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APPENDIX 11-2

CARBON CALCULATIONS

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		Possible range of values		Record source of data
	Enter expected value here	Record source of data	Enter minimum value here	Record source of data	
Windfarm characteristics					
Dimensions					
No. of turbines	8	Fixed	8		8
Lifetime of windfarm (years)	35		35		35
Performance					
Power rating of turbines (turbine capacity) (MW)	6.1		6		6.2
Capacity factor	Direct input of capacity fa		Direct input of capacity fa		Direct input of capacity fa
Enter estimated capacity factor (percentage efficiency)	0.35		0.35		0.35
Backup					
Extra capacity required for backup (%)	5		5		5
Additional emissions due to reduced thermal efficiency of the reserve generation (%)	10		10		10
Carbon dioxide emissions from turbine life - (eg. manufacture, construction, decommissioning)	Calculate wrt installed ca		Calculate wrt installed ca		Calculate wrt installed ca
Characteristics of peatland before windfarm development					
Type of peatland	Acid t		Acid t		Acid t
Average annual air temperature at site (°C)	9.8		5.1		15.6
Average depth of peat at site (m)	1.10		1.10		1.10
C Content of dry peat (% by weight)	53.23		19.57		64.28
Average extent of drainage around drainage features at site (m)	15.00		15.00		15.00
Average water table depth at site (m)	0.50		0.10		1.00
Dry soil bulk density (g cm ⁻³)	0.132		0.072		0.293
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)	7.5		7.5		7.5
Average rate of carbon sequestration in timber (tC ha ⁻¹ yr ⁻¹)	3.45		3.50		3.55
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)	0.207		0.207		0.207
Fossil fuel-mix emission factor (t CO ₂ MWh ⁻¹)	0.424		0.424		0.424
Borrow pits					
Number of borrow pits	0		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
Foundations and hard-standing area associated with each turbine					
Method used to calculate CO ₂ loss from foundations and hard-standing	Rectangular with vertical		Rectangular with vertical		Rectangular with vertical
Average length of turbine foundations (m)	25		25		25
Average width of turbine foundations (m)	25		25		25
Average depth of peat removed from turbine foundations (m)	1.10		1.10		1.10
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)	1.10		1.10		1.10
Access tracks					
Total length of access track (m)	9000		9000		9000
Existing track length (m)	2400		2400		2400
Length of access track that is floating road (m)	1800		1800		1800
Floating road width (m)	5		5		5
Floating road depth (m)					
Length of floating road that is drained (m)					
Average depth of drains associated with floating roads (m)					
Length of access track that is excavated road (m)	4800		4800		4800
Excavated road width (m)	5		5		5
Average depth of peat excavated for road (m)	1.10		1.10		1.10
Length of access track that is rock filled road (m)					
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)					
Average depth of peat cut for cable trenches (m)	1.20		1.20		1.20
Additional peat excavated (not already accounted for above)					
Volume of additional peat excavated (m ³)	1970		1970		1970
Area of additional peat excavated (m ²)	2700.0		2700.0		2700.0
Peat Landslide Hazard					
Peat Landslide Hazard	Negligible		Negligible		Negligible
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)	25		25		25
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)	25		25		25
Restoration of peat removed from borrow pits					
Area of borrow pits to be restored (ha)					
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)					
Period of time when effectiveness of the restoration of peat removed from borrow pits can be guaranteed (years)	25		25		25
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)	15.00		10.00		5.00
Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)					
Restoration of site after decommissioning					
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
Will you attempt to block all artificial ditches and facilitate rewetting?	No		No		No
Will the habitat of the site be restored on decommissioning?	No		No		No
Will you control grazing on degraded areas?	No		No		No
Will you manage areas to favour reintroduction of species?	No		No		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]).
 We recommend that a site-specific capacity factor should be used as measured during planning stage, and should represent the average emission factor recorded 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% (Dale et al 2004).
 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 CO₂ emissions is 394 to 8147 t CO₂ 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 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 m³ ha⁻¹ yr⁻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 CO₂ MWh⁻¹; Grid-Mix EF for 2014 = 0.394 t CO₂ MWh⁻¹. Source = DUKES, 2015b.
 Note: Fossil Fuel-Mix Emission Factor. The emission factor from electricity supplied in 2014 from all fossil fuels = 0.542 t CO₂ 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 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/2006/12/211623031>

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) = 15 years.

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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. SERRAD Report. ISBN 978 0 7559 1498 2. 186pp.).

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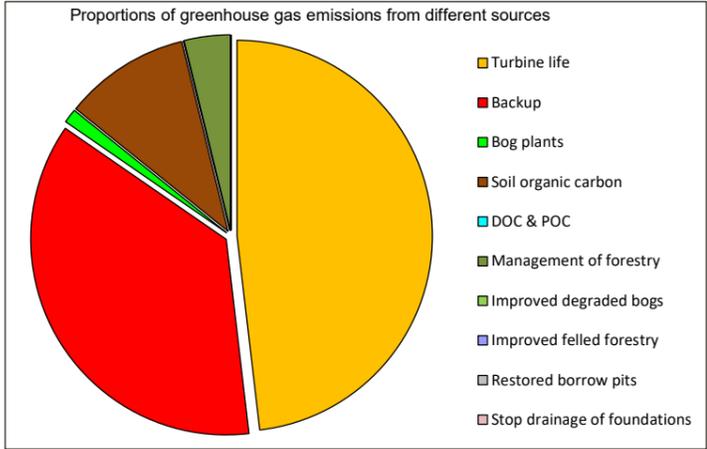
Results
PAYBACK TIME AND CO₂ EMISSIONS
 Note: The carbon payback time of the windfarm is calculated by comparing the loss of C from the site due to windfarm development with the carbon-savings achieved by the windfarm while displacing electricity generated from coal-fired capacity or grid-mix.

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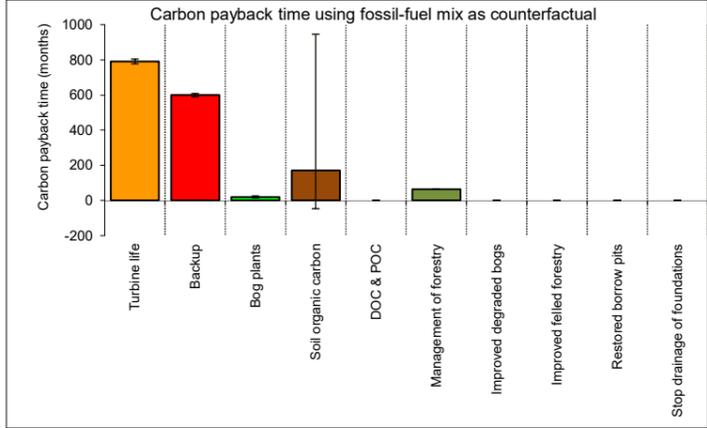
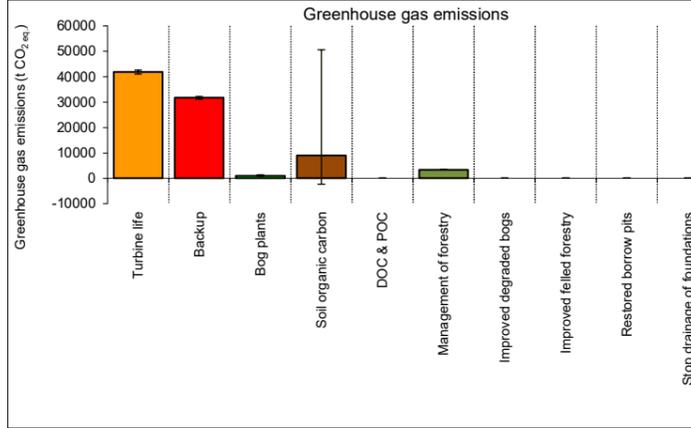
	Exp.	Min.	Max.
1. Windfarm CO₂ emission saving over...			
...coal-fired electricity generation (tCO ₂ yr ⁻¹)	1414	1391	1437
...grid-mix of electricity generation (tCO ₂ yr ⁻¹)	310	305	315
...fossil fuel - mix of electricity generation (tCO ₂ yr ⁻¹)	634	624	645
Energy output from windfarm over lifetime (MWh)	52367	51509	53226
Total CO₂ losses due to wind farm (t CO₂ eq.)			
2. Losses due to turbine life (eg. manufacture, construction, decommissioning)	41856	41108	42603
3. Losses due to backup	31720	31200	32240
4. Losses due to reduced carbon fixing potential	1008	717	1344
5. Losses from soil organic carbon	9041	-2298	50665
6. Losses due to DOC & POC leaching	0	0	0
7. Losses due to felling forestry	3321	3369	3417
Total losses of carbon dioxide	86946	74096	130269
8. Total CO₂ gains due to improvement of site (t CO₂ 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 CO₂ eq.)	86946	74096	130269
Carbon Payback Time			
...coal-fired electricity generation (years)	61.5	51.6	93.7
...grid-mix of electricity generation (years)	280.7	235.4	427.6
...fossil fuel - mix of electricity generation (years)	137.1	114.9	208.8
Ratio of soil carbon loss to gain by restoration (TARGET ratio (Natural Resources Wales) < 1.0)	No gains!	No gains!	No gains!
Ratio of CO₂ eq. emissions to power generation (g / kWh) (TARGET ratio by 2030 (electricity generation) < 50 g /kWh)	1660	1392	2529



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

Greenhouse gas emissions	Exp.	Min.	Max.
Turbine life	41856	747	747
Backup	31720	520	520
Bog plants	1008	291	336
Soil organic carbon	9041	11339	41624
DOC & POC	0	0	0
Management of forestry	3321	0	96
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.	Exp.	Min.	Max.
Turbine life	41856	747	747	792	14	14
Backup	31720	520	520	600	10	10
Bog plants	1008	291	336	19	6	6
Soil organic carbon	9041	11339	41624	171	218	775
DOC & POC	0	0	0	0	0	0
Management of forestry	3321	-48	96	63	-1	2
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
	86946			1645		

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Results
PAYBACK TIME AND CO₂ 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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Windfarm CO₂ emission saving

Note: The total emission savings are given by estimating the total possible electrical output of the windfarm multiplied by the emission factor for the counterfactual case (coal-fire generation and electricity from grid)

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Values taken from input sheet	Total			Forestry Area 1			Forestry Area 2			Forestry Area 3			Forestry Area 4			Forestry Area 5		
	Exp	Min	Max	Exp	Min	Max	Exp	Min	Max	Exp	Min	Max	Exp	Min	Max	Exp	Min	Max
Power Generation Characteristics																		
No. of turbines	8	8	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power rating of turbines (turbine capacity) (MW)	6.1	6	6.2	6.1	6	6.2	6.1	6	6.2	6.1	6	6.2	6.1	6	6.2	6.1	6	6.2
Power of windfarm (MW)	48.8	48	49.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Estimated downtime for maintenance etc (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Counterfactual emission factors																		
Coal-fired plant emission factor (t CO ₂ MWh ⁻¹)	0.945	0.945	0.945	0.945	0.945	0.945	0.945	0.945	0.945	0.945	0.945	0.945	0.945	0.945	0.945	0.945	0.945	0.945
Grid-mix emission factor (t CO ₂ MWh ⁻¹)	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207
Fossil fuel-mix emission factor (t CO ₂ MWh ⁻¹)	0.424	0.424	0.424	0.424	0.424	0.424	0.424	0.424	0.424	0.424	0.424	0.424	0.424	0.424	0.424	0.424	0.424	0.424

Calculation of capacity factor		Direct input of capacity factor		
		Exp	Min	Max
Entered capacity factor (%)		0.35	0.35	0.35

Parameters	Slope (a)			Intercept (b)		
	Exp	Min	Max	Exp	Min	Max
Partial power curves for different turbines						
User-defined	0.0	0.0	0.0	0.0	0.0	0.0
Vestas 2.0 MW Optispeed C2	1392.5	1392.5	1392.5	-4291.9	-4291.9	-4291.9

Calculation of capacity factor from forestry management	Total			Forestry Area 1			Forestry Area 2			Forestry Area 3			Forestry Area 4			Forestry Area 5		
	Exp	Min	Max	Exp	Min	Max	Exp	Min	Max	Exp	Min	Max	Exp	Min	Max	Exp	Min	Max
Wind speed ratio calculated in 7d				#####	#####	#####	#####	#####	#####	#####	#####	#####	#####	#####	#####	#####	#####	#####
Average site windspeed (m s ⁻¹)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual theoretical energy output from turbine (MW turbine ⁻¹ yr ⁻¹)	53436	52560	54312	53436	52560	54312	53436	52560	54312	53436	52560	54312	53436	52560	54312	53436	52560	54312
Power curve				User-defined	User-defined	User-defined	Partial power curves for different turbines											
(Power curve code)				1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Slope (a)				0	0	0	Exp	Min	Max									
Intercept (b)				0	0	0	Exp	Min	Max									
Annual power output from an individual turbine (MW turbine ⁻¹ yr ⁻¹)				#####	#####	#####	#####	#####	#####	#####	#####	#####	#####	#####	#####	#####	#####	#####
Calculated capacity factor (%)				#####	#####	#####	#####	#####	#####	#####	#####	#####	#####	#####	#####	#####	#####	#####

Calculation of annual energy output from wind farm	Total	Forestry Area 1			Forestry Area 2			Forestry Area 3			Forestry Area 4			Forestry Area 5		
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Direct input of capacity factor Capacity factor(%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual energy output from windfarm (MW yr⁻¹)	1496	1472	1521	0	0	0	0	0	0	0	0	0	0	0	0	0	0

RESULTS	Total			Area 1			Area 2			Area 3			Area 4			Area 5		
Windfarm CO₂ emission saving over...																		
...coal-fired electricity generation (tCO ₂ yr ⁻¹)	1414	1390.74	1437.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
...grid-mix of electricity generation (tCO ₂ yr ⁻¹)	310	304.638	314.792	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
...fossil fuel - mix of electricity generation (tCO ₂ yr ⁻¹)	634	623.992	644.792	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

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Windfarm CO₂ emission saving
 Note: The total emission savings are given by estimating the total possible electrical output of the windfarm multiplied by the emission factor for the counterfactual case (coal-fire generation and electricity from grid)

Emissions due to turbine life

Note: The carbon payback time of the windfarm due to turbine life (eg. manufacture, construction, decommissioning) 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.

Method used to estimate CO₂ emissions from turbine life (eg. manufacture, construction,	Calculate wrt installed capacity
---	----------------------------------

	Exp	Min	Max
Direct input of emissions due to turbine life (t CO₂ windfarm⁻¹)	0	0	0
Calculation of emissions due to turbine life from energy output			
CO ₂ emissions due to turbine life (tCO ₂ turbine ⁻¹)	5232	5139	5325
No. of turbines	8	8	8
Total calculated CO ₂ emission of the wind farm due to turbine life (t CO ₂ windfarm ⁻¹)	41856	41108	42603

	Total			Construction Area 1			Construction Area 2			Construction Area 3			Construction Area 4			Construction Area 5		
	Exp	Min	Max	Exp	Min	Max	Exp	Min	Max	Exp	Min	Max	Exp	Min	Max	Exp	Min	Max
Calculation of emissions due to cement used in construction																		
Volume of cement used (m ³)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO ₂ emission rate (t CO ₂ m ⁻³ cement)	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316
Total CO ₂ emissions due to cement used	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

RESULTS			
Losses due to turbine life (eg.	41856	41108	42603
Additional CO₂ payback time of windfarm due to turbine life (eg. manufacture, construction, decommissioning)			
...coal-fired electricity generation (months)	355	355	356
...grid-mix of electricity generation (months)	1622	1619	1624
...fossil fuel - mix of electricity generation (months)	792	791	793

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Emissions due to turbine life

Note: The carbon payback time of the windfarm due to turbine life (eg. manufacture, construction, decommissioning) 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.

http://www.concretecentre.com/PDF/SCF_Table%207%20Embodied%20CO2_April%202013.pdf



Embodied carbon dioxide (CO_{2,e}) of concretes used in buildings

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CONCRETE APPLICATION	Concrete designation	CO ₂ e (kgCO ₂ e/m ³) ¹			CO ₂ e (kgCO ₂ e/tonne) ¹		
		CEM I concrete	30% fly ash concrete	50% ggbs concrete	CEM I concrete	30% fly ash concrete	50% ggbs concrete
Blinding, mass fill, strip footings, mass foundations, trench foundations ²	GEN1	177	128	101	77	55	44
Reinforced Foundations ²	RC25/30**	316	263	197	133	111	83
Ground floors ²	RC28/35*	316	261	186	134	110	79
Structural: in situ floors, superstructure, walls, basements ²	RC32/40**	369	313	231	154	131	96
High strength concrete ²	RC40/50**	432	351	269	178	146	111
		CO ₂ e (kgCO ₂ e/m ³)			CO ₂ e (kgCO ₂ e/tonne)		
Unreinforced Precast flooring ³			-			165	
Reinforced precast flooring ³			-			171	
Average Generic Concrete Block ⁴			-			84	

* includes 30kg/m³ steel reinforcement

** includes 100kg/m³ steel reinforcement

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Emissions due to backup power generation

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

	Expected	Minimum	Maximum
Reserve capacity required for backup			
No. of turbines	8	8	8
Power rating of turbines (turbine capacity) (MW)	6.1	6	6.2
Power of wind farm (MW h ⁻¹)	48.8	48	49.6
Rated capacity (MW yr ⁻¹)	427488	420480	434496
Extra capacity required for backup (%)	5	5	5
Additional emissions due to reduced thermal efficiency of the reserve generation (%)	10	10	10
Reserve capacity (MWh yr ⁻¹)	2137	2102	2172

Carbon dioxide emissions due to backup power generation			
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)	0.207	0.207	0.207
Fossil fuel- mix emission factor (t CO ₂ MWh ⁻¹)	0.424	0.424	0.424
Lifetime of windfarm (years)	35	35	35
Annual emissions due to backup from...			
...coal-fired electricity generation (tCO ₂ yr ⁻¹)	2020	1987	2053
...grid-mix of electricity generation (tCO ₂ yr ⁻¹)	442	435	450
...fossil fuel - mix of electricity generation (tCO ₂ yr ⁻¹)	906	891	921

RESULTS			
Total emissions due to backup from...			
...coal-fired electricity generation (tCO ₂)	70696	69537	71855
...grid-mix of electricity generation (tCO ₂)	15486	15232	15740
...fossil fuel - mix of electricity generation (tCO ₂)	31720	31200	32240
Additional CO₂ payback time of windfarm due to backup			
...coal-fired electricity generation (months)	600	600	600
...grid-mix of electricity generation (months)	600	600	600
...fossil fuel - mix of electricity generation (months)	600	600	600

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Emissions due to backup power generation

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

Note: 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.

Emissions due to loss of bog plants

Note: Annual C fixation by the site is calculated by multiplying area of the windfarm by the annual C accumulation due to bog plant fixation

	Expected	Minimum	Maximum
Area where carbon accumulation by bog plants is lost			
Total area of land lost due to windfarm construction (m ²)	56100	56100	56100
Total area affected by drainage due to windfarm construction (m ²)	188270	188270	188270
Total area where fixation by plants is lost (m ²)	244370	244370	244370
Total loss of carbon accumulation			
Carbon accumulation in undrained peats (tC ha ⁻¹ yr ⁻¹)	0.25	0.2	0.3
Lifetime of windfarm (years)	35	35	35
Time required for regeneration of bog plants after restoration (years)	10	5	15
Carbon accumulation up to time of restoration (tCO ₂ eq. ha ⁻¹)	41	29	55

RESULTS			
Total loss of carbon accumulation by bog plants			
Total area where fixation by plants is lost (ha)	24	24	24
Carbon accumulation over lifetime of windfarm (tCO ₂ eq. ha ⁻¹)	41	29	55
Total loss of carbon fixation by plants at the site (t CO₂)	1008	717	1344
Additional CO₂ payback time of windfarm due to loss of CO₂ fixing potential			
...coal-fired electricity generation (months)	9	6	11
...grid-mix of electricity generation (months)	39	28	51
...fossil fuel - mix of electricity generation (months)	19	14	25

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Emissions due to loss of bog plants

Note: Annual C fixation by the site is calculated by multiplying area of the windfarm by the annual C accumulation due to bog plant fixation

Assumptions:
 1. Bog plants are 100% lost from the area where peat is removed for construction.
 2. Bog plants are 100% lost from the area where peat is drained.
 3. The recovery of carbon accumulation by plants on restoration of land is as given in inputs.

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Emissions due to loss of soil organic carbon

Note: Loss of C stored in peatland is estimated from % site lost by peat removal (sheet 5a), CO₂ loss from removed peat (sheet 5b), % site affected by drainage (sheet 5c), and the CO₂ loss from drained peat (sheet 5d).

	Expected result	Minimum result	Maximum result
CO₂ loss due to windfarm construction			
CO ₂ loss from removed peat (t CO ₂ equiv)	8244	-2298	30646
CO ₂ loss from drained peat (t CO ₂ equiv)	797	0	20019
RESULTS			
Total CO₂ loss from peat (removed + drained) (t CO₂ equiv)	9041	-2298	50665
Additional CO₂ payback time of windfarm due to loss of soil CO₂			
...coal-fired electricity generation (months)	77	-20	423
...grid-mix of electricity generation (months)	350	-91	1931
...fossil fuel - mix of electricity generation (months)	171	-44	943

Check
Check

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Emissions due to loss of soil organic carbon

Note: Loss of C stored in peatland is estimated from % site lost by peat removal (sheet 5a), CO₂ loss from removed peat (sheet 5b), % site affected by drainage (sheet 5c), and the CO₂ loss from drained peat (sheet 5d).

Volume of Peat Removed

Note: % 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 sheet.

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Peat removed from borrow pits	Total		
	Exp	Min	Max
Number of borrow pits	0	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	0	0
Area of land lost in borrow pits (m ²)	0	0	0
Volume of peat removed from borrow pits (m ³)	0	0	0

Peat removed from turbine foundations	Total			Construction Area 1			Construction Area 2			Construction Area 3			Construction Area 4			Construction Area 5		
	Exp	Min	Max	Exp	Min	Max	Exp	Min	Max	Exp	Min	Max	Exp	Min	Max	Exp	Min	Max
Method used to calculate CO ₂ loss from foundations	Rectangular with vertical walls																	
Calculation method code	1																	
No. of turbines	8	8	8	8	8	8	0	0	0	0	0	0	0	0	0	0	0	0
Diameter at surface (m)				25	25	25	0	0	0	0	0	0	0	0	0	0	0	0
Diameter at bottom (m)				25	25	25	0	0	0	0	0	0	0	0	0	0	0	0
Depth of foundations (m)				25	25	25	0	0	0	0	0	0	0	0	0	0	0	0
"Area" of land lost in hard-standing (m ²)	5000	5000	5000	5000	5000	5000	0	0	0	0	0	0	0	0	0	0	0	0
Volume of peat removed from foundation area (m ³)	5500	5500	5500	5500	5500	5500	0	0	0	0	0	0	0	0	0	0	0	0

Peat removed from hard-standing	Total			Construction Area 1			Construction Area 2			Construction Area 3			Construction Area 4			Construction Area 5		
	Exp	Min	Max	Exp	Min	Max	Exp	Min	Max	Exp	Min	Max	Exp	Min	Max	Exp	Min	Max
Method used to calculate CO ₂ loss from foundations	Rectangular with vertical walls																	
Calculation method code	1																	
No. of turbines	8	8	8	8	8	8	0	0	0	0	0	0	0	0	0	0	0	0
Diameter at surface (m)				55	55	55	0	0	0	0	0	0	0	0	0	0	0	0
Diameter at bottom (m)				35	35	35	0	0	0	0	0	0	0	0	0	0	0	0
Depth of hardstanding (m)				55	55	55	0	0	0	0	0	0	0	0	0	0	0	0
Area of land lost in hard-standing (m ²)	15400	15400	15400	15400	15400	15400	0	0	0	0	0	0	0	0	0	0	0	0
Volume of peat removed from hardstandingarea (m ³)	16940	16940	16940	16940	16940	16940	0	0	0	0	0	0	0	0	0	0	0	0

Peat removed from access tracks	Total		
	Exp	Min	Max
Floating roads			
Length of access track that is floating road (m)	1800	1800	1800
Floating road width (m)	5	5	5

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Floating road depth (m)	0	0	0
Area of land lost in floating roads (m ²)	9000	9000	9000
Volume of peat removed for floating roads	0	0	0
Excavated roads			
Length of access track that is excavated road (m)	4800	4800	4800
Excavated road width (m)	5	5	5
Average depth of peat excavated for road (m)	1.1	1.1	1.1
Area of land lost in excavated roads (m ²)	24000	24000	24000
Volume of peat removed for excavated roads	26400	26400	26400
Rock-filled roads			
Length of access track that is rock filled road (m)	0	0	0
Rock filled road width (m)	0	0	0
Rock filled road depth (m)	0	0	0
Area of land lost in excavated roads (m ²)	0	0	0
Volume of peat removed for rock-filled roads	0	0	0
Total area of land lost in access tracks (m ²)	33000	33000	33000
Total volume of peat removed due to access tracks (m ³)	26400	26400	26400

Additional peat excavated - (not already accounted for above)			
Volume of additional peat excavated (m ³)	1970	1970	1970
Area of additional peat excavated (m ²)	2700	2700	2700

RESULTS	Total		
	Exp	Min	Max
Total volume of peat removed (m³) due to windfarm construction	50810	50810	50810
Total area of land lost due to windfarm construction (m²)	56100	56100	56100

Click here to move to 5b. CO2 loss from removed peat [Click here](#)

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Volume of Peat Removed
 Note: % 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 to the volume of peat removed, area of land lost and % site lost at the bottom of this worksheet.

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CO₂ loss from removed peats
 Note: 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

	Expected	Minimum	Maximum
CO₂ loss from removed peat			
C Content of dry peat (% by weight)	53.23	19.57	64.28
Dry soil bulk density (g cm ⁻³)	0.13	0.07	0.29
% C contained in removed peat that is lost as CO ₂	100	100	100
Total volume of peat removed (m ³) due to windfarm construction	50810	50810	50810
CO ₂ loss from removed peat (t CO ₂)	13092	2625	35092

Assumption: If peat is not restored, 100% of the carbon contained in the removed peat is lost as CO₂

Check

CO₂ loss from undrained peat left in situ			
Total area of land lost due to windfarm construction (ha)	6	6	6
CO ₂ loss from undrained peat left in situ (t CO ₂ ha ⁻¹)	864	878	793
CO ₂ loss from undrained peat left in situ (t CO ₂)	4848	4923	4446

CO₂ loss attributable to peat removal only			
CO ₂ loss from removed peat (t CO ₂)	13092	2625	35092
CO ₂ loss from undrained peat left in situ (t CO ₂)	4848	4923	4446
RESULTS			
CO₂ loss attributable to peat removal only (t CO₂)	8244	-2298	30646

Click here to move to 5. Loss of soil CO₂ [Click here](#)
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CO₂ loss from removed peats
 Note: 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

Volume of peat drained

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

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Extent of drainage around each metre of drainage ditch	Total		
	Exp	Min	Max
Average extent of drainage around drainage features at site (m)	15	15	15

Peat affected by drainage around borrow pits	Total		
	Exp	Min	Max
Number of borrow pits	0	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)	0.0	0.0	0.0
Area affected by drainage per borrow pit (m ²)	900	900	900
Total area affected by drainage around borrowpits (m ²)	0	0	0
Total volume affected by drainage around borrowpits (m ³)	0	0	0

Peat affected by drainage around turbine foundation and hardstanding	Total			Construction Area 1			Construction Area 2			Construction Area 3			Construction Area 4			Construction Area 5		
	Exp	Min	Max	Exp	Min	Max	Exp	Min	Max	Exp	Min	Max	Exp	Min	Max	Exp	Min	Max
No. of turbines	8	8	8	8	8	8	0	0	0	0	0	0	0	0	0	0	0	0
Average length of turbine foundations at base (m)				25	25	25	0	0	0	0	0	0	0	0	0	0	0	0
Average width of turbine foundations at base(m)				25	25	25	0	0	0	0	0	0	0	0	0	0	0	0
Average depth of peat removed from turbine foundations (m)				1.1	1.1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average length of hard-standing at base (m)				55	55	55	0	0	0	0	0	0	0	0	0	0	0	0
Average width of hard-standing at base (m)				35	35	35	0	0	0	0	0	0	0	0	0	0	0	0
Average depth of peat removed from hard-standing (m)				1.1	1.1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum depth of drains (m)				1.1	1.1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total length of foundation and hardstanding (m)				80	80	80	0	0	0	0	0	0	0	0	0	0	0	0
Total width of foundation and hardstanding (m)				60	60	60	0	0	0	0	0	0	0	0	0	0	0	0
Area affected by drainage of foundation and hardstanding area (m ²)	5100	5100	5100	5100	5100	5100	0	0	0	0	0	0	0	0	0	0	0	0
Total area affected by drainage of foundation and hardstanding area (m ²)	40800	40800	40800	40800	40800	40800	0	0	0	0	0	0	0	0	0	0	0	0
Total volume affected by drainage of foundation and hardstanding area (m ³)	22440	22440	22440	22440	22440	22440	0	0	0	0	0	0	0	0	0	0	0	0

Peat affected by drainage of access tracks	Total		
	Exp	Min	Max
<u>Floating roads</u>			
Length of floating road that is drained (m)	0	0	0
Floating road width (m)	5.0	5.0	5.0

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Average depth of drains associated with floating roads (m)	0.00	0.00	0.00
Area affected by drainage of floating roads (m ²)	0	0	0
Volume affected by drainage of floating roads (m ³)	0	0	0
Excavated Road			
Length of access track that is excavated road (m)	4800	4800	4800
Excavated road width (m)	5	5	5
Average depth of peat excavated for road (m)	1.1	1.1	1.1
Area affected by drainage of excavated roads (m ²)	144000	144000	144000
Volume affected by drainage of excavated roads (m ³)	79200	79200	79200
Rock-filled roads			
Length of rock filled road that is drained (m)	0	0	0
Rock filled road width (m)	0	0	0
Average depth of drains associated with rock filled roads (m)	0.0	0.0	0.0
Area affected by drainage of rock-filled roads (m ²)	0	0	0
Volume affected by drainage of rock-filled roads (m ³)	0	0	0
Total area affected by drainage of access track (m ²)	144000	144000	144000
Total volume affected by drainage of access track (m ³)	79200	79200	79200

Peat affected by drainage of cable trenches	Exp	Total	
		Min	Max
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)	1.2	1.2	1.2
Total area affected by drainage of cable trenches (m ²)	0	0	0
Total volume affected by drainage of cable trenches (m ³)	0.00	0.00	0.00

Drainage around additional peat excavated	Exp	Total	
		Min	Max
Volume of additional peat excavated (m ³)	1970.0	1970.0	1970.0
Area of additional peat excavated (m ²)	2700.0	2700.0	2700.0
Average depth of excavated peat (m)	1	1	1
Radius of area excavated (m)	29	29	29
Radius of excavated and drained area (m)	44	44	44
Total area affected by drainage (m ²)	3470	3470	3470
Total volume affected by drainage (m ³)	2531.70	2531.70	2531.70

Assumption: Area excavated is assumed to be a circle

RESULTS	Total		
	Exp	Min	Max
Total area affected by drainage due to windfarm (m ²)	188270	188270	188270
Total volume affected by drainage due to windfarm (m ³)	104171.7	104171.7	104171.7

Click here to move to 5d. CO2 loss from drained peat [Click here](#)

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

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CO₂ loss due to drainage

Note: 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).

Click here to move to 5. Loss of soil CO₂ [Click here](#)

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	Expected	Minimum	Maximum
Drained Land			
Total area affected by drainage due to wind farm construction (ha)	19	19	19
Will the hydrology of the site be restored on decommissioning?	No	No	No
Will the habitat of the site be restored on decommissioning?	No	No	No

Calculations of C Loss from Drained Land if Site is NOT Restored after Decommissioning

Check	Total volume affected by drainage due to wind farm (m ³)	104172	104172	104172
	C Content of dry peat (% by weight)	53	20	64
	Dry soil bulk density (g cm ⁻³)	0.13	0.07	0.29
	Total GHG emissions from Drained Land (t CO₂ equiv.)	26841	5382	71946
	Total GHG Emissions from Undrained Land (t CO₂ equiv.)	26043	5382	51927

Assumption: Losses of GHG from drained and undrained land have the same proportion throughout the emission period.

Calculations of C loss from Drained Land if Site IS Restored after Decommissioning**1. Losses if Land is Drained**

	Flooded period (days year ⁻¹)	0	0	0
	Lifetime of windfarm (years)	35	35	35
	Time required for regeneration of bog plants after restoration (years)	10	5	15
	Methane Emissions from Drained Land			
Check	Rate of methane emission in drained soil ((t CH ₄ -C) ha ⁻¹ yr ⁻¹)	-0.002	-0.019	0.019
	Conversion factor: CH ₄ -C to CO ₂ equivalents	30.67	30.67	30.67
	CH ₄ emissions from drained land (t CO ₂ equiv.)	-40	-431	546
	Carbon Dioxide Emissions from Drained Land			
Check	Rate of carbon dioxide emission in drained soil (t CO ₂ ha ⁻¹ yr ⁻¹)	19.84	22.51	21.38
	CO ₂ emissions from drained land (t CO ₂)	16807	16953	20127
	Total GHG emissions from Drained Land (t CO₂ equiv.)	16767	16521	20673

Assumption: The drained soil is not flooded at any time of the year.

Note: Conversion = (23 x 16/12) = 30.67 CO₂ equiv. (CH₄-C)⁻¹

2. Losses if Land is Undrained

	Flooded period (days year ⁻¹)	178	178	178
	Lifetime of windfarm (years)	35	35	35
	Time required for regeneration of bog plants after restoration (years)	10	5	15
	Methane Emissions from Undrained Land			
Check	Rate of methane emission in undrained soil ((t CH ₄ -C) ha ⁻¹ yr ⁻¹)	0.00	-0.02	0.16
	Conversion factor: CH ₄ -C to CO ₂ equivalents	30.67	30.67	30.67
	CH ₄ emissions from undrained land (t CO ₂ equiv.)	-34	-431	2588
	Carbon Dioxide Emissions from Undrained Land			
Check	Rate of carbon dioxide emission in undrained soil (t CO ₂ ha ⁻¹ yr ⁻¹)	18.62	22.51	4.40
	CO ₂ emissions from undrained land (t CO ₂)	16303	16953	12333
	Total GHG Emissions from Undrained Land (t CO₂ equiv.)	16269	16521	14921

Note: Conversion = (23 x 16/12) = 30.67 CO₂ equiv. (CH₄-C)⁻¹

3. CO₂ Losses due to Drainage

	Total GHG emissions from drained land (t CO ₂ equiv.)	26841	5382	71946
	Total GHG emissions from undrained land (t CO ₂ equiv.)	26043	5382	51927
	RESULTS			
	Total GHG emissions due to drainage (t CO₂ equiv.)	797	0	20019

Click here to move to 5. Loss of soil CO₂ [Click here](#)

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CO₂ loss due to drainage

Note: 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).

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Emission rates from soils

Note: 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).

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Selected Methodology = Site specific (required for planning applications)
Type of peatland = Acid Bog

Calculations following IPCC default methodology	Expected	Minimum	Maximum
Emission characteristics of acid bogs (IPCC, 1997)			
Flooded period (days year ⁻¹)	178	178	178
Annual rate of methane emission (t CH ₄ -C ha ⁻¹ yr ⁻¹)	0.04015	0.04015	0.04015
Annual rate of carbon dioxide emission (t CO ₂ ha ⁻¹ yr ⁻¹)	35.2	35.2	35.2

Emission characteristics of fens (IPCC, 1997)			
Flooded period (days year ⁻¹)	169	169	169
Annual rate of methane emission (t CH ₄ -C ha ⁻¹ yr ⁻¹)	0.219	0.219	0.219
Annual rate of carbon dioxide emission (t CO ₂ ha ⁻¹ yr ⁻¹)	35.2	35.2	35.2

Selected emission characteristics (IPCC, 1997)			
Flooded period (days year ⁻¹)	178	178	178
Annual rate of methane emission (t CH ₄ -C ha ⁻¹ yr ⁻¹)	0.04015	0.04015	0.04015
Annual rate of carbon dioxide emission (t CO ₂ ha ⁻¹ yr ⁻¹)	35.2	35.2	35.2

Calculations following ECOSSE based methodology			
Drained Land			
Total area affected by drainage due to wind farm construction (ha)	19	19	19
Total volume affected by drainage due to wind farm construction (m ³)	104172	104172	104172

Soil Characteristics that Determine Emission Rates			
Average annual air temperature at the site (°C)	9.8	5.1	15.6
Average water table depth at site (m)	0.50	1.00	0.10
Average water table depth of drained land (m)	0.55	1.00	0.55

Annual Emission Rates following site specific methodology			
Acid bogs			
Rate of carbon dioxide emission in drained soil (t CO ₂ ha ⁻¹ yr ⁻¹)	19.84	22.51	21.38
Rate of carbon dioxide emission in undrained soil (t CO ₂ ha ⁻¹ yr ⁻¹)	18.62	22.51	4.40
Rate of methane emission in drained soil ((t CH ₄ -C) ha ⁻¹ yr ⁻¹)	-0.002	-0.019	0.019
Rate of methane emission in undrained soil ((t CH ₄ -C) ha ⁻¹ yr ⁻¹)	0.00	-0.02	0.16
Fens			
Rate of carbon dioxide emission in drained soil (t CO ₂ ha ⁻¹ yr ⁻¹)	58.39	62.17	61.65
Rate of carbon dioxide emission in undrained soil (t CO ₂ ha ⁻¹ yr ⁻¹)	55.46	62.17	10.91
Rate of methane emission in drained soil ((t CH ₄ -C) ha ⁻¹ yr ⁻¹)	-0.001	-0.007	0.003
Rate of methane emission in undrained soil ((t CH ₄ -C) ha ⁻¹ yr ⁻¹)	0.00	-0.01	0.21

Selected emission characteristics following site specific methodology			
Rate of carbon dioxide emission in drained soil (t CO ₂ ha ⁻¹ yr ⁻¹)	19.84	22.51	21.38
Rate of carbon dioxide emission in undrained soil (t CO ₂ ha ⁻¹ yr ⁻¹)	18.62	22.51	4.40
Rate of methane emission in drained soil ((t CH ₄ -C) ha ⁻¹ yr ⁻¹)	-0.002	-0.019	0.019
Rate of methane emission in undrained soil ((t CH ₄ -C) ha ⁻¹ yr ⁻¹)	0.00	-0.02	0.16

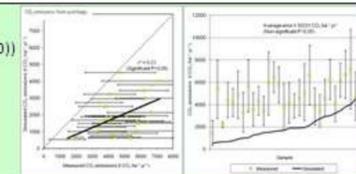
RESULTS			
Selected Emission Rates			
Rate of carbon dioxide emission in drained soil (t CO ₂ ha ⁻¹ yr ⁻¹)	19.84	22.51	21.38
Rate of carbon dioxide emission in undrained soil (t CO ₂ ha ⁻¹ yr ⁻¹)	18.62	22.51	4.40
Rate of methane emission in drained soil ((t CH ₄ -C) ha ⁻¹ yr ⁻¹)	-0.002	-0.019	0.019
Rate of methane emission in undrained soil ((t CH ₄ -C) ha ⁻¹ yr ⁻¹)	0.00	-0.02	0.16

Assumption: The period of flooding is taken to be 178 days yr⁻¹ for acid bogs and 169 days yr⁻¹ based on the monthly mean temperature and the lengths of inundation (IPCC, 1997. Revised 1996 IPCC guidelines for national greenhouse gas inventories, Vol 3, table 5-13)

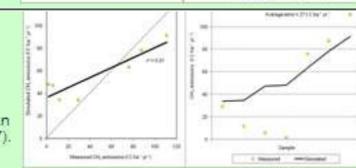
Assumption: The CH₄ emission rate provided for acid bogs is 11 (1-38) mg CH₄-C m⁻² day⁻¹ x 365 days; and for fens is 60 (21-162) mg CH₄-C m⁻² day⁻¹ x 365 days (Asefmann & Crutzen, 1989. J. Atmos. Chem. 8, 307-358)

Assumption: CO₂ emissions on drainage of organic soils for upland crops (e.g., grain, vegetables) are 3.667x9.6 (7.9-11.3) t CO₂ ha⁻¹ yr⁻¹ in temperate climates (Armentano and Menges, 1986. J. Ecol. 74, 755-774).

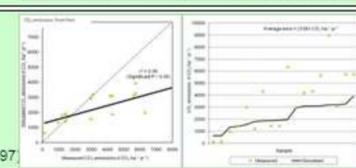
Note: Carbon dioxide emissions from acid bogs. Equation derived by regression analysis against 60 measurements (Nayak et al, 2009). The equation derived was $R_{CO_2} = (3.667/1000) \times ((6700 \times \exp(-0.26 \times \exp(-0.0515 \times ((W \times 100) - 50)))) + ((72.54 \times T) - 800))$ where R_{CO_2} is the annual rate of CO₂ emissions (t CO₂ (ha)⁻¹ yr⁻¹), T = average annual peat temperature (°C) and W is the water table depth (m). The equation shows a significant correlation with measurements ($r^2 = 0.53$; $P > 0.05$). Evaluation against 29 independent experiments shows a significant association ($r^2 = 0.21$; $P > 0.05$) and an average error of 3023 t CO₂ ha⁻¹ yr⁻¹ which is non-significant ($P < 0.05$) (Smith et al, 1997).



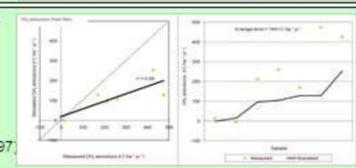
Note: Methane emissions from acid bogs. Equation derived by regression analysis against 60 measurements (Nayak et al, 2009). The equation derived was $R_{CH_4} = (1/1000) \times (500 \times \exp(-0.1234 \times (W \times 100)) + ((3.529 \times T) - 36.67))$ where R_{CH_4} is the annual rate of CH₄ emissions (t CH₄-C (ha)⁻¹ yr⁻¹), T = average annual air temperature (°C) and W is the water table depth (m). The equation shows a significant correlation with measurements ($r^2 = 0.54$; $P > 0.05$). Evaluation against 7 independent experiments shows a significant association ($r^2 = 0.81$; $P > 0.05$) and an average error of 27 t CH₄-C ha⁻¹ yr⁻¹ (significance not defined due to lack of replicates - Smith et al, 1997).



Note: Carbon dioxide emissions from fens. Equation derived by regression analysis against 44 measurements (Nayak et al, 2009). The equation derived was $R_{CO_2} = (3.667/1000) \times (16244 \times \exp(-0.175 \times \exp(-0.073 \times ((W \times 100) - 50))) + (153.23 \times T))$ where R_{CO_2} is the annual rate of CO₂ emissions (t CO₂ (ha)⁻¹ yr⁻¹), T = average annual peat temperature (°C) and W is the water table depth (m). The equation shows a significant correlation with measurements ($r^2 = 0.42$; $P > 0.05$). Evaluation against 18 independent experiments shows a significant association ($r^2 = 0.56$; $P > 0.05$) and an average error of 2108 t CO₂ ha⁻¹ yr⁻¹ (significance not defined due to lack of replicates - Smith et al, 1997).



Note: Methane emissions from fens. Equation derived by regression analysis against experimental data from 35 measurements (Nayak et al, 2009). The equation derived was $R_{CH_4} = (1/1000) \times (-10 + 563.62 \times \exp(-0.097 \times (W \times 100)) + 0.662 \times T)$ where R_{CH_4} is the annual rate of CH₄ emissions (t CH₄-C (ha)⁻¹ yr⁻¹), T = average annual air temperature (°C) and W is the water table depth (m). The equation shows a significant correlation with measurements ($r^2 = 0.41$; $P > 0.05$). Evaluation against 7 independent experiments shows a significant association ($r^2 = 0.69$; $P > 0.05$) and an average error of 164 t CH₄-C ha⁻¹ yr⁻¹ (significance not defined due to lack of replicate - Smith et al, 1997).



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Emission rates from soils

Note: 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).

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Emissions due to loss of DOC and POC
 Note: 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)

	Expected	Minimum	Maximum
Total C loss			
Gross CO ₂ loss from restored drained land (t CO ₂)	0	0	0
Gross CH ₄ loss from restored drained land (t CO ₂ equiv.)	0	0	0
Gross CO ₂ loss from improved land (t CO ₂)			
Degraded Bog	0	0	0
Felled Forestry	0	0	0
Borrow Pits	0	0	0
Foundations & Hardstanding	0	0	0
Gross CH ₄ loss from improved land (t CO ₂ equiv.)			
Degraded Bog	0	0	0
Felled Forestry	0	0	0
Borrow Pits	0	0	0
Foundations & Hardstanding	0	0	0
Conversion factor: CH ₄ -C to CO ₂ equivalents	30.6667	30.6667	30.6667
% total soil C losses, lost as DOC	26	7	40
% DOC loss emitted as CO ₂ over the long term	100	100	100
% total soil C losses, lost as POC	8	4	10
% POC loss emitted as CO ₂ over the long term	100	100	100
Total gaseous loss of C (t C)	0	0	0
Total C loss as DOC (t C)	0	0	0
Total C loss as POC (t C)	0	0	0

Note: Only restored drained land included because if land is not

Assumption: DOC loss ranges between 7 - 40% of the total gaseous loss if calculated from the reported (minimum and maximum) values in Worrall 2009 and is **26%** of the total gaseous loss if calculated from the mean of reported maximum and minimum value in Worrall 2009. These DOC values are flux based on soil water concentration (i.e. 12.5 - 85.9 MgC/KM²/yr) and not on flux at catchment outlet (i.e. 10.3 - 21.8 MgC/KM²/yr)
 Worrall, F. et al., 2009. The multi-annual carbon budget of a peat-covered catchment. *Science of The Environment*

Assumption: In the long term, 100% of leached DOC is assumed to be lost as CO₂

Assumption: POC loss ranges between 4-10% of the total gaseous loss if calculated from the reported values and is **8%** of the total gaseous loss if calculated from the mean of reported maximum and minimum value in Worrall 2009. POC range is (7 - 22.4 MgC/KM²/yr) (Worrall et al, 2009).

Assumption: In the long term, 100% of leached POC is assumed to be lost as CO₂

RESULTS			
Total CO ₂ loss due to DOC leaching (t CO ₂)	0	0	0
Total CO ₂ loss due to POC leaching (t CO ₂)	0	0	0
Total CO₂ loss due to DOC & POC leaching (t CO₂)	0	0	0
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

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Emissions due to loss of DOC and POC
 Note: 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)

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Emissions due to forest felling - calculation using simple management data

Note: 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.

	Expected	Minimum	Maximum
Emissions due to forestry felling			
Area of forestry plantation to be felled (ha)	7.5	7.5	7.5
Carbon sequestered (tC ha ⁻¹ yr ⁻¹)	3.45	3.5	3.55
Lifetime of windfarm (years)	35	35	35
Carbon sequestered over the lifetime of the windfarm (t C ha ⁻¹)	120.75	122.5	124.25
RESULTS			
Total carbon loss due to felling of forestry (t CO₂)	3321	3369	3417
Additional CO₂ payback time of windfarm due to management of forestry			
...coal-fired electricity generation (months)	28	29	29
...grid-mix of electricity generation (months)	129	133	130
...fossil fuel - mix of electricity generation (months)	63	65	64

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Emissions due to forest felling - calculation using simple management data

Note: 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.

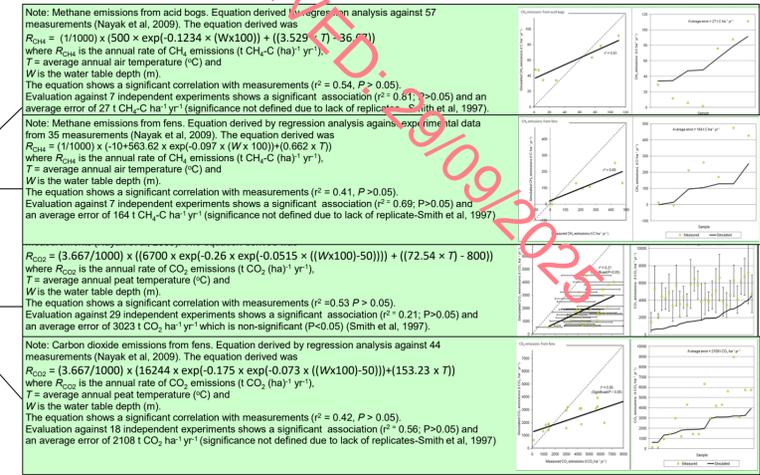
Gains due to site improvement
 Note: Note. CO₂ losses are calculated using two approaches: IPCC default methodology and more site specific equations derived for this project. The IPCC methodology is included because it is the established approach, although it contains no site detail. The new equations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

Selected Methodology = Site specific (required for planning applications)
Type of peatland = Acid Bog

Reduction in GHG emissions due to improvement of site	Expected result				Minimum result				Maximum result			
	Degraded Bog	Felled Forestry	Borrow Pits	Foundations & Hardstanding	Degraded Bog	Felled Forestry	Borrow Pits	Foundations & Hardstanding	Degraded Bog	Felled Forestry	Borrow Pits	Foundations & Hardstanding
1. Description of site												
Period of time when effectiveness of the improvement can be guaranteed (years)	25	25	25	35	25	25	25	35	25	25	25	35
Area to be improved (ha)	0	0	0	0	0	0	0	0	0	0	0	0
Average air temperature at site (°C)	9.8	9.8	9.8	9.8	5.1	5.1	5.1	5.1	15.6	15.6	15.6	15.6
Depth of peat drained (m)	1.10	1.10	0.00	1.10	1.10	1.10	0.00	1.10	1.10	1.10	0.00	1.10
Depth of peat above water table before improvement (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Depth of peat above water table after improvement (m)	0.00	0.00	0.00	1.10	0.00	0.00	0.00	1.10	0.00	0.00	0.00	1.10
2. Losses with improvement												
Flooded period (days year ⁻¹)	178	178	178	178	178	178	178	178	178	178	178	178
Time required for hydrology and habitat to return to its previous state on restoration (years)	0	0	0	0	0	0	0	0	0	0	0	0
Improved period (years)	25	25	25	35	25	25	25	35	25	25	25	35
Methane emissions from improved land												
Site specific methane emission from improved soil on acid bogs (t CH ₄ -C ha ⁻¹ yr ⁻¹)	0.498	0.498	0.498	-0.002	0.481	0.481	0.481	-0.019	0.518	0.518	0.518	0.018
Site specific methane emission from improved soil on fens (t CH ₄ -C ha ⁻¹ yr ⁻¹)	0.560	0.560	0.560	-0.003	0.557	0.557	0.557	-0.007	0.564	0.564	0.564	0.000
IPCC annual rate of methane emission on acid bogs (t CH ₄ -C ha ⁻¹ yr ⁻¹)	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
IPCC annual rate of methane emission on fens (t CH ₄ -C ha ⁻¹ yr ⁻¹)	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219
Selected annual rate of methane emission (t CH ₄ -C ha ⁻¹ yr ⁻¹)	0.498	0.498	0.498	-0.002	0.481	0.481	0.481	-0.019	0.518	0.518	0.518	0.018
CH ₄ emissions from improved land (t CO ₂ equiv.)	0	0	0	0	0	0	0	0	0	0	0	0
Carbon dioxide emissions from improved land												
Site specific CO ₂ emission from improved soil on acid bogs (t CO ₂ ha ⁻¹ yr ⁻¹)	0.48	0.48	0.48	23.95	-0.77	-0.77	-0.77	22.70	2.02	2.02	2.02	25.50
Site specific CO ₂ emissions from improved soil on fens (t CO ₂ ha ⁻¹ yr ⁻¹)	5.57	5.57	5.57	64.95	2.92	2.92	2.92	62.30	8.82	8.82	8.82	68.20
IPCC annual rate of carbon dioxide emission on acid bogs (t CO ₂ ha ⁻¹ yr ⁻¹)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IPCC annual rate of carbon dioxide emission on fens (t CO ₂ ha ⁻¹ yr ⁻¹)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selected annual rate of carbon dioxide emission (t CO ₂ ha ⁻¹ yr ⁻¹)	0.48	0.48	0.48	23.95	-0.77	-0.77	-0.77	22.70	2.02	2.02	2.02	25.50
CO ₂ emissions from improved land (t CO ₂)	0	0	0	0	0	0	0	0	0	0	0	0
Total GHG emissions from improved land (t CO₂ equiv.)	0	0	0	0	0	0	0	0	0	0	0	0
3. Losses without improvement												
Flooded period (days year ⁻¹)	0	0	0	0	0	0	0	0	0	0	0	0
Time required for hydrology and habitat to return to its previous state on restoration (years)	0	0	0	0	0	0	0	0	0	0	0	0
Improved period (years)	25	25	25	35	25	25	25	35	25	25	25	35
Methane emissions from unimproved land												
Site specific methane emission from unimproved soil on acid bogs (t CH ₄ -C ha ⁻¹ yr ⁻¹)	0.498	0.498	0.498	0.498	0.481	0.481	0.481	0.481	0.518	0.518	0.518	0.518
Site specific methane emission from unimproved soil on fens (t CH ₄ -C ha ⁻¹ yr ⁻¹)	0.560	0.560	0.560	0.560	0.557	0.557	0.557	0.557	0.564	0.564	0.564	0.564
IPCC annual rate of methane emission on acid bogs (t CH ₄ -C ha ⁻¹ yr ⁻¹)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
IPCC annual rate of methane emission on fens (t CH ₄ -C ha ⁻¹ yr ⁻¹)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Selected annual rate of methane emission (t CH ₄ -C ha ⁻¹ yr ⁻¹)	0.498	0.498	0.498	0.498	0.481	0.481	0.481	0.481	0.518	0.518	0.518	0.518
CH ₄ emissions from unimproved land (t CO ₂ equiv.)	0	0	0	0	0	0	0	0	0	0	0	0
Carbon dioxide emissions from unimproved land												
Site specific CO ₂ emission from unimproved soil on acid bogs (t CO ₂ ha ⁻¹ yr ⁻¹)	0.48	0.48	0.48	0.48	-0.77	-0.77	-0.77	-0.77	2.02	2.02	2.02	2.02
Site specific CO ₂ emissions from unimproved soil on fens (t CO ₂ ha ⁻¹ yr ⁻¹)	5.57	5.57	5.57	5.57	2.92	2.92	2.92	2.92	8.82	8.82	8.82	8.82
IPCC annual rate of carbon dioxide emission on acid bogs (t CO ₂ ha ⁻¹ yr ⁻¹)	35.20	35.20	35.20	35.20	35.20	35.20	35.20	35.20	35.20	35.20	35.20	35.20
IPCC annual rate of carbon dioxide emission on fens (t CO ₂ ha ⁻¹ yr ⁻¹)	35.20	35.20	35.20	35.20	35.20	35.20	35.20	35.20	35.20	35.20	35.20	35.20
Selected annual rate of carbon dioxide emission (t CO ₂ ha ⁻¹ yr ⁻¹)	0.48	0.48	0.48	0.48	-0.77	-0.77	-0.77	-0.77	2.02	2.02	2.02	2.02
CO ₂ emissions from unimproved land (t CO ₂)	0	0	0	0	0	0	0	0	0	0	0	0
Total GHG emissions from unimproved land (t CO₂ equiv.)	0	0	0	0	0	0	0	0	0	0	0	0
RESULTS												
4. Reduction in GHG emissions due to improvement of site												
Total GHG emissions from improved land (t CO ₂ equiv.)	0	0	0	0	0	0	0	0	0	0	0	0
Total GHG emissions from unimproved land (t CO ₂ equiv.)	0	0	0	0	0	0	0	0	0	0	0	0
Reduction in GHG emissions due to improvement (t CO₂ equiv.)	0	0	0	0	0	0	0	0	0	0	0	0
Additional CO₂ payback time of windfarm due to site improvement												
...coal-fired electricity generation (months)	0	0	0	0	0	0	0	0	0	0	0	0
...grid-mix of electricity generation (months)	0	0	0	0	0	0	0	0	0	0	0	0
...fossil fuel - mix of electricity generation (months)	0	0	0	0	0	0	0	0	0	0	0	0

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Gains due to site improvement
 Note: 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).



Note: Methane emissions from acid bogs. As above

Note: Methane emissions from fens. As above

Note: CO₂ emissions from acid bogs. As above

Note: CO₂ emissions from fens. As above

TII CARBON TOOL

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Ch 15: Material Assets, Table 15-8					Distance Assumptions	TII Embodied Carbon Tool Inputs (https://web.tii.ie/index.html)						TII Transport Inputs (https://web.tii.ie/index.html)		
Material	Total no. Truck Loads	Truck Types	TII Embodied Carbon	TII Traffic	Distance (km)	Category	Sub-Category	Material	Quantity	Unit	Embodied tCO2e	Transport Type	Distance (km)	Transport TCO2e
Concrete	856	Concrete mixer	✓	✓	23	Series number 1700 - Structural Concrete	In Situ Concrete - General	In-Situ Concrete, General	15,360,064.00	kg	1587.62	HGV - Rigid - Average	19688	20.2306
Delivery of plant	35	Large artic		✓	89.15							HGV- All - Average	3120.25	3.3839
Fencing & gates	3	Large artic		✓	23							HGV- All - Average	69	0.0748
Compound setup	32	Large artic		✓	89.15							HGV- All - Average	2852.8	3.0939
Steel	22	Large artic	✓	✓	23	Other	Structural Steelwork	Anchorage and holding down bolt assemblies	506	tonnes	907.31	HGV- All - Average	506	0.5488
Sand / binding / stone / pile foundation	175	Trucks	✓	✓	23	Series 600 - Earthwork	Backfill/Fill	Aggregates and sand, general UK, mixture of land won, marine, secondary and recycled, bulk, loose	3500000	kg	26.15	HGV - Articulated - Average	4025	4.5273
Ducting and cabling (internal)	235	Large artic		✓	23							HGV- All - Average	5405	5.8617
Crane (to lift steel)	1	Large artic		✓	89.15							HGV- All - Average	89.15	0.0967
Cranes for turbines	12	Large artic		✓	89.15							HGV- All - Average	1069.8	1.1602
Refuelling for plant	189	Large artic		✓	23							HGV- All - Average	4347	4.7143
Stone for Proposed Wind Farm	15038	Trucks	✓	✓	23	Series 2400 - Brickwork, Blockwork and Stonework	Brickwork and Blockwork	General Stone	300760	tonnes	23760	HGV - Articulated - Average	345874	389.0401
Tree felling	76	Large artic		✓	23							HGV - Articulated - Average	1748	1.9661
Site maintenance	137	Large artic		✓	23							HGV- All - Average	3151	3.4173
Miscellaneous	91	Large artic		✓	23							HGV- All - Average	2093	2.2699
Stone for Grid Connection	708	Trucks	✓	✓	23	Series 2400 - Brickwork, Blockwork and Stonework	Brickwork and Blockwork	General Stone	14160	tonnes	1118.64	HGV - Articulated - Average	16284	18.3161
Stone for Substation	652	Trucks	✓		23	Series 2400 - Brickwork, Blockwork and Stonework	Brickwork and Blockwork	General Stone	13040	tonnes	1030.16	HGV - Articulated - Average	14996	16.8674
Stone for Temporary construction compound	131	Trucks	✓		23	Series 2400 - Brickwork, Blockwork and Stonework	Brickwork and Blockwork	General Stone	2620	tonnes	206.98	HGV - Articulated - Average	3013	3.389
Materials for Proposed Grid Connection	2535	Large artic			23							HGV- All - Average	58305	63.2318
Total											28,637			542

List of Assumptions

Embodied Carbon Assumptions		
Item	Description	Assumption
Volume of Concrete Mixer	Calculation completed based on the average concrete mixer holding 8m ³ of concrete	8
Volume of Average Artic Truck	Calculation completed based on the average artic truck having a carrying capacity of 20 tonnes	20
Ducting and cabling (internal)	Embodied carbon of electrical equipment not included as an option in TII Carbon Tool	-
Grid connection cable laying	Embodied carbon of electrical equipment not included as an option in TII Carbon Tool	-
Tree Felling	Embodied carbon of tree felling is included in the Macauley Institute Carbon Calculator for Wind Farms on Peatland	-
Turbine Lifecycle	Embodied carbon of the overall turbine lifecycle is included in the Macauley Institute Carbon Calculator for Wind Farms on Peatland	-
Volume of Concrete Material	There will be approximately 6,848m ³ of concrete required for the Proposed project., The TII Carbon Tool require this material to be in kg. The density of concrete to be used at the Proposed Wind Farm is assumed to have average density of approximately 2,243m ³ /kg. Based on an assumed 6,848m ³ of concrete being required (based on 856 truckloads of concrete with an 8m ³ carrying capacity) this would result in approximately 5,760,024kg being used for the Proposed Project	15,360,064
Volume of Steel	An assumed 506 tonnes of steel is required (based on 22 truckloads of steel with a 20-tonne carrying capacity) for the Proposed Project	506
Volume of Sand/Binding Stone	There will be approximately 3,500 tonnes of sand/binding stone required for the Proposed Project., The TII Carbon Tool require this material to be in kg. Based on an assumed 3,500 tonnes of sand/binding stone being required (based on 175 truckloads of material with 20 tonnes carrying capacity) this would result in approximately 3,500,000kg being used for the Proposed Project	3,500,000
Volume of Stone	An assumed total of 380,167 tonnes of stone is required (based on 16,529 truckloads of stone with a 20-tonne carrying capacity) for the Proposed Wind Farm, Proposed Grid Connection, proposed onsite 38kV Substation, and proposed met mast.	380,167

Please note that the assumptions for the embodied carbon and traffic assumptions are made based on best estimates of material sources. In reality the location of material sources will be dependent on what is available at the time of construction. The implications of distance variations on the estimation for carbon calculations is of a very low magnitude within the context of the overall carbon calculations and considered appropriate for the purposes of assessment in the EIAR.

Traffic Assumptions		
Item	Description	Assumption
Import (P) Distance	For modelling purposes, the average distance from Shannon Foynes Port, Limerick City and Port of Galway, Co. Galway for transport of all other materials for the site	89.15
Quarry (Q) Distance	Distances from key towns/cities for the Deliveries of Stone and Ready-Mix Concrete from Quarries to the Site	23

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Concrete Mixer Emission factor	Calculated from an HGV - Rigid - All emission factor as provided in the TII Carbon Tool. Source: 2024 DEZLNZ emission factors - 'Delivery vehicles' tab, All Rigid HGVs and used Average laden weight. 2024 DEZLNZ emission factors - 'WTT - delivery vehs & freight' tab, all Rigid HGVs and used Average laden weight.	1.02756
Large Artic Emission Factor	Calculated from an HGV - All - Average emission factor as provided in the TII Carbon Tool. Source: 2024 DEZLNZ emission factors - 'Delivery vehicles' tab, All artics HGVs and used Average laden weight. 2024 DEZLNZ emission factors - 'WTT - delivery vehs & freight' tab, all artics HGVs and used Average laden weight.	1.0845
Truck Emissions Factor	Calculated from an HGV - Articulated - Average emission factor as provided in the TII Carbon Tool	1.30212

Please note that the assumptions for the embodied carbon and traffic assumptions are made based on best estimates of material sources. In reality the location of material sources will be dependent on what is available at the time of construction. The implications of distance variations on the estimation for carbon calculations is of a very low magnitude within the context of the overall carbon calculations and considered appropriate for the purposes of assessment in the EIAR.

Carbon Fixing Vegetation Assumptions		
Item	Description	Assumption
Calculation of Carbon Storage Potential in Enhancement Measures	The carbon storage capacity of restored habitats will vary over time as vegetation matures and land use and the baseline environment change. Therefore, while it can be assumed that native woodland replanting and enhancement of wet heath habitat on the Site will result in an increased capacity of carbon storage due to the carbon storage potential that exists within these habitats, to ensure the assessment below is identified under a theoretical precautionary scenario the quantification of these potential carbon savings (via an increase in carbon storage potential) associated with these measures has not been included in the carbon savings assessment. Please note, the carbon sequestration potential associated with the replanting of native woodland will be able to be determined in the future via the Teagasc Forest Carbon Tool; currently this is not able to be completed due to Teagasc carrying out further analysis and validation on current data and the sequestration potential not being available in the public domain.	Not considered in assessment or quantified
Calculation of Carbon Loss from removal of carbon fixing vegetation	Carbon losses associated with the removal of other carbon-fixing vegetation will result in additional carbon losses. These have not been quantified as the lack of consistent national-level field data and methodologies limits the ability to make accurate projections on carbon sequestration potential for other carbon fixing habitat types, i.e., hedgerow, grassland, etc., and therefore carbon loss associated with removal. While it can be assumed that loss of carbon fixing vegetation will occur as part of the Proposed Project due to the removal of these habitat types, the exact carbon loss is not quantifiable.	Not considered in assessment or quantified