Appendix 14B

Carbon Calculator Spreadsheet

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

Click here to return to Instructions Click here

Input data	Expected values: Enter expected value here	Expected values: Record source of data	Possible range of values: Enter minimum value here	Record source of data	Possible range of values: Enter maximum value here	Record source of data
Windfarm characteristics						
Dimensions						
No. of turbines	12	Fixed	12		12	
Lifetime of windfarm (years)	35	Fixed	30		30	
Performance						
Power rating of turbines (turbine capacity) (MW)	4.5	Assumed	5		5	
Capacity factor	Direct input of capacity fa		Direct input of capacity fa		Direct input of capacity fa	
Enter estimated capacity factor (percentage efficiency)	30.0	Long term average capacity factor (IWEA)	30.0		30.0	
Backup						
Extra capacity required for backup (%)	5	Value from SNH guidance	5		5	
Additional emissions due to reduced thermal efficiency of the reserve generation (%)	10	Value from SNH guidance. Over 20% of national electricity is from renewables.	10		10	
Carbon dioxide emissions from turbine life - (eg. manufacture, construction, decommissioning)	Calculate wrt installed ca		Calculate wrt installed ca		Calculate wrt installed ca	
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)	15.97	Section 2.2 Chapter 2.	3.15		3.15	
Average rate of carbon sequestration in timber (tC ha-1 yr-1)	3.60	Value from SNH guidance	3.60		3.60	
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})	0.375	Energy Related Co2 emissions I Ireland 2005 to 2018. SEAI.	0.394		0.394	
Fossil fuel-mix emission factor (t CO_2 MWh^{-1})						
Borrow pits						
Number of borrow pits	0	No borrow pits. Only peat desosition areas	0		0	
Average length of pits (m)	0		0		0	
Average width of pits (m)	0		0		0	
Average depth of peat removed from pit (m)	0.00		0.00		0.00	
Improvement of C sequestration at site by blocking drains, restoration of habitat etc						
Improvement of felled plantation land		Assumed to be nil				
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)	0.00		0.00		0.00	
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	
Early removal of drainage from foundations and hardstanding	0.0		0.0		0.0	
Water table depth around foundations and hardstanding before restoration (m)	0.00	Estimate from previous projects on peat	0.20		0.20	
Water table depth around foundations and hardstanding after restoration (m)	0.00	Estimate from previous projects on peat	0.20		0.20	
Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)	36		36		36	
Restoration of site after decomissioning						
Will the hydrology of the site be restored on decommissioning?	No		Yes		Yes	
Will you attempt to block any gullies that have formed due to the windfarm?	No		Yes		Yes	
Will you attempt to block all artificial ditches and facilitate rewetting?	No		Yes		Yes	
Will the habitat of the site be restored on decommissioning?	Yes		Yes		Yes	
Will you control grazing on degraded areas?	Not appli		Yes		Yes	
Will you manage areas to favour reintroduction of species	Not ap		Yes		Yes	

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: Time required for regeneration of previous habitat. Loss of fixation should be assumed to be

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: 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

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

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

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.).

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

Click here to return to Instructions Click here

Results

PAYBACK TIME AND CO_2 EMISSIONS

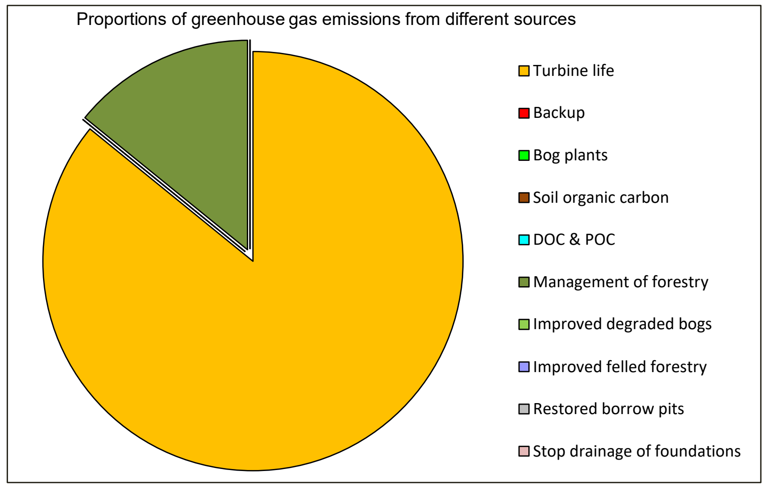
Note: The carbon payback time of the windfarm is calculated by comparing the loss of C from the site due to windfarm development with the carbon-savings achieved by the windfarm while displacing electricity generated from coal-fired capacity or grid-mix.

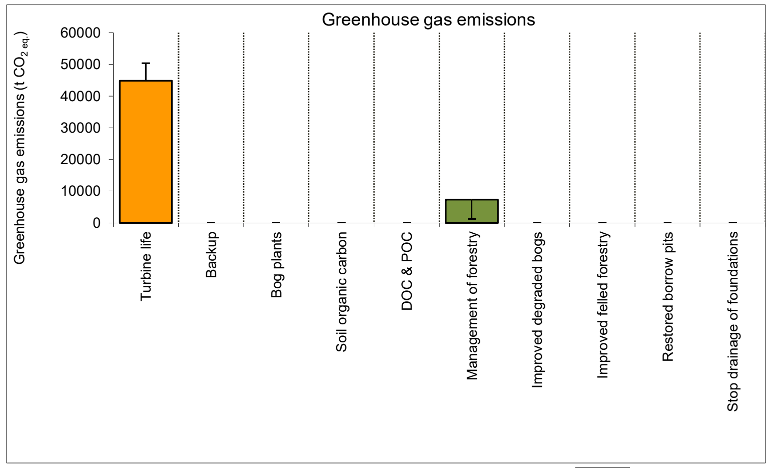
Click here to return to Input data — Click here

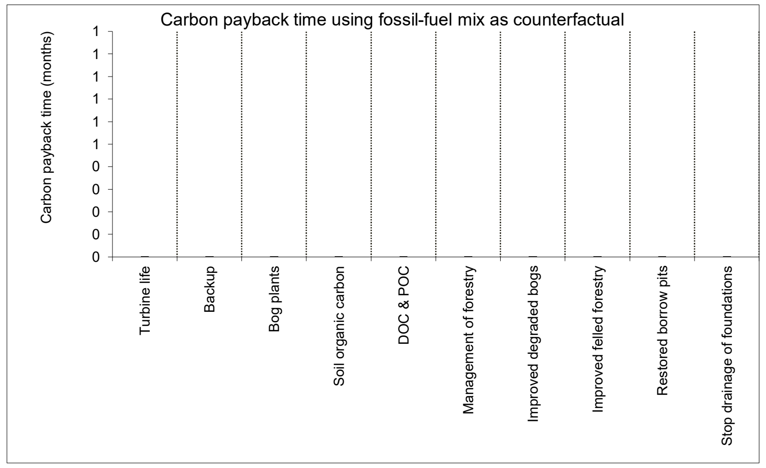
Click here to return to Instructions — Click here

	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})	53217	62126	62126
…fossil fuel - mix of electricity generation (tCO_2 yr^{-1})	0	0	0
Energy output from windfarm over lifetime (MWh)	4966920	4730400	4730400
Total CO_2 losses due to wind farm (t CO_2 eq.)			
2. Losses due to turbine life (eg. manufacture, construction, decomissioning)	44844	50450	50450
3. Losses due to backup	0	0	0
7. Losses due to felling forestry	7379	1248	1248
Total losses of carbon dioxide	52223	51698	51698
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	#REF!	#REF!
8b. Change in emissions due to improvement of felled forestry	0	#REF!	#REF!
8c. Change in emissions due to restoration of peat from borrow pits	0	#REF!	#REF!
8d. Change in emissions due to removal of drainage from foundations & hardstanding	0	#REF!	#REF!
Total change in emissions due to improvements	0	#REF!	#REF!

RESULTS	*Exp.*	*Min.*	*Max.*
Net emissions of carbon dioxide (t $CO_{2\ eq.}$)	52223	#REF!	#REF!
Carbon Payback Time			
…coal-fired electricity generation (years)	#DIV/0!	#REF!	#REF!
…grid-mix of electricity generation (years)	1.0	#REF!	#REF!
…fossil fuel - mix of electricity generation (years)	#DIV/0!	#REF!	#REF!
Ratio of soil carbon loss to gain by restoration (TARGET ratio (Natural Resources Wales) < 1.0)	No gains!	#REF!	#REF!
Ratio of CO_2 eq. emissions to power generation (g / kWh) (TARGET ratio by 2030 (electricity generation) < 50 g /kWh)	11	#REF!	#REF!







Check Check Check Check Check Check Check Check Check Check

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

Greenhouse gas emissions

	Exp.	*Min*	*Max*
Turbine life	44844	0	5606
Backup	0	0	0
Bog plants	#REF!	#REF!	#REF!
Soil organic carbon	#REF!	#REF!	#REF!
DOC & POC	#REF!	#REF!	#REF!
Management of forestry	7379	6131	0
Improved degraded bogs	0	#REF!	#REF!
Improved felled forestry	0	#REF!	#REF!
Restored borrow pits	0	#REF!	#REF!
Stop drainage of foundations	0	#REF!	#REF!

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

Greenhouse gas emissions				Carbon payback time (months)		
	Exp.	*Min.*	*Max.*	*Exp.*	*Min.*	*Max.*
Turbine life	44844	-5606	5606	#DIV/0!	#DIV/0!	#DIV/0!
Backup	0	0	0	#DIV/0!	#DIV/0!	#DIV/0!
Bog plants	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
Soil organic carbon	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
DOC & POC	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
Management of forestry	7379	6131	-6131	#DIV/0!	#DIV/0!	#DIV/0!
Improved degraded bogs	0	#REF!	#REF!	#DIV/0!	#REF!	#REF!
Improved felled forestry	0	#REF!	#REF!	#DIV/0!	#REF!	#REF!
Restored borrow pits	0	#REF!	#REF!	#DIV/0!	#REF!	#REF!
Stop drainage of foundations	0	#REF!	#REF!	#DIV/0!	#REF!	#REF!
	#REF!			#REF!		

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.

Click here to return to Input data — Click here

Click here to return to Instructions — Click here