

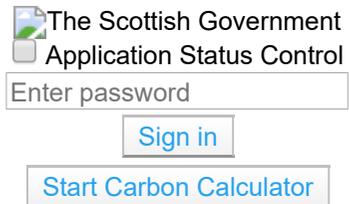
## Cover

CARBON CALCULATOR TOOL v . . .

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About...

Scottish Government and SEPA users only:



The Scottish Government  
Application Status Control

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Start Carbon Calculator

This tool calculates payback time for windfarm sited on peatlands using methods given in Nayak et al, 2008 (<http://www.gov.scot/Publications/2008/06/25114657/0>) and revised equations for GHG emissions (Nayak, D.R., Miller, D., Nolan, A., Smith, P. and Smith, J.U., 2010, Calculating carbon budgets of wind farms on Scottish peatland. Mires and Peat 4: Art. 9. Online: <http://mires-and-peat.net/pages/volumes/map04/map0409.php>)

# Admin

CARBON CALCULATOR TOOL v . . . - APPLICATION STATUS CONTROL

Help

Reference Code:

Windfarm Name	Version	Methodology used for calculating emission factors	Status Date	Status
No data available in table				

[Previous](#)[Next](#)

Selected:

Start

CARBON CALCULATOR TOOL v . . .

- Will the site be drained on construction of the windfarm?
- Is the soil at the site highly organic?
- Does windfarm construction require a significant amount of deforestation?  
i.e. is removal in excess of keyholing the turbines within the forest boundary?

If you already have an Application Reference, type it here (or paste it in the first box):

Search

New application

# CoreInput

## Core input data

1. Windfarm characteristics 2. Peatland 3. Bog plants 4. Forestry Plantation 5. Emission factors 6. Borrow pits 7. Foundations and hard-standing 8. Access tracks 9. Cable trenches 10. Additional peat 11. Improvement actions 12. Restoration after decommissioning 13. Methodology & application details

## Forestry input data

## Construction input data

Save  Signed off for submission

Note: Results are only available once ALL data are correct and complete, and a new version will be created.

New app...

Ref: **UW4P-GOM1-F0UM** v

MENU≡

Help

Core input data

Forestry input data

Construction input data

Windfarm characteristics Page 1 of 12

### Expected values

#### Dimensions

Number of Turbines

10

Chapter 4 - Description

### Minimum

10

### Maximum

10

Duration of consent (years)

30

Chapter 4 - Description

25

30

#### Performance

Power rating of 1 turbine (MW)

4.8

Chapter 4 - Description

4.8

4.8

## Payback Time

### Payback Time

Payback Time - Chart Output Data

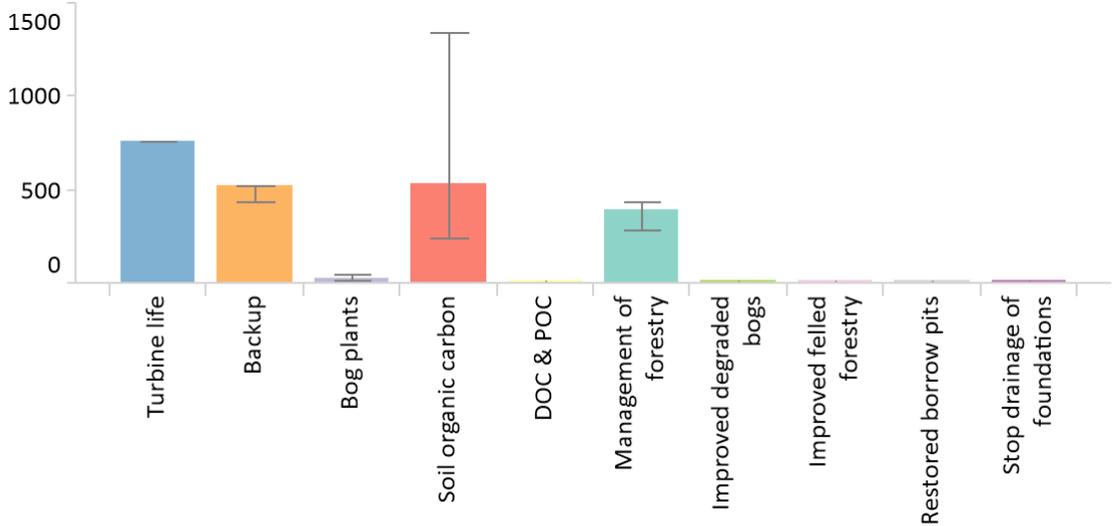
	Exp.	Min.	Max.
<b>1. Windfarm CO2 emission saving over...</b>			
...coal-fired electricity generation (t CO2 / yr)	1,354	1,315	1,393
...grid-mix of electricity generation (t CO2 / yr)	373	363	384
...fossil fuel-mix of electricity generation (t CO2 / yr)	662	643	681
Energy output from windfarm over lifetime (MWh)	44,150	35,741	45,412
<b>Total CO2 losses due to wind farm (tCO2 eq.)</b>	<b>Exp.</b>	<b>Min.</b>	<b>Max.</b>
<b>2. Losses due to turbine life (eg. manufacture, construction, decommissioning)</b>	41,595	41,595	41,595
<b>3. Losses due to backup</b>	28,382	23,652	28,382
<b>4. Losses due to reduced carbon fixing potential</b>	1,401	569	2,624
<b>5. Losses from soil organic matter</b>	29,232	13,481	74,910
<b>6. Losses due to DOC &amp; POC leaching</b>	0	0	0
<b>7. Losses due to felling forestry</b>	21,463	15,785	24,095
<b>Total losses of carbon dioxide</b>	122,074	95,082	171,606
<b>8. Total CO2 gains due to improvement of site (t CO2 eq.)</b>	<b>Exp.</b>	<b>Min.</b>	<b>Max.</b>
<b>8a. Change in emissions due to improvement of degraded bogs</b>	0	0	0
<b>8b. Change in emissions due to improvement of felled forestry</b>	0	0	0
<b>8c. Change in emissions due to restoration of peat from borrow pits</b>	0	0	0
<b>8d. Change in emissions due to removal of drainage from foundations &amp; hardstanding</b>	0	0	0
<b>Total change in emissions due to improvements</b>	0	0	0
<b>RESULTS</b>	<b>Exp.</b>	<b>Min.</b>	<b>Max.</b>
<b>Net emissions of carbon dioxide (t CO2 eq.)</b>	122,074	95,082	171,606
<b>Carbon Payback Time</b>			
...coal-fired electricity generation (years)	90.2	68.3	130.5
...grid-mix of electricity generation (years)	327.1	247.7	473.4
...fossil fuel-mix of electricity generation (years)	184.3	139.6	266.7
<b>Ratio of soil carbon loss to gain by restoration (not used in Scottish applications)</b>	<b>No gains!</b>	<b>No gains!</b>	<b>No gains!</b>

# Payback Time - Charts

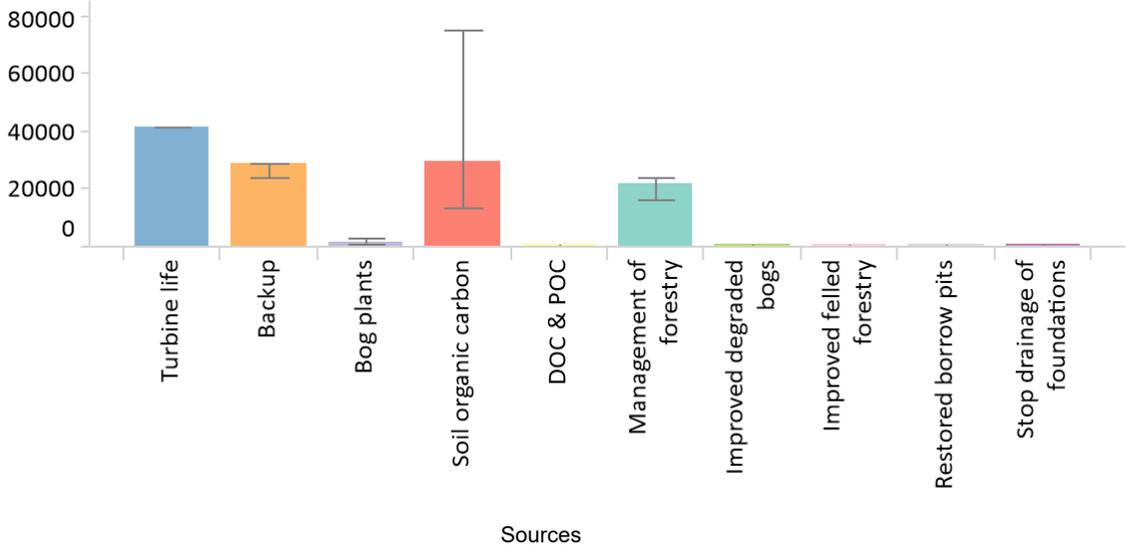
Payback Time

Payback Time - Chart Output Data

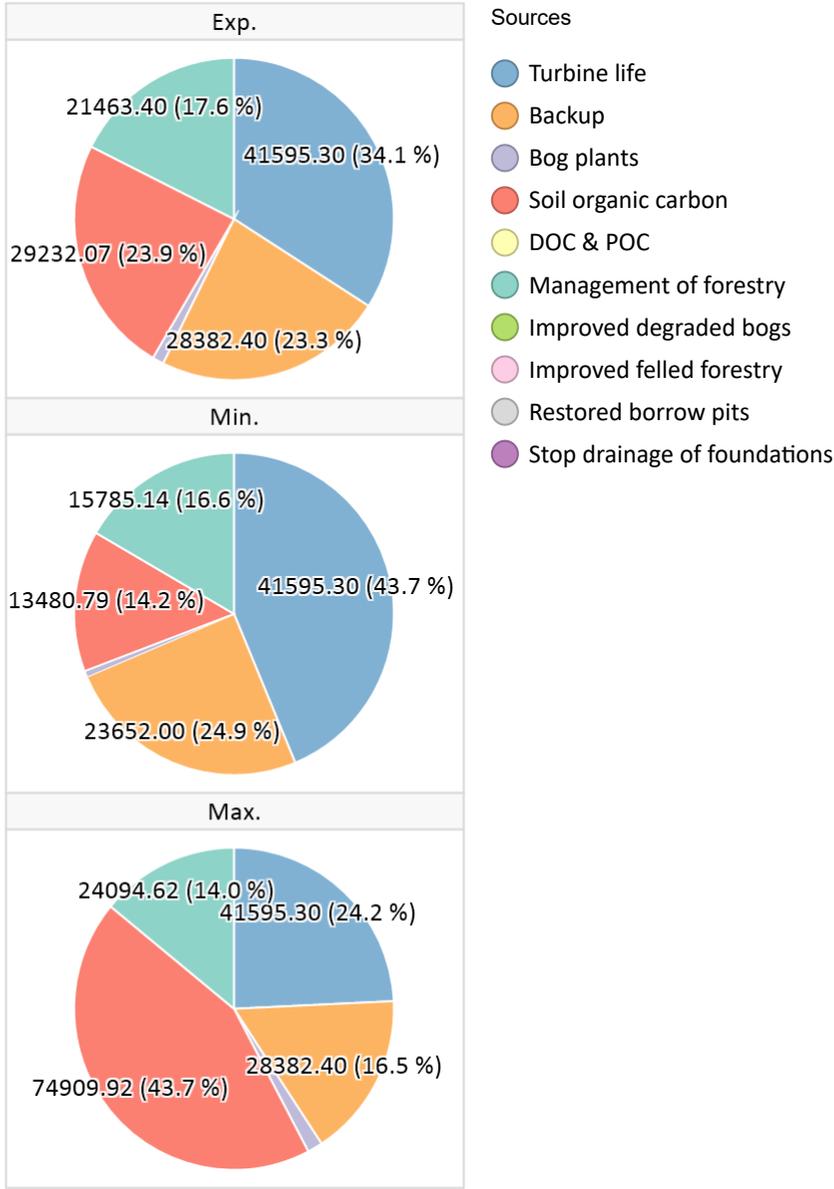
Carbon payback time (months) using fossil-fuel mix as counterfactual



Greenhouse gas emissions (t CO2 eq.)



Proportions of greenhouse gas emissions from different sources



Payback Time

Payback Time - Chart/Output Data

Print this page

Carbon Calculator v1.6.0

Croagh Wind Farm Location: 54.157377 -8.22834

Coillte Renewable Energy

## Core input data

Input data	Expected value	Minimum value	Maximum value	Source of data
Windfarm characteristics				
Dimensions				
No. of turbines	10	10	10	Chapter 4 - Description
Duration of consent (years)	30	25	30	Chapter 4 - Description
Performance				
Power rating of 1 turbine (MW)	4.8	4.8	4.8	Chapter 4 - Description
Capacity factor	0.35	0.34	0.36	Chapter 4 - Description
Backup				
Fraction of output to backup (%)	5	5	5	SNH Calculator Guidance
Additional emissions due to reduced thermal efficiency of the reserve generation (%)	10	10	10	Fixed
Total CO2 emission from turbine life (tCO2 MW <sup>-1</sup> ) (eg. manufacture, construction, decommissioning)	Calculate wrt installed capacity	Calculate wrt installed capacity	Calculate wrt installed capacity	
Characteristics of peatland before windfarm development				
Type of peatland	Acid bog	Acid bog	Acid bog	Chapter 6 - Biodiversity
Average annual air temperature at site (°C)	9.3	5.7	12.9	Chapter 10 Air & Climate
Average depth of peat at site (m)	2.1	1.6	2.7	Chapter 8 - Land, Soils & Geology
C Content of dry peat (% by weight)	55	50	60	Default Value Used
Average extent of drainage around drainage features at site (m)	15	10	20	Chapter 9 - Water
Average water table depth at site (m)	0.5	0.1	1	IDL - Boreholes
Dry soil bulk density (g cm <sup>-3</sup> )	0.1	0.09	0.11	Default Value Used

## 5. Loss of soil CO<sub>2</sub> (a, b)

Payback Time

Payback Time - Charts/Output Data

### Emissions due to loss of soil organic carbon

Loss of C stored in peatland is estimated from % site lost by peat removal (table 5a), CO<sub>2</sub> loss from removed peat (table 5b), % site affected by drainage (table 5c), and the CO<sub>2</sub> loss from drained peat (table 5d)

#### 5. Loss of soil CO<sub>2</sub>

	Exp.	Min.
CO <sub>2</sub> loss from removed peat (t CO <sub>2</sub> equiv.)	24150.72	13480.79
CO <sub>2</sub> loss from drained peat (t CO <sub>2</sub> equiv.)	5081.35	0
<b>RESULTS</b>		
Total CO <sub>2</sub> loss from peat (removed + drained) (t CO <sub>2</sub> equiv.)	29232.07	13480.79
Additional CO <sub>2</sub> payback time of windfarm due to loss of soil C...		
...coal-fired electricity generation (months)	259.08	122.99
...grid-mix of electricity generation (months)	939.97	446.23
...fossil fuel - mix of electricity generation (months)	529.68	251.45

### CO<sub>2</sub> loss from removed peats

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

#### 5b. CO<sub>2</sub> loss from removed peat

	Exp.	Min.
CO <sub>2</sub> loss from removed peat (t CO <sub>2</sub> )	32730.80	20192.06
CO <sub>2</sub> loss from undrained peat left in situ (t CO <sub>2</sub> )	8580.08	6711.27
<b>RESULTS</b>		
CO <sub>2</sub> loss attributable to peat removal only (t CO <sub>2</sub> )	24150.72	13480.79

### Volume of Peat Removed

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

#### 5a. Volume of peat removed

	Exp.
Peat removed from borrow pits	
Area of land lost in borrow pits (m <sup>2</sup> )	25000
Volume of peat removed from borrow pits (m <sup>3</sup> )	12500
Peat removed from turbine foundations	
Area of land lost in foundation (m <sup>2</sup> )	4000
Volume of peat removed from foundation area (m <sup>3</sup> )	8000
Peat removed from hard-standing	
Area of land lost in hard-standing (m <sup>2</sup> )	19250
Volume of peat removed from hard-standing area (m <sup>3</sup> )	38500
Peat removed from access tracks	
Area of land lost in floating roads (m <sup>2</sup> )	6000
Volume of peat removed from floating roads (m <sup>3</sup> )	6000
Area of land lost in excavated roads (m <sup>2</sup> )	35400
Volume of peat removed from excavated roads (m <sup>3</sup> )	70800
Area of land lost in rock-filled roads (m <sup>2</sup> )	0
Volume of peat removed from rock-filled roads (m <sup>3</sup> )	0
Total area of land lost in access tracks (m <sup>2</sup> )	41400
Total volume of peat removed due to access tracks (m <sup>3</sup> )	76800
<b>RESULTS</b>	
Total area of land lost due to windfarm construction (m <sup>2</sup> )	102900
Total volume of peat removed due to windfarm construction (m <sup>3</sup> )	162300

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

Payback Time  
 Payback Time - Charts/Output Data

### Volume of peat drained

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

#### 5c. Volume of peat drained

	Exp.
Total area affected by drainage around borrow pits (m2)	11400
Total volume affected by drainage around borrow pits (m3)	2850
Peat affected by drainage around turbine foundation and hardstanding	
Total area affected by drainage of foundation and hardstanding area (m2)	48000
Total volume affected by drainage of foundation and hardstanding area (m3)	48000
Peat affected by drainage of access tracks	
Total area affected by drainage of access track(m2)	213000
Total volume affected by drainage of access track(m3)	186000
Peat affected by drainage of cable trenches	
Total area affected by drainage of cable trenches(m2)	0
Total volume affected by drainage of cable trneches(m3)	0
Drainage around additional peat excavated	
Total area affected by drainage (m2)	6827.6
Total volume affected by drainage (m3)	13655.2
<b>RESULTS</b>	

### Emission rates from soils

Note, CO2 losses are calculated using two approaches: IPCC default methodology and more site specific equations derived for this project. The IPCC methodology is included because it is the established approach, although it contains no site detail. The new

#### 5e. Emission rates from soils

	Exp.	Min.	Max.
Calculations following IPCC default methodology			
Flooded period (days/year)	178	178	178
Annual rate of methane emission (t CH4-C/ha year)	0.04	0.04	0.04
Annual rate of carbon dioxide emission (t CO2/ha year)	25.2	25.2	25.2

### CO2 loss due to drainage

Note, CO2 losses are calculated using two approaches: IPCC default methodology and more site specific equations derived for this project. The IPCC methodology is included because it is the established approach, although it contains no site detail. The new

#### 5d. CO2 loss from drained peat

	Exp.
Calculations of C Loss from Drained Land if Site is NOT Restored after Decommissioning	
Total GHG emissions from Drained Land (t CO2 equiv.)	5051
Total GHG emissions from Undrained Land (t CO2 equiv.)	4543
Calculations of C Loss from Drained Land if Site IS Restored after Decommissioning	
Losses if Land is Drained	
CH4 emissions from drained land (t CO2 equiv.)	-13
CO2 emissions from drained land (t CO2)	260
Total GHG emissions from Drained Land (t CO2 equiv.)	5051
Losses if Land is Undrained	
CH4 emissions from undrained land (t CO2 equiv.)	-11
CO2 emissions from undrained land (t CO2)	2339
Total GHG emissions from Undrained Land (t CO2 equiv.)	4543
<b>RESULTS</b>	
Total GHG emissions due to drainage (t CO2 equiv.)	508

## 7. Forestry CO2 loss

Payback Time

Payback Time - Charts/Output Data

### CO<sub>2</sub> loss from forests - calculation using detailed management information

Forest carbon calculator (Perks et al, 2009)

Total potential carbon sequestration loss due to felling of forestry for the wind farm (t CO <sub>2</sub> )
Total emissions due to cleared land (t CO <sub>2</sub> )
Emissions due to harvesting operations (t CO <sub>2</sub> )
Fossil fuel equivalent saving from use of felled forestry as biofuel (t CO <sub>2</sub> )
Fossil fuel equivalent saving from use of replanted forestry as biofuel (t CO <sub>2</sub> )
<b>RESULTS</b>
Total carbon loss associated with forest management(t CO <sub>2</sub> )

### Emissions due to forest felling - calculation using simple management data

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

	Exp.	Min.	Max.
Area of forestry plantation to be felled (ha)	54.2	49.2	59.2
Carbon sequestered (t C ha <sup>-1</sup> yr <sup>-1</sup> )	3.6	3.5	3.7
Lifetime of windfarm (years)	30	25	30
Carbon sequestered over the lifetime of the windfarm (t C ha <sup>-1</sup> )	108	87.5	111
<b>RESULTS</b>			
Total carbon loss due to felling of forestry (t CO <sub>2</sub> )	21463.4	15785.14	24094.62
Additional CO <sub>2</sub> payback time of windfarm due to management of forestry			
...coal-fired electricity generation (months)	190.23	144.02	207.62
...grid-mix of electricity generation (months)	690.16	522.51	753.25
...fossil fuel - mix of electricity generation (months)	388.91	294.44	424.46

## 8. CO2 gain - site improvement

Payback Time

Payback Time - Charts/Input Data

### Gains due to site improvement

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

#### Degraded Bog

	Exp.
<b>1. Description of site</b>	
Area to be improved (ha)	0
Depth of peat above water table before improvement (m)	0
Depth of peat above water table after improvement (m)	0
<b>2. Losses with improvement</b>	
Improved period (years)	0
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.496
CH4 emissions from improved land (t CO2 equiv.)	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	0.349
CO2 emissions from improved land (t CO2 equiv.)	0
Total GHG emissions from improved land (t CO2 equiv.)	0

#### Borrow Pits

	Exp.
<b>1. Description of site</b>	
Area to be improved (ha)	0
Depth of peat above water table before improvement (m)	0
Depth of peat above water table after improvement (m)	0
<b>2. Losses with improvement</b>	
Improved period (years)	0
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.496
CH4 emissions from improved land (t CO2 equiv.)	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	0.349
CO2 emissions from improved land (t CO2 equiv.)	0
Total GHG emissions from improved land (t CO2 equiv.)	0

#### Felled Forestry

	Exp.	Min.
<b>1. Description of site</b>		
Area to be improved (ha)	0	
Depth of peat above water table before improvement (m)	0	
Depth of peat above water table after improvement (m)	0	
<b>2. Losses with improvement</b>		
Improved period (years)	0	
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.496	0.4
CH4 emissions from improved land (t CO2 equiv.)	0	
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	0.349	-0.0
CO2 emissions from improved land (t CO2 equiv.)	0	
Total GHG emissions from improved land (t CO2 equiv.)	0	

#### Foundations & Hardstanding

	Exp.	Min.
<b>1. Description of site</b>		
Area to be improved (ha)	0	
Depth of peat above water table before improvement (m)	0	
Depth of peat above water table after improvement (m)	0	
<b>2. Losses with improvement</b>		
Improved period (years)	30	
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.496	0.4
CH4 emissions from improved land (t CO2 equiv.)	0	
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	0.349	-0.0
CO2 emissions from improved land (t CO2 equiv.)	0	
Total GHG emissions from improved land (t CO2 equiv.)	0	

### 3. CO2 loss backup

Payback Time

Payback Time - Charts/Inout Data

#### Emissions due to backup power generation

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

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

**Assumption:** Backup assumed to be by fossil-fuel-mix of electricity generation. Note that hydroelectricity may also be used for backup, so this assumption may make the value

	Exp.	Min.	Max.
Reserve energy (MWh/yr)	21,024	21,024	21,024
Annual emissions due to backup from fossil fuel-mix of electricity generation (tCO2/yr)	946	946	946
<b>RESULTS</b>			
Total emissions due to backup from fossil fuel-mix of electricity generation (tCO2)	28,382	23,652	28,382

# 1. CO2 emission saving

Payback Time  
 Payback Time - Charts/Output Data

## Emissions due to turbine life

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.

Capacity factor calculated from forestry data

Capacity factor - Direct input

Area name	Value type	Capacity factor (%)	Wind speed ratio	Average site windspeed (m/	Capacity factor (%)	Exp.	Min.	Max.
						0.4	0.3	0.4

	Exp.	Min.	Max.
Annual energy output from windfarm (MW/yr)			
<b>RESULTS</b>			
Emissions saving over coal-fired electricity generatio...	1,354	1,315	1,393
Emissions saving over grid-mix of electricity generati...	373	363	384
Emissions saving over fossil fuel - mix of electricity g...	662	643	681

## 2. CO2 loss turbine life

Payback Time

Payback Time - Charts/Output Data

### Emissions due to turbine life

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.

Calculation of emissions with relation to installed capacity

	Exp.	Min.
Emissions due to turbine from energy output (t CO2)	4017	
Emissions due to cement used in construction (t CO2)	1422	

Direct input of emissions due to turbine life

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

## RESULTS

	Exp.	Min.	Max.
Losses due to turbine life (manufacture, construction, etc.) (t CO2)	41595	41595	41595
<b>Additional CO2 payback time of windfarm due to turbine life</b>			
...coal-fired electricity generation (months)	369	380	358
...grid-mix of electricity generation (months)	1338	1377	1300
...fossil fuel - mix of electricity generation (months)	754	776	733

#### 4. Loss CO2 fixing pot.

Payback Time

Payback Time - Charts/Output Data

##### Emissions due to loss of bog plants

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

	Exp.	Min.	Max.
Area where carbon accumulation by bog plants is lost (ha)	38.21	25.86	53.01
Total loss of carbon accumulation up to time of restoration (tCO2 eq./ha)	37	22	50
<b>RESULTS</b>			
Total loss of carbon fixation by plants at the site (t CO2)	1401	569	2624
Additional CO2 payback time of windfarm due to loss of CO2 fixing potential			
...coal-fired electricity generation (months)	12	5	23
...grid-mix of electricity generation (months)	45	19	82
...fossil fuel - mix of electricity generation (months)	25	11	46

## 6. CO2 loss DOC & POC

Payback Time

Payback Time - Charts/Output Data

### Emissions due to loss of DOC and POC

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

	Exp.	Min.	Max.
Gross CO2 loss from restored drained land (t CO2)	0.00	0.00	0.00
Gross CH4 loss from restored drained land (t CO2 equiv.)	0.00	0.00	0.00
Gross CO2 loss from improved land (t CO2)	0.00	0.00	0.00
Gross CH4 loss from improved land (t CO2 equiv.)	0.00	0.00	0.00
Total gaseous loss of C (t C)	0.00	0.00	0.00
Total C loss as DOC (t C)	0.00	0.00	0.00
Total C loss as POC (t C)	0.00	0.00	0.00
<b>RESULTS</b>			
Total CO2 loss due to DOC leaching (t CO2)	0.00	0.00	0.00
Total CO2 loss due to POC leaching (t CO2)	0.00	0.00	0.00
Total CO2 loss due to DOC & POC leaching (t CO2)	0.00	0.00	0.00
<b>Additional CO2 payback time of windfarm due to DOC &amp; POC</b>			
...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