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.

Click here to move to Payback Time — Click here
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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	9		9		9		Chapter 2: Project Description
Lifetime of windfarm (years)	35	Fixed	35		35		Chapter 2: Project Description
Performance							
Power rating of turbines (turbine capacity) (MW)	6.5		6		7		Chapter 2: Project Description
Capacity factor	Direct input of capacity fa		Direct input of capacity fac		Direct input of capacity fac		
Enter estimated capacity factor (percentage efficiency)	35.0		31.5		38.5		
Backup							
Extra capacity required for backup (%)	5		5		5		All - Island Generation Capacity Statement 2021 - 2030
Additional emissions due to reduced thermal efficiency of the reserve generation (%)	10		10		10		Fixed
Carbon dioxide emissions from turbine life - (eg. manufacture, construction, decommissioning)	Calculate wrt installed cap 2		Calculate wrt installed cap 2		Calculate wrt installed cap 2		
Characteristics of peatland before windfarm development							
Type of peatland	Acid b 1		Acid b		Acid b		Chapter 6: Biodiversity
Average annual air temperature at site (°C)	10.65		6.1		16		Chapter 13: Air & Climate (Edenderry Monitoring Station)
Average depth of peat at site (m)	0.00		0.00		0.50		Chapter 9: Soils and Geology
C Content of dry peat (% by weight)	55		50		60		
Average extent of drainage around drainage features at site (m)	10.00		5.00		15.00		Chapter 10: Hydrology & Hydrogeology
Average water table depth at site (m)	1.00		0.10		1.00		Chapter 10: Hydrology & Hydrogeology
Dry soil bulk density (g cm^{-3})	0.10		0.09		0.11		Default Value
Characteristics of bog plants							
Time required for regeneration of bog plants after restoration (years)	10		5		15		Best Practice in Bog Restoration Ireland
Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha^{-1} yr^{-1})	0.25		0.24		0.26		Default Value
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)	0		0		0		Chapter 2: Project Description
Average rate of carbon sequestration in timber (tC ha-1 yr-1)	3.60		3.50		3.70		Cannell,1999
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})	0.945		0.945		0.945		
Grid-mix emission factor (t CO_2 MWh^{-1})	0.283		0.283		0.283		
Fossil fuel-mix emission factor (t CO_2 MWh^{-1})	0.432		0.432		0.432		
Borrow pits							
Number of borrow pits	0		0		0		Chapter 2: Project Description
Average length of pits (m)	0		0		0		Chapter 2: Project Description
Average width of pits (m)	0		0		0		Chapter 2: Project Description
Average depth of peat removed from pit (m)	0.00		0.00		0.00		Chapter 2: Project Description
Foundations and hard-standing area associated with each turbine							
Method used to calculate CO_2 loss from foundations and hard-standing	Rectangular with vertical w 1		Rectangular with vertical w 1		Rectangular with vertical w 1		
Average length of turbine foundations (m)	21.24		21.5		21.2		Chapter 2: Project Description - Largest foundation presumed for all turbines (worse case)
Average width of turbine foundations (m)	21.24		21.5		21.3		Chapter 2: Project Description - Largest foundation presumed for all turbines (worse case)
Average depth of peat removed from turbine foundations (m)	0.00		0.00		0.10		Chapter 2: Project Description - Largest foundation presumed for all turbines (worse case)
Average length of hard-standing (m)	59.9		59.8		60		Chapter 2: Project Description - Largest hardstand presumed for all turbines (worse case)
Average width of hard-standing (m)	59.9		59.8		60		Chapter 2: Project Description - Largest hardstand presumed for all turbines (worse case)
Average depth of peat removed from hard-standing (m)	0.00		0.00		0.10		Chapter 2: Project Description
Access tracks							
Total length of access track (m)	6780		6780		6780		Chapter 2: Project Description
Existing track length (m)	1080		1080		1080		Chapter 2: Project Description
Length of access track that is floating road (m)	0		0		0		
Floating road width (m)	0		0		0		Chapter 2: Project Description
Floating road depth (m)	0.00		0.00		0.00		Chapter 2: Project Description
Length of floating road that is drained (m)	0		0		0		Chapter 2: Project Description
Average depth of drains associated with floating roads (m)	0		0.00		0.10		Chapter 2: Project Description
Length of access track that is excavated road (m)	0		0		0		
Excavated road width (m)	0		0		0		Chapter 2: Project Description
Average depth of peat excavated for road (m)	0.00		0.00		0.00		Chapter 2: Project Description
Length of access track that is rock filled road (m)	5700		5700		5700		
Rock filled road width (m)	0		0		0		Chapter 2: Project Description
Rock filled road depth (m)	0		0		0		Chapter 2: Project Description
Length of rock filled road that is drained (m)	0		0		0		Chapter 2: Project Description
Average depth of drains associated with rock filled roads (m)	0.00		0.00		0.00		Chapter 2: Project Description
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)	0.00		0.00		0.00		Chapter 9: Soils and Geology
Average depth of peat cut for cable trenches (m)	0.00		0.00		0.00		Chapter 9: Soils and Geology
Additional peat excavated (not already accounted for above)							
Volume of additional peat excavated (m^3)	0		0		0		Chapter 9: Soils and Geology
Area of additional peat excavated (m^2)	0.0		0.0		0.0		Chapter 9: Soils and Geology
Peat Landslide Hazard							
Weblink: Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments	neglible		neglible		neglible		Chapter 9: Soils and Geology
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		
Water table depth in degraded bog before improvement (m)	0		0		0		
Water table depth in degraded bog after improvement (m)	0		0		0		
Time required for hydrology and habitat of bog to return to its previous state on improvement (years)	0		0		0		
Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years)	0		0		0		
Improvement of felled plantation land							
Area of felled plantation to be improved (ha)	0		0		0		Chapter 6: Biodiversity
Water table depth in felled area before improvement (m)	0		0		0		Chapter 6: Biodiversity
Water table depth in felled area after improvement (m)	0		0		0		Chapter 6: Biodiversity
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)	0		0		0		
Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years)	0		0		0		
Restoration of peat removed from borrow pits							
Area of borrow pits to be restored (ha)	0		0		0		Chapter 9: Soils and Geology
Depth of water table in borrow pit before restoration with respect to the restored surface (m)	0.00		0.00		0.00		Chapter 9: Soils and Geology
Depth of water table in borrow pit after restoration with respect to the restored surface (m)	0.00		0.00		0.00		Chapter 9: Soils and Geology
Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years)	0		0		0		
Period of time when effectiveness of the restoration of peat removed from borrow pits can be guaranteed (years)	0		0		0		
Early removal of drainage from foundations and hardstanding							
Water table depth around foundations and hardstanding before restoration (m)	0.00		0.00		0.00		Chapter 6: Biodiversity
Water table depth around foundations and hardstanding after restoration (m)	0.00		0.00		0.00		Chapter 6: Biodiversity
Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)	1.5		1		1		Chapter 6: Biodiversity
Restoration of site after decomissioning							
Will the hydrology of the site be restored on decommissioning?	Yes		Yes		Yes		
Will you attempt to block any gullies that have formed due to the windfarm?	Not appli 3		Not appli		Not appli		
Will you attempt to block all artificial ditches and facilitate rewetting?	Not appli 3		Not appli		Not appli		
Will the habitat of the site be restored on decommissioning?	Yes		Yes		Yes		
Will you control grazing on degraded areas?	Not appli 3		Not appl		Not appl		
Will you manage areas to favour reintroduction of species	Not appli 3		Not appli		Not appli		
Choice of methodology for calculating emission factors	IPCC default						

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])
We recommend that a site-specific capacity factor ~~site~~ should be used (as measured during planning stage), and should represent the average emission factor expected over the lifetime of the windfarm, accounting for decline in efficiency with age (Hughes, 2012). The 5 year average capacity factor (or "load factor") for UK onshore wind between 2010 and 2014, based on average beginning and end of year capacity, was 29.2% (DUKES, 2015).

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). 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 (Parliamentary Business, 2008) 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. 36 GW of wind plant to match 6 GW of conventional plant).

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 should 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 (Stoneman & Brooks,1997).
A 'fen' is a type of wetland fed by surface and/or groundwater (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 the 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 t C ha^{-1} yr^{-1} (Turunen et al., 2001; Botch et al., 1995). The SNH guidance uses a value of 0.25 t C ha^{-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 m^3 ha^{-1} yr^{-1}, compared to the value of 14 m^3 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 emission factor (EF) from electricity supplied in 2014 = 0.093 t CO_2 MWh^{-1}; Grid-Mix EF for 2014 = 0.394 t CO_2 MWh^{-1}. Source = DUKES, 2015b.

Note: Fossil Fuel-Mix Emission Factor. The emission factor from electricity supplied in 2014 from all fossil fuels = 0.642 t CO_2 MWh^{-1}. Source = DUKES, 2015b.

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 road that is drained. Refers to any drains running along the length of the

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 guarantee 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)

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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.

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

Note: Restoration of site. If 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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Click here to move to Payback Time — Click here
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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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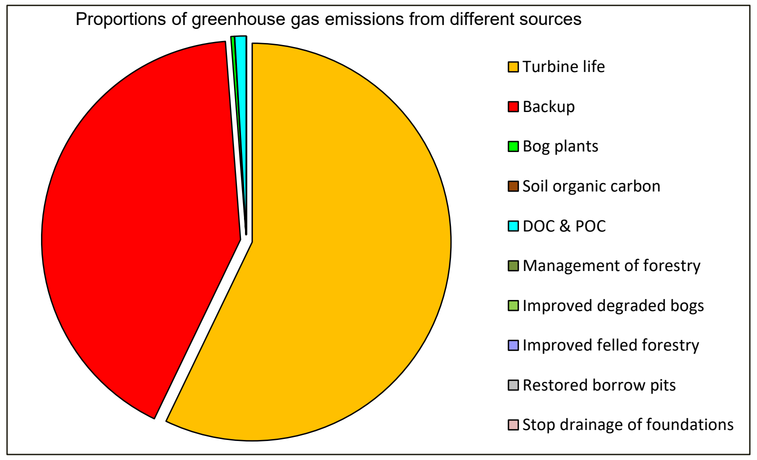
	Exp.	Min.	Max.
1. Windfarm CO_2 emission saving over…			
…coal-fired electricity generation ($tCO_2\ yr^{-1}$)	169496	140812	200788
…grid-mix of electricity generation ($tCO_2\ yr^{-1}$)	50759	42169	60130
…fossil fuel - mix of electricity generation ($tCO_2\ yr^{-1}$)	77484	64371	91789
Energy output from windfarm over lifetime (MWh)	6277635	5215266	7436583
Total CO_2 losses due to wind farm ($t\ CO_2$ eq.)			
2. Losses due to turbine life (eg. manufacture, construction, decomissioning)	53153	46247	54656
3. Losses due to backup	38742	35762	41722
4. Losses due to reduced carbon fixing potential	269	168	422
5. Losses from soil organic matter	-262	-1370	1790
6. Losses due to DOC & POC leaching	862	117	2231
7. Losses due to felling forestry	0	0	0
Total losses of carbon dioxide	92764	80924	100820
8. Total CO_2 gains due to improvement of site ($t\ CO_2$ eq.)			
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

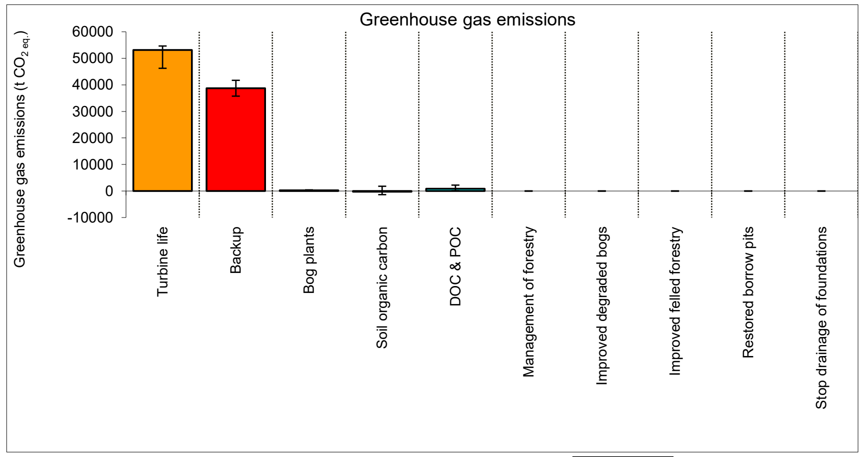
RESULTS	Exp.	Min.	Max.
Net emissions of carbon dioxide ($t\ CO_{2\ eq.}$)	**92764**	**80924**	**100820**
Carbon Payback Time			
…coal-fired electricity generation (years)	0.5	0.4	0.7
…grid-mix of electricity generation (years)	1.8	1.3	2.4
…fossil fuel - mix of electricity generation (years)	**1.2**	**0.9**	**1.6**
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)	**15**	**11**	**19**

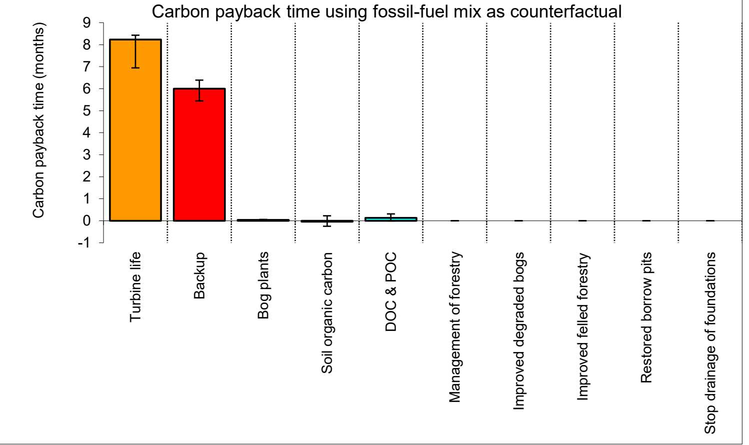


Data used in barchart of carbon payback time using fossil-fuel mix as counterfactual

Greenhouse gas emissions

	Exp.	Min	Max
Turbine life	53153	6906	1503
Backup	38742	2980	2980
Bog plants	269	101	153
Soil organic carbon	0	1108	2052
DOC & POC	862	744	1369
Management of forestry	0	0	0
Improved degraded bogs	0	0	0
Improved felled forestry	0	0	0
Restored borrow pits	0	0	0
Stop drainage of foundations	0	0	0





Data used in barchart of carbon payback time using fossil-fuel mix as counterfactual

Greenhouse gas emissions	Exp.	Min.	Max.	Carbon payback time (months) Exp.	Min.	Max.
Turbine life	53153	6906	1503	8	1	0
Backup	38742	2980	2980	6	1	0
Bog plants	269	101	153	0	0	0
Soil organic carbon	-262	1108	2052	0	0	0
DOC & POC	862	744	1369	0	0	0
Management of forestry	0	0	0	0	0	0
Improved degraded bogs	0	0	0	0	0	0
Improved felled forestry	0	0	0	0	0	0
Restored borrow pits	0	0	0	0	0	0
Stop drainage of foundations	0	0	0	0	0	0
	92764			14		

Check Check Check Check Check Check Check Check Check Check

Results

PAYBACK TIME AND CO_2 EMISSIONS

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