Core input data

ENTER INPUT DATA HERE! VALUES SHOULD ONLY BE CHANGED ON THIS SHEET. **DO NOT USE EXAMPLE VALUES AS DEFAULTS!** ENTER YOUR OWN VALUES THAT ARE SPECIFIC TO YOUR PARTICULAR SITE.

Note: The input parameters include some variables that can be specified by default values, but others that must be site specific. Variables that can be taken from defaults are marked with purple tags on left hand side.

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Input data	Expected values: Enter expected value here	Record source of data	Possible range of values: Enter minimum value here	Record source of data	Enter maximum value here	Record source of data
Windfarm characteristics						
Dimensions						
No. of turbines	25		25		25	
Lifetime of windfarm (years)	30	Fixed	25		35	
Performance						
Power rating of turbines (turbine capacity) (MW)	3.65		3.5		4.8	
Capacity factor	Direct input of capacity factor		Direct input of capacity factor		Direct input of capacity factor	
Enter estimated capacity factor (percentage efficiency)	0.3		0.3		0.3	
Backup						
Extra capacity required for backup (%)	1.15		1.1		1.2	
Additional emissions due to reduced thermal efficiency of the reserve generation (%)	10		9		11	
Carbon dioxide emissions from turbine life - (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	
Average annual air temperature at site (°C)	9.3		9.3		9.3	
Average depth of peat at site (m)	1.70		1.70		1.70	
C Content of dry peat (% by weight)	55		50		60	
Average extent of drainage around drainage features at site (m)	15.00		10.00		20.00	
Average water table depth at site (m)	1.50		1.00		2.00	
Dry soil bulk density (g cm^{-3})	0.10		0.09		0.11	
Characteristics of bog plants						
Time required for regeneration of bog plants after restoration (years)	10		5		15	
Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha^{-1} yr^{-1})	0.25		0.2		0.3	
Forestry Plantation Characteristics						
Method used to calculate CO_2 loss from forest felling	Enter simple data		Enter simple data		Enter simple data	
Area of forestry plantation to be felled (ha)	149.5		139.5		159.5	
Average rate of carbon sequestration in timber (tC ha-1 yr-1)	3.60		3.50		3.70	
Counterfactual emission factors						
To update counterfactual emission factors from the web — Click here (not yet operational)						
Coal-fired plant emission factor (t CO_2 MWh^{-1})						
Grid-mix emission factor (t CO_2 MWh^{-1})						
Fossil fuel-mix emission factor (t CO_2 MWh^{-1})						
Borrow pits						
Number of borrow pits	3		3		3	
Average length of pits (m)	210		210		210	
Average width of pits (m)	110		110		110	
Average depth of peat removed from pit (m)	0.60		0.60		0.60	
Foundations and hard-standing area associated with each turbine						
Method used to calculate CO_2 loss from foundations and hard-standing	Rectangular with vertical walls		Rectangular with vertical walls		Rectangular with vertical walls	
Average length of turbine foundations (m)	20		20		20	
Average width of turbine foundations (m)	20		20		20	
Average depth of peat removed from turbine foundations (m)	1.20		1.20		1.20	
Average length of hard-standing (m)	55		55		55	
Average width of hard-standing (m)	35		35		35	
Average depth of peat removed from hard-standing (m)	1.20		1.20		1.20	
Access tracks						
Total length of access track (m)	29		29		29	
Existing track length (m)	16.8		16.8		16.8	
Length of access track that is floating road (m)	3		3		3	
Floating road width (m)	6		5		7	
Floating road depth (m)	1.00		0.75		1.25	
Length of floating road that is drained (m)	6.4		0		6.4	
Average depth of drains associated with floating roads (m)	0.50		0.40		0.60	
Length of access track that is excavated road (m)	9.2		9.2		9.2	
Excavated road width (m)	7		6		8	
Average depth of peat excavated for road (m)	1.50		1.50		1.50	
Length of access track that is rock filled road (m)	0		0		0	
Rock filled road width (m)						
Rock filled road depth (m)						
Length of rock filled road that is drained (m)						
Average depth of drains associated with rock filled roads (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)						
Additional peat excavated (not already accounted for above)						
Volume of additional peat excavated (m^3)	44265		44265		44265	
Area of additional peat excavated (m^2)	80250.0		80250.0		80250.0	
Peat Landslide Hazard						
Weblink: Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity 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)						
Water table depth in degraded bog before improvement (m)						
Water table depth in degraded bog after improvement (m)						
Time required for hydrology and habitat of bog to return to its previous state on improvement (years)						
Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years)						
Improvement of felled plantation land						
Area of felled plantation to be improved (ha)						
Water table depth in felled area before improvement (m)						
Water table depth in felled area after improvement (m)						
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)						
Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years)						
Restoration of peat removed from borrow pits						
Area of borrow pits to be restored (ha)	0		0		0	
Depth of water table in borrow pit before restoration with respect to the restored surface (m)						
Depth of water table in borrow pit after restoration with respect to the restored surface (m)						
Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years)	5.0		1.0		10.0	
Period of time when effectiveness of the restoration of peat removed from borrow pits can be guaranteed (years)						
Early removal of drainage from foundations and hardstanding						
Water table depth around foundations and hardstanding before restoration (m)						
Water table depth around foundations and hardstanding after restoration (m)						
Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)	35		26		45	
Restoration of site after decomissioning						
Will the hydrology of the site be restored on decommissioning?	Yes		Yes		No	
Will you attempt to block any gullies that have formed due to the windfarm?	Yes		Yes		No	
Will you attempt to block all artificial ditches and facilitate rewetting?	Yes		Yes		No	
Will the habitat of the site be restored on decommissioning?	No		Yes		No	
Will you control grazing on degraded areas?	No		Yes		No	
Will you manage areas to favour reintroduction of species	No		Yes		No	

Choice of methodology for calculating emission factors	Site specific (required for planning applications)

Note: Capacity factor. The capacity factor of any power plant is the proportion of energy produced during a given period with respect to the energy that would have been produced had the wind farm been running continually and at maximum output (DECC (2004); see also www.bwea.com/ref/capacityfactors.html).
Capacity Factor = Electricity generated during the period [kWh]/ (Installed capacity [kW] x number of hours in the period [h])
The average capacity factor between 1998 and 2004 for Scotland was 30% (DTI, 2006, Energy Trends, March 2006). We recommend that a site-specific capacity factor site should be used (as measured during planning stage). The average capacity factor for the United Kingdom, in 2009, was 27%, and 28% for Scotland (Energy Trends, September 2010)

Note: Extra capacity required for backup . If 20% of national electricity is generated by wind energy, the extra capacity required for backup is 5% of the rated capacity of the wind plant (Dale et al 2004, Energy Policy, 32, 1949-56). We suggest this should be 5% of the actual output. If it is assumed that less than 20% of national electricity is generated by wind energy, a lower percentage should be entered (0%).
The House of Lords Economic Affairs Committee report on The Economics of Renewable Energy (2008) (www.parliament.the-stationery-office.co.uk/pa/ld200708/ldselect/ldeconaf/195/19507.htm#n36) notes that to cover peak demand a '20% margin of extra capacity has been sufficient to keep the risk of a power cut due to insufficient generation at a very low level.' The estimate provided by BERR was a range of 10% to 20% of installed capacity of wind energy. E.ON is reported as proposing that the capacity credit of wind power should be 8%, and The Renewable Energy Foundation proposed the use of the square root of the wind capacity (in GW) as conventional capacity (e.g.

Note: Extra emissions due to reduced thermal efficiency of the reserve power generation ≈ 10%

Note: Emissions from turbine life If total emissions for the windfarm are unknown, emissions will be calculated according to turbine capacity. The normal range of CO_2 emissions is 394 to 8147 t CO_2 MW (White & Kulcinski, 2000; White, 2007).

Note: Type of peatland An 'acid bog' is fed primarily by rainwater and often inhabited by sphagnum moss, thus making it acidic. See Stoneman & Brooks (1997).
A 'fen' is a type of wetland fed by surface and/or groundwater. See McBride et al. (2011).

Note: Time required for regeneration of previous habitat. Loss of fixation should be assumed to be over lifetime of windfarm only. This time could be longer if plants do not regenerate. The requirements for after-use planning include the provision of suitable refugia for peat-forming vegetation, the removal of structures, or an assessment of the impact of leaving them in situ. Methods used to reinstate the site will affect to likely time for regeneration of the previous habitat. This time could also be shorter if plants regenerate during lifetime of windfarm. If so, enter number of years estimated for regeneration.

Note: Carbon fixation by bog plants
Apparent C accumulation rate in peatland is 0.12 to 0.31 tC ha^{-1} yr^{-1} (Turunen et al., 2001; Botch et al., 1995). The SNH guidance uses a value of 0.25 tC ha^{-1} yr^{-1}.
^{1} yr^{-1}.

Note: Area of forestry plantation to be felled. If the forestry was planned to be removed, with no further rotations planted, before the windfarm development, the area to be felled should be entered as zero.

Note: Plantation carbon sequestration. This is dependent on the yield class of the forestry. The SNH technical guidance assumed yield class of 16 m3 ha^{-1} yr^{-1}, compared to the value of 14 m3 ha^{-1} yr^{-1} provided by the Forestry Commission. Carbon sequestered for yield class 16 m^3 ha^{-1} y^{-1} = 3.6 tC ha^{-1} yr^{-1} (Cannell, 1999).

Note: Coal-Fired Plant and Grid Mix Emission Factors. Coal-fired plant EF = 0.86 t CO_2 MWh^{-1}; Grid-Mix EF = 0.43 t CO_2 MWh^{-1}. Source = Defra, 2002.

Note: Fossil Fuel-Mix Emission Factor. The 5 year average emission factor calculated using estimated CO_2 emissions for 2002 and 2003 from the National Atmospheric Emission Inventory (Baggott et al., 2007), and for 2004 to 2006 (Digest of UK Energy Statistics, 2007) is 0.607 tCO_2 MWh^{-1}.

Note: Total length of access track. If areas of access track overlap with hardstanding area, exclude these from the total length of access track to avoid double counting of land area lost.

Note: Floating road depth. Accounts for sinking of floating road. Should be entered as the average depth of the road expected over the lifetime of the windfarm. If no sinking is expected, enter as zero

Note: Length of floating roat that is drained. Refers to any drains running along the length of the road

Note: Rock filled roads. Rock filled roads are assumed to be roads where no peat has been removed and rock has been placed on the surface and allowed to settle.

Note: Depth of peat cut for cable trenches. In shallow peats, the cable trenches may be cut below the peat. To avoid overestimating the depth of peat affected by the cable trenches, only enter the depth of the peat that is cut.

Note: Peat Landslide Hazard. It is assumed that measures have been taken to limit damage (Scottish Executive, 2006, Peat Landslide Hazard and Risk Assessments. Best Practice Guide for Proposed Electricity Generation Developments. Scottish Executive, Edinburgh. pp. 34-35) so that C losses due to peat landslide can be assumed to be negligible. Link: http://www.scotland.gov.uk/Publications/2006/12/21162303/1.

Note: Period of time when improvement can be guaranteed. This gurantee should be absolute. Therefore, if you enter a value beyond the lifetime of the windfarm you should provide strong supporting evidence that this improvement can be guaranteed for the full period given. This includes the time requirement for the improvement to become effective. For example if time required for hydrology and habitat to return to its previous state is 10 years and the restoration can be guaranteed over the lifetime of the windfarm (25 years), the period of time when the improvement can be guaranteed should be entered as 25 years, and the improvement will be effective for (25 - 10) = 15 years.

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Note: Period of time when improvement can be guaranteed. This is assumed to be the lifetme of the windfarm as restoration after windfarm decomissioning is already accounted for in restoration of the site

Note: Restoration of site. Ilf the water table at the site is returned to its original level or higher on decommissioning, and habitat at the site is restored, it is assumed that C losses continue only over the lifetime of the windfarm. Otherwise, C losses from drained peat are assumed to be 100%.

Note: Choice of methodology for calculating emission factors. The IPCC default methodology is the internationally accepted standard (IPCC, 1997). However, it is stated in IPCC (1997) that these are rough estimates, and "these rates and production periods can be used if countries do not have more appropriate estimates". Therefore, we have developed more site specific estimates for use here based on work from the Scottish Government funded ECOSSE project (Smith et al, 2007. ECOSSE: Estimating Carbon in Organic Soils - Sequestration and Emissions. Final Report. SEERAD Report. ISBN 978 0 7559 1498 2. 166pp.).

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Results

PAYBACK TIME AND CO_2 EMISSIONS

Note: The carbon payback time of the windfarm is calculated by comparing the loss of C from the site due to windfarm development with the carbon-savings achieved by the windfarm while displacing electricity generated from coal-fired capacity or grid-mix.

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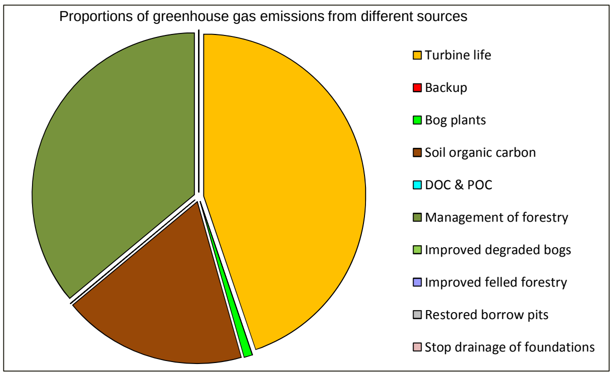
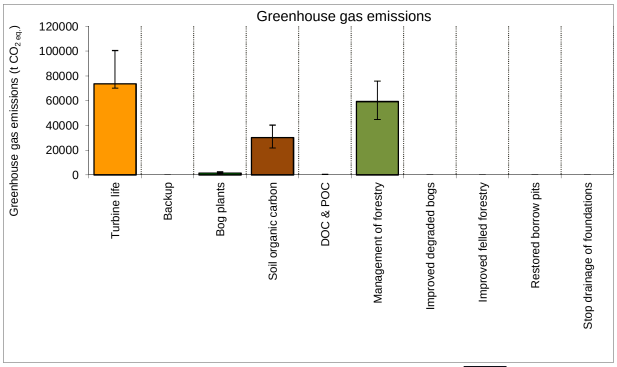
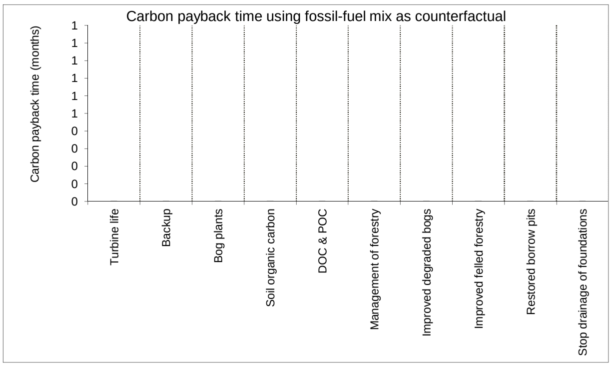
	Exp.	*Min.*	*Max.*
1. Windfarm CO_2 emission saving over…			
…coal-fired electricity generation ($tCO_2\ yr^{-1}$)	0	0	0
…grid-mix of electricity generation ($tCO_2\ yr^{-1}$)	0	0	0
…fossil fuel - mix of electricity generation ($tCO_2\ yr^{-1}$)	0	0	0
Energy output from windfarm over lifetime (MWh)	71942	57488	110376
Total CO_2 losses due to wind farm (t CO_2 eq.)			
2. Losses due to turbine life (eg. manufacture, construction, decomissioning)	73571	70067	100433
3. Losses due to backup	0	0	0
4. Losses due to reduced carbon fixing potential	1377	690	2437
5. Losses from soil organic matter	30094	21747	40172
6. Losses due to DOC & POC leaching	0	411	0
7. Losses due to felling forestry	59207	44760	75743
Total losses of carbon dioxide	164249	137675	218784
8. Total CO_2 gains due to improvement of site (t CO_2 eq.)			
8a. Gains due to improvement of degraded bogs	0	0	0
8b. Gains due to improvement of felled forestry	0	0	0
8c. Gains due to restoration of peat from borrow pits	0	0	0
8d. Gains due to removal of drainage from foundations & hardstanding	0	0	0
Total gains	0	0	0

RESULTS	*Exp.*	*Min.*	*Max.*
Net emissions of carbon dioxide (t $CO_{2\ eq.}$)	**164249**	**137675**	**218784**
Carbon Payback Time			
…coal-fired electricity generation (years)	#DIV/0!	#DIV/0!	#DIV/0!
…grid-mix of electricity generation (years)	#DIV/0!	#DIV/0!	#DIV/0!
…fossil fuel - mix of electricity generation (years)	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**
Ratio of soil carbon loss to gain by restoration (TARGET ratio (Natural Resources Wales) < 1.0)	**No gains!**	**No gains!**	**No gains!**
Ratio of CO_2 eq. emissions to power generation (g / kWh) (TARGET ratio by 2030 (electricity generation) < 50 g /kWh)	**2283**	**2395**	**1982**







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Results

PAYBACK TIME AND CO_2 EMISSIONS

Note: The carbon payback time of the windfarm is calculated by comparing the loss of C from the site due to windfarm development with the carbon-savings achieved by the windfarm while displacing electricity generated from coal-fired capacity or grid-mix.

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