	Exp.	Min.	Max.
1. Description of site			
Area to be improved (ha)	0	0	0
Depth of peat above water table before improvement (m)	0	0	0
Depth of peat above water table after improvement (m)	0	0	0
2. Losses with improvement			
Improved period (years)	13	13	13
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.04	0.04	0.04
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	0	0	0
CO2 emissions from improved land (t CO2 equiv.)	0	0	0
Total GHG emissions from improved land (t CO2 eqiv.)	0	0	0
3. Losses without improvement			
Improved period (years)	13	13	13
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0	0	0
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	35.2	35.2	35.2
CO2 emissions from unimproved land (t CO2 equiv.)	0	0	0

Borrow Pits

	Exp.	Min.	Max.
1. Description of site			
Area to be improved (ha)	0	0	0
Depth of peat above water table before improvement (m)	0	0	0
Depth of peat above water table after improvement (m)	0	0	0
2. Losses with improvement			
Improved period (years)	0	0	0
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.04	0.04	0.04
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	0	0	0
CO2 emissions from improved land (t CO2 equiv.)	0	0	0
Total GHG emissions from improved land (t CO2 eqiv.)	0	0	0
3. Losses without improvement			
Improved period (years)	0	0	0
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0	0	0
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	35.2	35.2	35.2
CO2 emissions from unimproved land (t CO2 equiv.)	0	0	0

Foundations & Hardstanding

	Exp.	Min.	Max.
1. Description of site			
Area to be improved (ha)	0	0	0
Depth of peat above water table before improvement (m)	0	0	0
Depth of peat above water table after improvement (m)	0	0	0
2. Losses with improvement			
Improved period (years)	35	35	35
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.04	0.04	0.04
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	0	0	0
CO2 emissions from improved land (t CO2 equiv.)	0	0	0
Total GHG emissions from improved land (t CO2 eqiv.)	0	0	0
3. Losses without improvement			
Improved period (years)	35	35	35
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0	0	0
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	35.2	35.2	35.2
CO2 emissions from unimproved land (t CO2 equiv.)	0	0	0

3. CO2 loss backup

Payback Time
Payback Time - ChartsInput Data
1. Windfarm CO2 emission saving 2. CO2 loss due to turbine life 3. CO2 loss due to backup 4. Loss of CO2 fixing potential 5. Loss of soil CO2 (a,b) 5. Loss of soil CO2 (c,d,e) 6. CO2 loss by DOC & POC loss 7. Forestry CO2 loss 8. CO2 gain - site improvement

Emissions due to backup power generation
CO2 loss due to back up is calculated from the extra capacity required for backup of the windfarm given in the input data.

Wind generated electricity is inherently variable, providing unique challenges to the electricity generating industry for provision of a supply to meet consumer demand (Netz, 2004). Backup power is required to accompany wind generation to stabilise the supply to the consumer. This backup power will usually be obtained from a fossil fuel source. At a high level of wind power penetration in the overall generating mix, and with current grid management techniques, the capacity for fossil fuel backup may become strained because it is being used to balance the fluctuating consumer demand with a variable and highly unpredictable output from wind turbines (White, 2007). The Carbon Trust (Carbon Trust/DTI, 2004) concluded that increasing levels of intermittent generation do not present major technical issues at the percentages of renewables expected by 2010 and 2020, but the UK renewables target at the time of that report was only 20%. When national reliance on wind power is low (less than ~20%), the additional fossil fuel generated power requirement can be considered to be insignificant and may be obtained from within the spare generating capacity of other power sectors (Dale et al, 2004). However, as the national supply from wind power increases above 20%, without improvements in grid management techniques, emissions due to backup power generation may become more significant. The extra capacity needed for backup power generation is currently estimated to be 5% of the rated capacity of the wind plant if wind power contributes more than 20% to the national grid (Dale et al 2004). Moving towards the SG target of 50% electricity generation from renewable sources, more short-term capacity may be required in terms of pumped-storage hydro-generated power, or a better mix of offshore and onshore wind generating capacity. Grid management techniques are anticipated to reduce this extra capacity, with improved demand side management, smart meters, grid reinforcement and other developments. However, given current grid management techniques, it is suggested that 5% extra capacity should be assumed for backup power generation if wind power contributes more than 20% to the national grid. At lower contributions, the extra capacity required for backup should be assumed to be zero. These assumptions should be revisited as technology improves.

Assumption: Backup assumed to be by fossil-fuel-mix of electricity generation. Note that hydroelectricity may also be used for backup, so this assumption may make the value for backup generation too high. These assumptions should be revisited as technology develops.

	Exp.	Min.	Max.
Reserve energy (MWh/yr)	40,997	40,427	41,566
Annual emissions due to backup from fossil fuel-mix of electricity generation (tCO2/yr)	1,771	1,746	1,796
RESULTS			
Total emissions due to backup from fossil fuel-mix of electricity generation (tCO2)	61,987	61,126	62,848

1. CO_2 emission saving

Emissions due to turbine life
The carbon payback time of the windfarm due to turbine life (eg. manufacture, construction, decomissioning) is calculated by comparing the emissions due to turbine life with carbon-savings achieved by the windfarm while displacing electricity generated from coal-fired capacity or grid-mix.

Capacity factor calculated from forestry data

Area name	Value type	Capacity factor (%)	Wind speed ratio	Average site windspeed (m/s)	Annual theoretical energy output (MW / turbine yr)

Capacity factor - Direct input

	Exp.	Min.	Max.
Capacity factor (%)	33.0	32.0	34.0

	Exp.	Min.	Max.
Annual energy output from windfarm (MW/yr)			
RESULTS			
Emissions saving over coal-fired electricity generatio...	271,120	259,253	283,215
Emissions saving over grid-mix of electricity generati...	52,325	50,034	54,659
Emissions saving over fossil fuel - mix of electricity g...	116,890	111,774	122,105

2. CO2 loss turbine life

Emissions due to turbine life
The carbon payback time of the windfarm due to turbine life (eg. manufacture, construction, decomissioning) is calculated by comparing the emissions due to turbine life with carbon-savings achieved by the windfarm while displacing electricity generated from coal-fired capacity or grid-mix.

Calculation of emissions with relation to installed capacity

	Exp.	Min.	Max.
Emissions due to turbine frome energy output (t CO2)	6260	6166	6353
Emissions due to cement used in construction (t CO2)	1896	1896	1896

Direct input of emissions due to turbine life

	Exp.	Min.	Max.
Emissions due to turbine life (tCO2/windfarm)			

RESULTS

	Exp.	Min.	Max.
Losses due to turbine life (manufacture, construction, etc.) (t CO2)	83273	82058	84488
Additional CO2 payback time of windfarm due to turbine life			
...coal-fired electricity generation (months)	4	4	4
...grid-mix of electricity generation (months)	19	20	19
...fossil fuel - mix of electricity generation (months)	9	9	8

4. Loss CO2 fixing pot.

Emissions due to loss of bog plants
Annual C fixation by the site is calculated by multiplying area of the windfarm by the annual C accumulation due to bog plant fixation.

	Exp.	Min.	Max.
Area where carbon accumulation by bog plants is lost (ha)	12.61	11.84	13.16
Total loss of carbon accumulation up to time of restoration (tCO2 eq./ha)	14	14	27
RESULTS			
Total loss of carbon fixation by plants at the site (t CO2)	171	161	357
Additional CO2 payback time of windfarm due to loss of CO2 fixing potential			
...coal-fired electricity generation (months)	0	0	0
...grid-mix of electricity generation (months)	0	0	0
...fossil fuel - mix of electricity generation (months)	0	0	0

6. CO2 loss DOC & POC

Emissions due to loss of DOC and POC
Note, CO2 losses from DOC and POC are calculated using a simple approach derived from generic estimates of the percentage of the total CO2 loss that is due to DOC or POC leaching.

No POC losses for bare soil included yet. If extensive areas of bare soil is present at site need modified calculation (Birnie et al, 1991)

	Exp.	Min.	Max.
Gross CO2 loss from restored drained land (t CO2)	0.00	0.00	0.00
Gross CH4 loss from restored drained land (t CO2 equiv.)	0.00	0.00	0.00
Gross CO2 loss from improved land (t CO2)	0.00	0.00	0.00
Gross CH4 loss from improved land (t CO2 equiv.)	0.00	0.00	0.00
Total gaseous loss of C (t C)	0.00	0.00	0.00
Total C loss as DOC (t C)	0.00	0.00	0.00
Total C loss as POC (t C)	0.00	0.00	0.00
RESULTS			
Total CO2 loss due to DOC leaching (t CO2)	0.00	0.00	0.00
Total CO2 loss due to POC leaching (t CO2)	0.00	0.00	0.00
Total CO2 loss due to DOC & POC leaching (t CO2)	0.00	0.00	0.00
Additional CO2 payback time of windfarm due to DOC & POC			
...coal-fired electricity generation (months)	0	0	0
...grid-mix of electricity generation (months)	0	0	0
...fossil fuel - mix of electricity generation (months)	0	0	0

Core input data

Input data	Expected value	Minimum value	Maximum value	Source of data
Windfarm characteristics				
Dimensions				
No. of turbines	13	13	13	number
Duration of consent (years)	35	35	35	years
Performance				
Power rating of 1 turbine (MW)	7.2	7.1	7.3	MW
Capacity factor	33	32	34	%
Backup				
Fraction of output to backup (%)	5	5	5	%
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	no
Average annual air temperature at site (°C)	9.82	1	15	C
Average depth of peat at site (m)	0	0	0	m
C Content of dry peat (% by weight)	19	19	20	%
Average extent of drainage around drainage features at site (m)	0.5	0.45	0.55	m
Average water table depth at site (m)	0	0	0	m
Dry soil bulk density (g cm^{-3})	0.05	0.05	0.06	g cm-3
Characteristics of bog plants				
Time required for regeneration of bog plants after restoration (years)	2	2	2	yr
Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha^{-1} yr^{-1})	0.1	0.1	0.2	tC ha-1 yr-1
Forestry Plantation Characteristics				
Area of forestry plantation to be felled (ha)	54.36	54.35	54.37	ha
Average rate of carbon sequestration in timber (tC ha^{-1} yr^{-1})	3.6	3.59	3.61	tC ha-1 yr-1
Counterfactual emission factors				
Coal-fired plant emission factor (t CO2 MWh^{-1})	1.002	1.002	1.002	
Grid-mix emission factor (t CO2 MWh^{-1})	0.19338	0.19338	0.19338	
Fossil fuel-mix emission factor (t CO2 MWh^{-1})	0.432	0.432	0.432	
Borrow pits				

Input data	Expected value	Minimum value	Maximum value	Source of data
Number of borrow pits	1	1	1	number
Average length of pits (m)	145	140	145	m
Average width of pits (m)	45	45	60	m
Average depth of peat removed from pit (m)	1e-9	1e-9	1e-9	m
Foundations and hard-standing area associated with each turbine				
Average length of turbine foundations (m)	0	0	0	m
Average width of turbine foundations (m)	0	0	0	m
Average depth of peat removed from turbine foundations(m)	0	0	0	m
Average length of hard-standing (m)	0	0	0	m
Average width of hard-standing (m)	0	0	0	m
Average depth of peat removed from hard-standing (m)	0	0	0	m
Volume of concrete used in construction of the ENTIRE windfarm				
Volume of concrete (m^3)	0	0	0	m3
Access tracks				
Total length of access track (m)	15507	15505	15509	m
Existing track length (m)	5264	5263	5265	m
Length of access track that is floating road (m)	0	0	0	m
Floating road width (m)	5	5	5	m
Floating road depth (m)	0.1	0.09	0.11	m
Length of floating road that is drained (m)	0	0	0	m
Average depth of drains associated with floating roads (m)	0	0	0	m
Length of access track that is excavated road (m)	10243	10242	10244	m
Excavated road width (m)	5.5	5	5.6	m
Average depth of peat excavated for road (m)	0	0	0	m
Length of access track that is rock filled road (m)	0	0	0	m
Rock filled road width (m)	5	5	5	m
Rock filled road depth (m)	300	299	301	m
Length of rock filled road that is drained (m)	10243	10242	10244	m
Average depth of drains associated with rock filled roads (m)	500	499	501	m
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)	0	0	0	
Area of additional peat excavated (m^2)	0	0	0	
Peat Landslide Hazard				
Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity	negligible	negligible	negligible	Fixed

Input data	Expected value	Minimum value	Maximum value	Source of data
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)	0	0	0	ha
Water table depth in degraded bog before improvement (m)	0	0	0	m
Water table depth in degraded bog after improvement (m)	0	0	0	m
Time required for hydrology and habitat of bog to return to its previous state on improvement (years)	2	2	2	years
Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years)	2	2	2	years
Improvement of felled plantation land				
Area of felled plantation to be improved (ha)	23	22	23	ha
Water table depth in felled area before improvement (m)	0	0	0	m
Water table depth in felled area after improvement (m)	0	0	0	m
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)	2	2	2	years
Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years)	15	15	15	years
Restoration of peat removed from borrow pits				
Area of borrow pits to be restored (ha)	1	1	1	ha
Depth of water table in borrow pit before restoration with respect to the restored surface (m)	0	0	0	m
Depth of water table in borrow pit after restoration with respect to the restored surface (m)	0	0	0	m
Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years)	15	15	15	yr
Period of time when effectiveness of the restoration of peat removed from borrow pits can be guaranteed (years)	2	2	2	yr
Early removal of drainage from foundations and hardstanding				
Water table depth around foundations and hardstanding before restoration (m)	0	0	0	m
Water table depth around foundations and hardstanding after restoration (m)	0	0	0	
Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)	0	0	0	
Restoration of site after decomissioning				

Input data	Expected value	Minimum value	Maximum value	Source of data
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?	No	No	No	na
Will you attempt to block all artificial ditches and facilitate rewetting?	No	No	No	na
Will the habitat of the site be restored on decommissioning?	Yes	Yes	Yes	
Will you control grazing on degraded areas?	Yes	Yes	Yes	Y
Will you manage areas to favour reintroduction of species	Yes	Yes	Yes	Y
Methodology				
Choice of methodology for calculating emission factors	IPCC default			

Forestry input data

N/A

Construction input data

Input data	Expected value	Minimum value	Maximum value	Source of data
Fossy				
Number of turbines in this area	13	13	13	units
Turbine foundations				
Depth of hole dug when constructing foundations (m)	1e-8	1e-8	1e-8	m
Aproximate geometric shape of whole dug when constructing foundations	Circular	Circular	Circular	m
Diameter at bottom	30	30	30	
Diameter at surface	30	30	30	
Hardstanding				
Depth of hole dug when constructing hardstanding (m)	1e-8	1e-8	1e-8	m
Aproximate geometric shape of whole dug when constructing hardstanding	Rectangular	Rectangular	Rectangular	m
Length at surface	80	80	80	
Width at surface	30	30	30	
Length at bottom	80	80	80	
Width at bottom	30	30	30	
Piling				
Is piling used?	No	No	No	No
Volume of Concrete				
Volume of concrete used (m^3) in the entire area	6000	6000	6000	m^3

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