

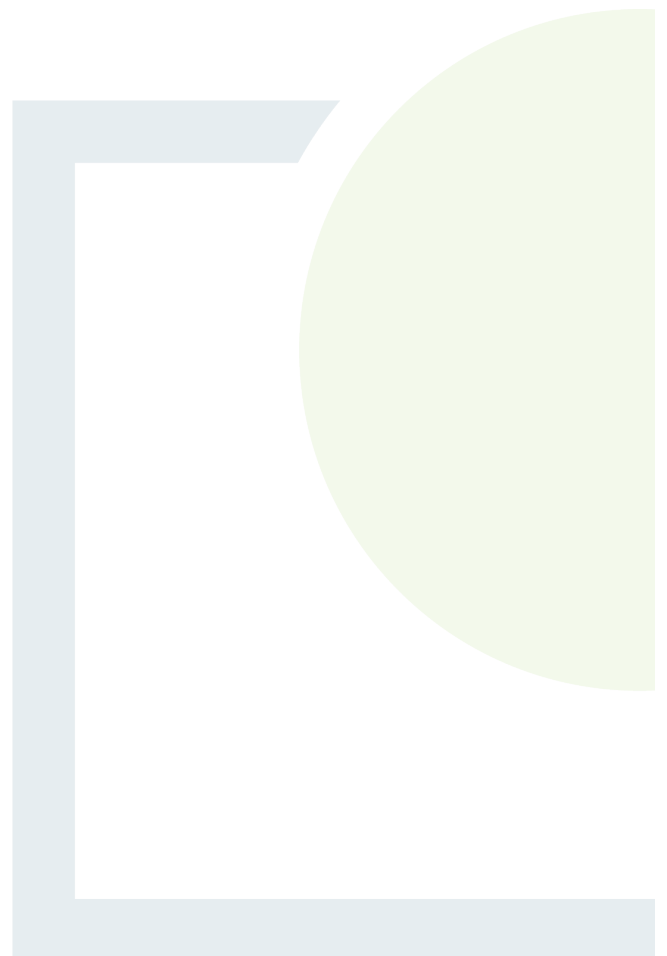


DESIGNING AND DELIVERING  
A SUSTAINABLE FUTURE

## APPENDIX 10

Air Quality and Climate

### Appendix 1.1 – Air and Climate Calculations



## APPENDIX 10.1

### Air and Climate Calculations

## Scottish Government Windfarm Carbon Assessment Tool - Version 2.14.1

27-01-23

This spreadsheet calculates payback time for windfarm sited on peatlands using methods given in Nayak et al, 2008 ( <http://www.scotland.gov.uk/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://www.mires-and-peat.net/map04/map\\_04\\_09.htm](http://www.mires-and-peat.net/map04/map_04_09.htm) ) )  
Version 2.0.0 - Adapted to include detail of forestry management, Smith et al., 2011.  
<http://www.scotland.gov.uk/WindFarmsAndCarbon>

Version 2.14.0 - Corrections to calculation of peat removed for hardstanding  
plus corrections to emission factors and changes as detailed in previous worksheets

Revised by J.U.Smith to correct forestry and restoration sheets

Version 2.14.1 - Equivalent to version 2.14.0 but with worksheets unprotected for your own use. Do not use this version in planning applications.

### INSTRUCTIONS

**A** There are 6 worksheets giving instructions, data entry and outputs, ....

#### Instructions

Do I need to use this tool?

....Click here to find out

[Click here](#)

Core input data

.... Data needed in all calculations

[Click here](#)

Forestry input data

.... Extra details sometimes needed for forestry calculations

Construction input data

.... Extra details sometimes needed for construction calculations

Payback time and CO<sub>2</sub> emissions

[Click here](#)

...and 8 numbered worksheets showing calculations:

1. Windfarm CO<sub>2</sub> emission saving

2. CO<sub>2</sub> loss due to turbine life

3. CO<sub>2</sub> loss due to backup

4. Loss of CO<sub>2</sub> Fixing Pot.

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

5a. Volume of peat removed

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

5c. Volume of peat drained

5d. CO<sub>2</sub> loss from drained peat

5e. Emission rates

6. CO<sub>2</sub> loss by DOC & POC loss

7i. Forestry CO<sub>2</sub> loss - simple

7ii. Forestry CO<sub>2</sub> loss - detailed

7a. C sequest. in trees (3PG)

7b. C seq. in soil under trees

7c. Average stand data

7d. Windspeed ratios

8. CO<sub>2</sub> gain - site improvement

In addition, there are spreadsheets containing references and requesting feedback.

#### References

Frequently asked questions

Notes on calculations are given in pale green text boxes.... [Click here to see example of Notes Box](#)

Protocols for measurements are given in pale yellow comment boxes.... [Click here to see example of Protocol Box](#)

Assumptions are given in pale blue text boxes.... [Click here to see example of Assumptions Box](#)

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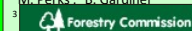
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### Note on official version number

#### Version X.Y.Z

X refers to the release number

Y refers to released updates on release X

Z refers to unreleased updates on release X.Y

Officially released versions will always have Z=0

If you make changes of your own, please do not refer to your modified spreadsheet using the official version number.

The latest version is published at [www.scotland.gov.uk/WindFarmsAndCarbon](http://www.scotland.gov.uk/WindFarmsAndCarbon)

Please check you are using the latest official version with Z=0 before submitting a planning application.

## Do I need to use this tool?

1. Will the site be drained on construction of the windfarm?

Yes ▼

2. Is the soil at the site highly organic?

Yes ▼

i.e. is the soil organo-mineral or organic, (i.e. a peaty gley or peat)?

3. Does windfarm construction require a significant amount of deforestation?

No ▼

i.e. is removal in excess of keyholing the turbines within the forest boundary?

You should use this tool because the soil is highly organic.

Please move to the Core input data sheet and complete the form to obtain an estimate of *C* payback time

[Click here to return to Instructions sheet](#)

[Click here](#)

[Click here to move on to Core input data sheet](#)

[Click here](#)



Core input data

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

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

Click here to move to Payback Time

Click here

Click here to return to Instructions

Click here

| Input data                                                                                                     | Expected values                         |                       | Possible range of values                |                       |                                         |                       |
|----------------------------------------------------------------------------------------------------------------|-----------------------------------------|-----------------------|-----------------------------------------|-----------------------|-----------------------------------------|-----------------------|
|                                                                                                                | Enter expected value here               | Record source of data | Enter minimum value here                | Record source of data | Enter maximum value here                | Record source of data |
| Windfarm characteristics                                                                                       |                                         |                       |                                         |                       |                                         |                       |
| Dimensions                                                                                                     |                                         |                       |                                         |                       |                                         |                       |
| No. of turbines                                                                                                | 11                                      | Fixed                 |                                         |                       |                                         |                       |
| Lifetime of windfarm (years)                                                                                   | 35                                      |                       |                                         |                       |                                         |                       |
| Performance                                                                                                    |                                         |                       |                                         |                       |                                         |                       |
| Power rating of turbines (turbine capacity) (MW)                                                               | 6.2                                     |                       |                                         |                       |                                         |                       |
| Capacity factor                                                                                                | Direct input of capacity f <sub>c</sub> |                       | Direct input of capacity f <sub>a</sub> |                       | Direct input of capacity f <sub>a</sub> |                       |
| Enter estimated capacity factor (percentage efficiency)                                                        | 31.0                                    |                       |                                         |                       |                                         |                       |
| Backup                                                                                                         |                                         |                       |                                         |                       |                                         |                       |
| Extra capacity required for backup (%)                                                                         | 5                                       |                       |                                         |                       |                                         |                       |
| Additional emissions due to reduced thermal efficiency of the reserve generation (%)                           | 10                                      |                       |                                         |                       |                                         |                       |
| Carbon dioxide emissions from turbine life - (eg. manufacture, construction, decommissioning)                  | Calculate wrt installed c <sub>aj</sub> |                       | Calculate wrt installed c <sub>aj</sub> |                       | Calculate wrt installed c <sub>aj</sub> |                       |
| Characteristics of peatland before windfarm development                                                        |                                         |                       |                                         |                       |                                         |                       |
| Type of peatland                                                                                               | Acid b                                  |                       | Acid b                                  |                       | Acid b                                  |                       |
| Average annual air temperature at site (°C)                                                                    | 10.7                                    |                       |                                         |                       |                                         |                       |
| Average depth of peat at site (m)                                                                              | 1.50                                    |                       |                                         |                       |                                         |                       |
| C Content of dry peat (% by weight)                                                                            | 60                                      |                       |                                         |                       |                                         |                       |
| Average extent of drainage around drainage features at site (m)                                                |                                         |                       |                                         |                       |                                         |                       |
| Average water table depth at site (m)                                                                          | 2.60                                    |                       |                                         |                       |                                         |                       |
| Dry soil bulk density (g cm <sup>-3</sup> )                                                                    | 0.25                                    |                       |                                         |                       |                                         |                       |
| Characteristics of bog plants                                                                                  |                                         |                       |                                         |                       |                                         |                       |
| Time required for regeneration of bog plants after restoration (years)                                         | 2                                       |                       |                                         |                       |                                         |                       |
| Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha <sup>-1</sup> yr <sup>-1</sup> ) | 0.6                                     |                       |                                         |                       |                                         |                       |
| Forestry Plantation Characteristics                                                                            |                                         |                       |                                         |                       |                                         |                       |
| Method used to calculate CO <sub>2</sub> loss from forest felling                                              | Enter simple data                       |                       | Enter simple data                       |                       | Enter simple data                       |                       |
| Area of forestry plantation to be felled (ha)                                                                  | 0                                       |                       |                                         |                       |                                         |                       |
| Average rate of carbon sequestration in timber (tC ha-1 yr-1)                                                  | 3.60                                    |                       |                                         |                       |                                         |                       |
| Counterfactual emission factors                                                                                |                                         |                       |                                         |                       |                                         |                       |
| To update counterfactual emission factors from the web                                                         | Click here (not yet operational)        |                       |                                         |                       |                                         |                       |
| Coal-fired plant emission factor (t CO <sub>2</sub> MWh <sup>-1</sup> )                                        | 1.02                                    |                       |                                         |                       |                                         |                       |
| Grid-mix emission factor (t CO <sub>2</sub> MWh <sup>-1</sup> )                                                | 0.204                                   |                       |                                         |                       |                                         |                       |
| Fossil fuel-mix emission factor (t CO <sub>2</sub> MWh <sup>-1</sup> )                                         | 0.43                                    |                       |                                         |                       |                                         |                       |
| Borrow pits                                                                                                    |                                         |                       |                                         |                       |                                         |                       |
| Number of borrow pits                                                                                          | 1                                       |                       |                                         |                       |                                         |                       |
| Average length of pits (m)                                                                                     | 468                                     |                       |                                         |                       |                                         |                       |
| Average width of pits (m)                                                                                      | 190                                     |                       |                                         |                       |                                         |                       |
| Average depth of peat removed from pit (m)                                                                     | 0.00                                    |                       |                                         |                       |                                         |                       |
| Foundations and hard-standing area associated with each turbine                                                |                                         |                       |                                         |                       |                                         |                       |

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](http://www.bwea.com/ref/capacityfactors.html)). Capacity Factor = Electricity generated during the period [kWh]/ (Installed capacity [kW] x number of hours in the period [h]) We recommend that a site-specific capacity factor site-should be used (as measured during planning stage), and should represent the average emission factor expected over the lifetime of the windfarm, accounting for decline in efficiency with age (Hughes, 2012). The 5 year average capacity factor (or "load factor") for UK onshore wind between 2010 and 2014, based on average beginning and end of year capacity, was 29.2% (DUKES, 2015).

Note: Extra capacity required for backup. If 20% of national electricity is generated by wind energy, the extra capacity required for backup is 5% of the rated capacity of the wind plant (Dale et al 2004). We suggest this should be 5% of the actual output. If it is assumed that less than 20% of national electricity is generated by wind energy, a lower percentage should be entered (0%). The House of Lords Economic Affairs Committee report on The Economics of Renewable Energy (Parliamentary Business, 2008) notes that to cover peak demand a '20% margin of extra capacity has been sufficient to keep the risk of a power cut due to insufficient generation at a very low level.' The estimate provided by BERR was a range of 10% to 20% of installed capacity of wind energy. E.ON is reported as proposing that the capacity credit of wind power should be 8%, and The Renewable Energy Foundation proposed the use of the square root of the wind capacity (in GW) as conventional capacity (e.g. 36 GW of wind plant to match 6 GW of conventional plant).

Note: Extra emissions due to reduced thermal efficiency of the reserve power generation ≈ 10% (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 CO<sub>2</sub> emissions is 394 to 8147 t CO<sub>2</sub> 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<sup>-1</sup> yr<sup>-1</sup> (Turunen et al., 2001; Botch et al., 1995). The SNH guidance uses a value of 0.25 t C ha<sup>-1</sup> yr<sup>-1</sup>.

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

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

Note: Coal-Fired Plant and Grid Mix Emission Factors. Coal-Fired Plant Emission Factor (EF) = 1.02 tCO<sub>2</sub>e/MWh (Source: [Green Collective](#)) Grid Mix EF = 0.204 tCO<sub>2</sub>e/MWh (Source: [SEAI](#), standard factors published annually)

Note: Fossil Fuel-Mix Emission Factor = 0.43 tCO<sub>2</sub>e/MWh (Source: [SEAI](#), modelling for a counter-factual scenario suggests gas dominates marginal demand so would be most reflective of a fossil fuel mix)

|                                                                                                                                           |                             |  |                             |  |                             |  |  |
|-------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|--|-----------------------------|--|-----------------------------|--|--|
| Method used to calculate CO <sub>2</sub> loss from foundations and hard-standing                                                          | Rectangular with vertical ▼ |  | Rectangular with vertical ▼ |  | Rectangular with vertical ▼ |  |  |
| Average length of turbine foundations (m)                                                                                                 | 27.5                        |  |                             |  |                             |  |  |
| Average width of turbine foundations (m)                                                                                                  | 27.5                        |  |                             |  |                             |  |  |
| Average depth of peat removed from turbine foundations (m)                                                                                | 1.03                        |  |                             |  |                             |  |  |
| Average length of hard-standing (m)                                                                                                       | 88                          |  |                             |  |                             |  |  |
| Average width of hard-standing (m)                                                                                                        | 30                          |  |                             |  |                             |  |  |
| Average depth of peat removed from hard-standing (m)                                                                                      | 1.10                        |  |                             |  |                             |  |  |
| Access tracks                                                                                                                             |                             |  |                             |  |                             |  |  |
| Total length of access track (m)                                                                                                          | 18400                       |  |                             |  |                             |  |  |
| Existing track length (m)                                                                                                                 | 2950                        |  |                             |  |                             |  |  |
| Length of access track that is floating road (m)                                                                                          | 13350                       |  |                             |  |                             |  |  |
| Floating road width (m)                                                                                                                   | 6                           |  |                             |  |                             |  |  |
| Floating road depth (m)                                                                                                                   | 0.60                        |  |                             |  |                             |  |  |
| Length of floating road that is drained (m)                                                                                               | 13350                       |  |                             |  |                             |  |  |
| Average depth of drains associated with floating roads (m)                                                                                | 0.50                        |  |                             |  |                             |  |  |
| Length of access track that is excavated road (m)                                                                                         | 2100                        |  |                             |  |                             |  |  |
| Excavated road width (m)                                                                                                                  | 6                           |  |                             |  |                             |  |  |
| Average depth of peat excavated for road (m)                                                                                              | 0.20                        |  |                             |  |                             |  |  |
| Length of access track that is rock filled road (m)                                                                                       | 2100                        |  |                             |  |                             |  |  |
| Rock filled road width (m)                                                                                                                | 6                           |  |                             |  |                             |  |  |
| Rock filled road depth (m)                                                                                                                | 0.8                         |  |                             |  |                             |  |  |
| Length of rock filled road that is drained (m)                                                                                            | 2100                        |  |                             |  |                             |  |  |
| Average depth of drains associated with rock filled roads (m)                                                                             | 0.50                        |  |                             |  |                             |  |  |
| Cable Trenches                                                                                                                            |                             |  |                             |  |                             |  |  |
| Length of any cable trench on peat that does not follow access tracks and is lined with a permeable medium (eg. sand) (m)                 | 0                           |  |                             |  |                             |  |  |
| Average depth of peat cut for cable trenches (m)                                                                                          | 1.00                        |  |                             |  |                             |  |  |
| Additional peat excavated (not already accounted for above)                                                                               |                             |  |                             |  |                             |  |  |
| Volume of additional peat excavated (m <sup>3</sup> )                                                                                     | 12982                       |  |                             |  |                             |  |  |
| Area of additional peat excavated (m <sup>2</sup> )                                                                                       | 11019.0                     |  |                             |  |                             |  |  |
| Peat Landslide Hazard                                                                                                                     |                             |  |                             |  |                             |  |  |
| <a href="#">Weblink: Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments</a> |                             |  |                             |  |                             |  |  |
| Improvement of C sequestration at site by blocking drains, restoration of habitat etc                                                     |                             |  |                             |  |                             |  |  |
| Improvement of degraded bog                                                                                                               |                             |  |                             |  |                             |  |  |
| Area of degraded bog to be improved (ha)                                                                                                  |                             |  |                             |  |                             |  |  |
| Water table depth in degraded bog before improvement (m)                                                                                  |                             |  |                             |  |                             |  |  |
| Water table depth in degraded bog after improvement (m)                                                                                   |                             |  |                             |  |                             |  |  |
| Time required for hydrology and habitat of bog to return to its previous state on improvement (years)                                     |                             |  |                             |  |                             |  |  |
| Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years)                                            |                             |  |                             |  |                             |  |  |
| Improvement of felled plantation land                                                                                                     |                             |  |                             |  |                             |  |  |
| Area of felled plantation to be improved (ha)                                                                                             |                             |  |                             |  |                             |  |  |
| Water table depth in felled area before improvement (m)                                                                                   |                             |  |                             |  |                             |  |  |
| Water table depth in felled area after improvement (m)                                                                                    |                             |  |                             |  |                             |  |  |
| Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)                       |                             |  |                             |  |                             |  |  |
| Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years)                                       |                             |  |                             |  |                             |  |  |
| Restoration of peat removed from borrow pits                                                                                              |                             |  |                             |  |                             |  |  |
| Area of borrow pits to be restored (ha)                                                                                                   |                             |  |                             |  |                             |  |  |
| Depth of water table in borrow pit before restoration with respect to the restored surface (m)                                            |                             |  |                             |  |                             |  |  |

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/2006/12/21162303/1>.

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

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.

|                                                                                                                                                                                                                                                                                                                                                                                                                                                              |               |  |      |  |      |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|--|------|--|------|--|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Depth of water table in borrow pit after restoration with respect to the restored surface (m)                                                                                                                                                                                                                                                                                                                                                                |               |  |      |  |      |  | <div>Note: <u>Period of time when improvement can be guaranteed</u>. This gurantee should be absolute. Therefore, if you enter a value beyond the lifetime of the windfarm you should provide strong supporting evidence that this improvement can be guaranteed for the full period given. This includes the time requirement for the improvement to become effective. For example if time required for hydrology and habitat to return to its previous state is 10 years and the restoration can be guaranteed over the lifetime of the windfarm (25 years), the period of time when the improvement can be guaranteed should be entered as 25 years, and the improvement will be effective for (25 -10) = 15 years.</div> |
| 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)                                                                                                                                                                                                                                                                                                                                              |               |  |      |  |      |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <u>Early removal of drainage from foundations and hardstanding</u>                                                                                                                                                                                                                                                                                                                                                                                           |               |  |      |  |      |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Water table depth around foundations and hardstanding before restoration (m)                                                                                                                                                                                                                                                                                                                                                                                 |               |  |      |  |      |  | <div>Note: <u>Period of time when improvement can be guaranteed</u>. This is assumed to be the lifetime of the windfarm as restoration after windfarm decommissioning is already accounted for in restoration of the site</div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Water table depth around foundations and hardstanding after restoration (m)                                                                                                                                                                                                                                                                                                                                                                                  |               |  |      |  |      |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)                                                                                                                                                                                                                                                                                                                                              |               |  |      |  |      |  | <div>Note: <u>Restoration of site</u>. 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%.</div>                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Restoration of site after decomissioning</b>                                                                                                                                                                                                                                                                                                                                                                                                              |               |  |      |  |      |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Will the hydrology of the site be restored on decommissioning?                                                                                                                                                                                                                                                                                                                                                                                               | Yes           |  | Yes  |  | Yes  |  | <div>Yes</div> <div>No</div> <div>---</div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Will you attempt to block any gullies that have formed due to the windfarm?                                                                                                                                                                                                                                                                                                                                                                                  | Not appli▼    |  | Yes▼ |  | Yes▼ |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Will you attempt to block all artificial ditches and facilitate rewetting?                                                                                                                                                                                                                                                                                                                                                                                   | Not appli▼    |  | Yes▼ |  | Yes▼ |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Will the habitat of the site be restored on decommissioning?                                                                                                                                                                                                                                                                                                                                                                                                 | Yes           |  | Yes  |  | Yes  |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Will you control grazing on degraded areas?                                                                                                                                                                                                                                                                                                                                                                                                                  | Yes▼          |  | Yes▼ |  | Yes▼ |  | <div>---</div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Will you manage areas to favour reintroduction of species                                                                                                                                                                                                                                                                                                                                                                                                    | Yes▼          |  | Yes▼ |  | Yes▼ |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Choice of methodology for calculating emission factors</b>                                                                                                                                                                                                                                                                                                                                                                                                | IPCC default▼ |  |      |  |      |  | <div>Note: <u>Choice of methodology for calculating emission factors</u>. The IPCC default methodology is the internationally accepted standard (IPCC, 1997). However, it is stated in IPCC (1997) that these are rough estimates, and "these rates and production periods can be used if countries do not have more appropriate estimates". Therefore, we have developed more site specific estimates for use here based on work from the Scottish Government funded ECOSSE project (Smith et al, 2007. ECOSSE: Estimating Carbon in Organic Soils - Sequestration and Emissions. Final Report. SEERAD Report. ISBN 978 0 7559 1498 2. 166pp.).</div>                                                                       |
| <div><b>Core input data</b><br/>ENTER INPUT DATA HERE! VALUES SHOULD ONLY BE CHANGED ON THIS SHEET. <b>DO NOT USE EXAMPLE VALUES AS DEFAULTS!</b> ENTER YOUR OWN VALUES THAT ARE SPECIFIC TO YOUR PARTICULAR SITE.<br/><br/>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.</div> |               |  |      |  |      |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |

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## Results

### PAYBACK TIME AND CO<sub>2</sub> 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.

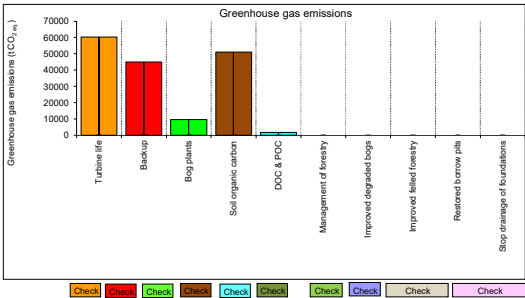
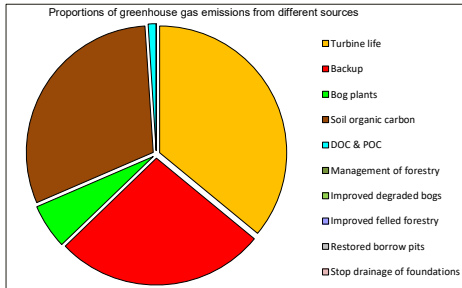
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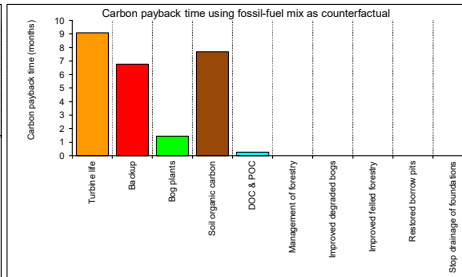
|                                                                                        | Exp.    |
|----------------------------------------------------------------------------------------|---------|
| <b>1. Windfarm CO<sub>2</sub> emission saving over...</b>                              |         |
| ...coal-fired electricity generation (tCO <sub>2</sub> yr <sup>-1</sup> )              | 188908  |
| ...grid-mix of electricity generation (tCO <sub>2</sub> yr <sup>-1</sup> )             | 37782   |
| ...fossil fuel - mix of electricity generation (tCO <sub>2</sub> yr <sup>-1</sup> )    | 79638   |
| Energy output from windfarm over lifetime (MWh)                                        | 6482137 |
| <b>Total CO<sub>2</sub> losses due to wind farm (t CO<sub>2</sub> eq.)</b>             |         |
| 2. Losses due to turbine life (eg. manufacture, construction, decommissioning)         | 60212   |
| 3. Losses due to backup                                                                | 44957   |
| 4. Losses due to reduced carbon fixing potential                                       | 9585    |
| 5. Losses from soil organic matter                                                     | 50974   |
| 6. Losses due to DOC & POC leaching                                                    | 1730    |
| 7. Losses due to felling forestry                                                      | 0       |
| Total losses of carbon dioxide                                                         | 167457  |
| <b>8. Total CO<sub>2</sub> gains due to improvement of site (t CO<sub>2</sub> eq.)</b> |         |
| 8a. Change in emissions due to improvement of degraded bogs                            | 0       |
| 8b. Change in emissions due to improvement of felled forestry                          | 0       |
| 8c. Change in emissions due to restoration of peat from borrow pits                    | 0       |
| 8d. Change in emissions due to removal of drainage from foundations & hardstanding     | 0       |
| Total change in emissions due to improvements                                          | 0       |

## RESULTS

|                                                                                                                                           | Exp.     |
|-------------------------------------------------------------------------------------------------------------------------------------------|----------|
| <b>Net emissions of carbon dioxide (t CO<sub>2</sub> eq.)</b>                                                                             |          |
|                                                                                                                                           | 167457   |
| <b>Carbon Payback Time</b>                                                                                                                |          |
| ...coal-fired electricity generation (years)                                                                                              | 0.9      |
| ...grid-mix of electricity generation (years)                                                                                             | 4.4      |
| ...fossil fuel - mix of electricity generation (years)                                                                                    | 2.1      |
| <b>Ratio of soil carbon loss to gain by restoration (TARGET ratio (Natural Resources Wales) &lt; 1.0)</b>                                 | No gain! |
| <b>Ratio of CO<sub>2</sub> eq. emissions to power generation (g / kWh) (TARGET ratio by 2030 (electricity generation) &lt; 50 g /kWh)</b> | 28       |



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## Results

### PAYBACK TIME AND CO<sub>2</sub> 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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Data used in barchart of carbon payback time using fossil-fuel mix as counterfactual

| Greenhouse gas emissions     | Exp.  | Min   | Max |
|------------------------------|-------|-------|-----|
| Turbine life                 | 60212 | 60212 | 0   |
| Backup                       | 44957 | 44957 | 0   |
| Bog plants                   | 9585  | 9585  | 0   |
| Soil organic carbon          | 50974 | 50974 | 0   |
| DOC & POC                    | 1730  | 1730  | 0   |
| Management of forestry       | 0     | 0     | 0   |
| Improved degraded bogs       | 0     | 0     | 0   |
| Improved felled forestry     | 0     | 0     | 0   |
| Restored borrow pits         | 0     | 0     | 0   |
| Stop drainage of foundations | 0     | 0     | 0   |

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

| Greenhouse gas emissions     | Exp.   | Min.  | Max.   | Carbon payback time (months) | Exp. | Min. | Max. |
|------------------------------|--------|-------|--------|------------------------------|------|------|------|
| Turbine life                 | 60212  | 60212 | -60212 | 9                            | 9    |      |      |
| Backup                       | 44957  | 44957 | -44957 | 7                            | 7    |      |      |
| Bog plants                   | 9585   | 9585  | -9585  | 1                            | 1    |      |      |
| Soil organic carbon          | 50974  | 50974 | -50974 | 8                            | 8    |      |      |
| DOC & POC                    | 1730   | 1730  | -1730  | 0                            | 0    |      |      |
| Management of forestry       | 0      | 0     | 0      | 0                            | 0    |      |      |
| Improved degraded bogs       | 0      | 0     | 0      | 0                            | 0    |      |      |
| Improved felled forestry     | 0      | 0     | 0      | 0                            | 0    |      |      |
| Restored borrow pits         | 0      | 0     | 0      | 0                            | 0    |      |      |
| Stop drainage of foundations | 0      | 0     | 0      | 0                            | 0    |      |      |
|                              | 167457 |       |        | 25                           | 25   |      |      |

### Windfarm CO<sub>2</sub> 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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|                                |   |                                 |     |     |
|--------------------------------|---|---------------------------------|-----|-----|
| Calculation of capacity factor | 1 | Direct input of capacity factor |     |     |
|                                |   | Exp                             | Min | Max |
| Entered capacity factor (%)    |   | 31                              | 0   | 0   |

| Parameters                                         | Slope (a) |        |        | Intercept (b) |         |         |
|----------------------------------------------------|-----------|--------|--------|---------------|---------|---------|
|                                                    | Exp       | Min    | Max    | Exp           | Min     | Max     |
| <b>Partial power curves for different turbines</b> |           |        |        |               |         |         |
| 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 |

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| RESULTS                                                                             | Total  |   |   | Area 1 |   |   | Area 2 |   |   | Area 3 |   |   | Area 4 |   |   | Area 5 |   |   |
|-------------------------------------------------------------------------------------|--------|---|---|--------|---|---|--------|---|---|--------|---|---|--------|---|---|--------|---|---|
| Windfarm CO <sub>2</sub> emission saving over...                                    |        |   |   |        |   |   |        |   |   |        |   |   |        |   |   |        |   |   |
| ...coal-fired electricity generation (tCO <sub>2</sub> yr <sup>-1</sup> )           | 188908 | 0 | 0 | 0      | 0 | 0 | 0      | 0 | 0 | 0      | 0 | 0 | 0      | 0 | 0 | 0      | 0 | 0 |
| ...grid-mix of electricity generation (tCO <sub>2</sub> yr <sup>-1</sup> )          | 37782  | 0 | 0 | 0      | 0 | 0 | 0      | 0 | 0 | 0      | 0 | 0 | 0      | 0 | 0 | 0      | 0 | 0 |
| ...fossil fuel - mix of electricity generation (tCO <sub>2</sub> yr <sup>-1</sup> ) | 79638  | 0 | 0 | 0      | 0 | 0 | 0      | 0 | 0 | 0      | 0 | 0 | 0      | 0 | 0 | 0      | 0 | 0 |

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**Windfarm CO<sub>2</sub> 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, decomissioning) 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 CO <sub>2</sub> emissions from turbine life (eg. manufacture, construction, decommissioning)? | Calculate wrt installed capacity |
|-----------------------------------------------------------------------------------------------------------------------|----------------------------------|

|                                                                                                                            |       |     |     |
|----------------------------------------------------------------------------------------------------------------------------|-------|-----|-----|
|                                                                                                                            | Exp   | Min | Max |
| Direct input of emissions due to turbine life (t CO <sub>2</sub> windfarm <sup>-1</sup> )                                  | 0     | 0   | 0   |
| Calculation of emissions due to turbine life from energy output                                                            |       |     |     |
| CO <sub>2</sub> emissions due to turbine life (tCO <sub>2</sub> turbine <sup>-1</sup> )                                    | 5325  | 0   | 0   |
| No. of turbines                                                                                                            | 11    | 0   | 0   |
| Total calculated CO <sub>2</sub> emission of the wind farm due to turbine life (t CO <sub>2</sub> windfarm <sup>-1</sup> ) | 58580 | 0   | 0   |

|                                                                          | 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 <sup>3</sup> )                                  | 5165  | 0     | 0     | 0                   | 0     | 0     | 0                   | 0     | 0     | 0                   | 0     | 0     | 0                   | 0     | 0     | 0                   | 0     | 0     |
| CO <sub>2</sub> emission rate (t CO <sub>2</sub> m <sup>-3</sup> 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 <sub>2</sub> emissions due to cement used in construction       | 1632  | 0     | 0     | 0                   | 0     | 0     | 0                   | 0     | 0     | 0                   | 0     | 0     | 0                   | 0     | 0     | 0                   | 0     | 0     |

|                                                                                                                        |       |   |   |
|------------------------------------------------------------------------------------------------------------------------|-------|---|---|
| RESULTS                                                                                                                |       |   |   |
| Losses due to turbine life (eg. manufacture, construction, decomissioning) (t CO <sub>2</sub> windfarm <sup>-1</sup> ) | 60212 | 0 | 0 |
| Additional CO <sub>2</sub> payback time of windfarm due to turbine life (eg. manufacture, contruction, decomissioning) |       |   |   |
| ...coal-fired electricity generation (months)                                                                          | 4     | 0 | 0 |
| ...grid-mix of electricity generation (months)                                                                         | 19    | 0 | 0 |
| ...fossil fuel - mix of electricity generation (months)                                                                | 9     | 0 | 0 |

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Emissions due to turbine life

Note: The carbon payback time of the windfarm due to turbine life (eg. manufacture, construction, decomissioning) 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<sub>2</sub>e ) of concretes used in buildings

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

\*

includes 30kg/m<sup>3</sup> steel reinforcement

\*\*

includes 100kg/m<sup>3</sup> steel reinforcement

Emissions due to backup power generation

Note: CO<sub>2</sub> 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                                                                      | 11       | 0       | 0       |
| Power rating of turbines (turbine capacity) (MW)                                     | 6.2      | 0       | 0       |
| Power of wind farm (MW h <sup>-1</sup> )                                             | 68.2     | 0       | 0       |
| Rated capacity (MW yr <sup>-1</sup> )                                                | 597432   | 0       | 0       |
| Extra capacity required for backup (%)                                               | 5        | 0       | 0       |
| Additional emissions due to reduced thermal efficiency of the reserve generation (%) | 10       | 0       | 0       |
| Reserve capacity (MWh yr <sup>-1</sup> )                                             | 2987     | 0       | 0       |

|                                                                                     |       |   |   |
|-------------------------------------------------------------------------------------|-------|---|---|
| Carbon dioxide emissions due to backup power generation                             |       |   |   |
| Coal-fired plant emission factor (t CO <sub>2</sub> MWh <sup>-1</sup> )             | 1.02  | 0 | 0 |
| Grid-mix emission factor (t CO <sub>2</sub> MWh <sup>-1</sup> )                     | 0.204 | 0 | 0 |
| Fossil fuel- mix emission factor (t CO <sub>2</sub> MWh <sup>-1</sup> )             | 0.43  | 0 | 0 |
| Lifetime of windfarm (years)                                                        | 35    | 0 | 0 |
| Annual emissions due to backup from...                                              |       |   |   |
| ...coal-fired electricity generation (tCO <sub>2</sub> yr <sup>-1</sup> )           | 3047  | 0 | 0 |
| ...grid-mix of electricity generation (tCO <sub>2</sub> yr <sup>-1</sup> )          | 609   | 0 | 0 |
| ...fossil fuel - mix of electricity generation (tCO <sub>2</sub> yr <sup>-1</sup> ) | 1284  | 0 | 0 |

|                                                                    |        |   |   |
|--------------------------------------------------------------------|--------|---|---|
| RESULTS                                                            |        |   |   |
| Total emissions due to backup from...                              |        |   |   |
| ...coal-fired electricity generation (tCO <sub>2</sub> )           | 106642 | 0 | 0 |
| ...grid-mix of electricity generation (tCO <sub>2</sub> )          | 21328  | 0 | 0 |
| ...fossil fuel - mix of electricity generation (tCO <sub>2</sub> ) | 44957  | 0 | 0 |
| Additional CO <sub>2</sub> payback time of windfarm due to backup  |        |   |   |
| ...coal-fired electricity generation (months)                      | 7      | 0 | 0 |
| ...grid-mix of electricity generation (months)                     | 7      | 0 | 0 |
| ...fossil fuel - mix of electricity generation (months)            | 7      | 0 | 0 |

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Emissions due to backup power generation

Note: CO<sub>2</sub> 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  |
|----------------------------------------------------------------------------------------------------------|-------------|----------|----------|
| <b>Area where carbon accumulation by bog plants is lost</b>                                              |             |          |          |
| Total area of land lost due to windfarm construction (m <sup>2</sup> )                                   | 242598      | 0        | 0        |
| Total area affected by drainage due to windfarm construction (m <sup>2</sup> )                           | 80100       | 0        | 0        |
| Total area where fixation by plants is lost (m <sup>2</sup> )                                            | 322698      | 0        | 0        |
| <b>Total loss of carbon accumulation</b>                                                                 |             |          |          |
| Carbon accumulation in undrained peats (tC ha <sup>-1</sup> yr <sup>-1</sup> )                           | 0.6         | 0        | 0        |
| Lifetime of windfarm (years)                                                                             | 35          | 0        | 0        |
| Time required for regeneration of bog plants after restoration (years)                                   | 100         | 0        | 0        |
| Carbon accumulation up to time of restoration (tCO <sub>2</sub> eq. ha <sup>-1</sup> )                   | 297         | 0        | 0        |
| <b>RESULTS</b>                                                                                           |             |          |          |
| <b>Total loss of carbon accumulation by bog plants</b>                                                   |             |          |          |
| Total area where fixation by plants is lost (ha)                                                         | 32          | 0        | 0        |
| Carbon accumulation over lifetime of windfarm (tCO <sub>2</sub> eq. ha <sup>-1</sup> )                   | 297         | 0        | 0        |
| <b>Total loss of carbon fixation by plants at the site (t CO<sub>2</sub>)</b>                            | <b>9585</b> | <b>0</b> | <b>0</b> |
| <b>Additional CO<sub>2</sub> payback time of windfarm due to loss of CO<sub>2</sub> fixing potential</b> |             |          |          |
| ...coal-fired electricity generation (months)                                                            | 1           | 0        | 0        |
| ...grid-mix of electricity generation (months)                                                           | 3           | 0        | 0        |
| ...fossil fuel - mix of electricity generation (months)                                                  | 1           | 0        | 0        |

**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 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

**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), CO<sub>2</sub> loss from removed peat (sheet 5b), % site affected by drainage (sheet 5c), and the CO<sub>2</sub> loss from drained peat (sheet 5d).

|                                                                                              |                                                                  | Expected result | Minimum result | Maximum result |
|----------------------------------------------------------------------------------------------|------------------------------------------------------------------|-----------------|----------------|----------------|
| <b>CO<sub>2</sub> loss due to windfarm construction</b>                                      |                                                                  |                 |                |                |
| <input type="checkbox"/> Check                                                               | CO <sub>2</sub> loss from removed peat (t CO <sub>2</sub> equiv) | 46064           | 0              | 0              |
| <input type="checkbox"/> Check                                                               | CO <sub>2</sub> loss from drained peat (t CO <sub>2</sub> equiv) | 4910            | 0              | 0              |
| <b>RESULTS</b>                                                                               |                                                                  |                 |                |                |
| <b>Total CO<sub>2</sub> loss from peat (removed + drained) (t CO<sub>2</sub> equiv)</b>      |                                                                  | <b>50974</b>    | <b>0</b>       | <b>0</b>       |
| <b>Additional CO<sub>2</sub> payback time of windfarm due to loss of soil CO<sub>2</sub></b> |                                                                  |                 |                |                |
| ...coal-fired electricity generation (months)                                                |                                                                  | 3               | 0              | 0              |
| ...grid-mix of electricity generation (months)                                               |                                                                  | 16              | 0              | 0              |
| ...fossil fuel - mix of electricity generation (months)                                      |                                                                  | 8               | 0              | 0              |

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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), CO<sub>2</sub> loss from removed peat (sheet 5b), % site affected by drainage (sheet 5c), and the CO<sub>2</sub> 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.

| Peat removed from borrow pits                             | Exp   | Total<br>Min | Max |
|-----------------------------------------------------------|-------|--------------|-----|
| Number of borrow pits                                     | 1     | 0            | 0   |
| Average length of pits (m)                                | 468   | 0            | 0   |
| Average width of pits (m)                                 | 190   | 0            | 0   |
| Average depth of peat removed from pit (m)                | 0     | 0            | 0   |
| Area of land lost in borrow pits (m <sup>2</sup> )        | 88920 | 0            | 0   |
| Volume of peat removed from borrow pits (m <sup>3</sup> ) | 0     | 0            | 0   |

| Peat removed from turbine foundations                          | Exp                             | Total<br>Min | Max | Construction Area 1<br>Exp | Min | Max | Construction Area 2<br>Exp | Min | Max | Construction Area 3<br>Exp | Min | Max | Construction Area 4<br>Exp | Min | Max | Construction Area 5<br>Exp | Min | Max |
|----------------------------------------------------------------|---------------------------------|--------------|-----|----------------------------|-----|-----|----------------------------|-----|-----|----------------------------|-----|-----|----------------------------|-----|-----|----------------------------|-----|-----|
| Method used to calculate CO <sub>2</sub> loss from foundations | Rectangular with vertical walls |              |     |                            |     |     |                            |     |     |                            |     |     |                            |     |     |                            |     |     |
| Calculation method code                                        |                                 | 1            |     |                            |     |     |                            |     |     |                            |     |     |                            |     |     |                            |     |     |
| No. of turbines                                                | 11                              | 0            | 0   | 11                         | 0   | 0   | 0                          | 0   | 0   | 0                          | 0   | 0   | 0                          | 0   | 0   | 0                          | 0   | 0   |
| Diameter at surface (m)                                        |                                 |              |     | 28                         | 0   | 0   | 0                          | 0   | 0   | 0                          | 0   | 0   | 0                          | 0   | 0   | 0                          | 0   | 0   |
| Diameter at bottom (m)                                         |                                 |              |     | 28                         | 0   | 0   | 0                          | 0   | 0   | 0                          | 0   | 0   | 0                          | 0   | 0   | 0                          | 0   | 0   |
| Depth of foundations (m)                                       |                                 |              |     | 28                         | 0   | 0   | 0                          | 0   | 0   | 0                          | 0   | 0   | 0                          | 0   | 0   | 0                          | 0   | 0   |
|                                                                |                                 |              |     | 1                          | 0   | 0   | 0                          | 0   | 0   | 0                          | 0   | 0   | 0                          | 0   | 0   | 0                          | 0   | 0   |
| "Area" of land lost in hard-standing (m <sup>2</sup> )         | 8319                            | 0            | 0   | 8319                       | 0   | 0   | 0                          | 0   | 0   | 0                          | 0   | 0   | 0                          | 0   | 0   | 0                          | 0   | 0   |
| Volume of peat removed from foundation area (m <sup>3</sup> )  | 8568.313                        | 0            | 0   | 8568.313                   | 0   | 0   | 0                          | 0   | 0   | 0                          | 0   | 0   | 0                          | 0   | 0   | 0                          | 0   | 0   |

|                                                                |                                 |   |   |       |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|----------------------------------------------------------------|---------------------------------|---|---|-------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Peat removed from hard-standing                                |                                 |   |   |       |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Method used to calculate CO <sub>2</sub> loss from foundations | Rectangular with vertical walls |   |   |       |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Calculation method code                                        |                                 | 1 |   |       |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| No. of turbines                                                | 11                              | 0 | 0 | 11    | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Diameter at surface (m)                                        |                                 |   |   | 88    | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Diameter at bottom (m)                                         |                                 |   |   | 30    | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Depth of hardstanding (m)                                      |                                 |   |   | 88    | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|                                                                |                                 |   |   | 30    | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|                                                                |                                 |   |   | 1     | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Area of land lost in hard-standing (m <sup>2</sup> )           | 29040                           | 0 | 0 | 29040 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Volume of peat removed from hardstandingarea (m <sup>3</sup> ) | 31944                           | 0 | 0 | 31944 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Peat removed from access tracks                  | Exp   | Total<br>Min | Max |
|--------------------------------------------------|-------|--------------|-----|
| Floating roads                                   |       |              |     |
| Length of access track that is floating road (m) | 13350 | 0            | 0   |
| Floating road width (m)                          | 6     | 0            | 0   |

|                                                                     |        |   |   |
|---------------------------------------------------------------------|--------|---|---|
| Floating road depth (m)                                             | 0.6    | 0 | 0 |
| Area of land lost in floating roads (m <sup>2</sup> )               | 80100  | 0 | 0 |
| Volume of peat removed for floating roads                           | 48060  | 0 | 0 |
| Excavated roads                                                     |        |   |   |
| Length of access track that is excavated road (m)                   | 2100   | 0 | 0 |
| Excavated road width (m)                                            | 6      | 0 | 0 |
| Average depth of peat excavated for road (m)                        | 0.2    | 0 | 0 |
| Area of land lost in excavated roads (m <sup>2</sup> )              | 12600  | 0 | 0 |
| Volume of peat removed for excavated roads                          | 2520   | 0 | 0 |
| Rock-filled roads                                                   |        |   |   |
| Length of access track that is rock filled road (m)                 | 2100   | 0 | 0 |
| Rock filled road width (m)                                          | 6      | 0 | 0 |
| Rock filled road depth (m)                                          | 0.8    | 0 | 0 |
| Area of land lost in excavated roads (m <sup>2</sup> )              | 12600  | 0 | 0 |
| Volume of peat removed for rock-filled roads                        | 10080  | 0 | 0 |
| Total area of land lost in access tracks (m <sup>2</sup> )          | 105300 | 0 | 0 |
| Total volume of peat removed due to access tracks (m <sup>3</sup> ) | 60660  | 0 | 0 |

|                                                                  |       |   |   |
|------------------------------------------------------------------|-------|---|---|
| Additional peat excavated -<br>(not already accounted for above) |       |   |   |
| Volume of additional peat excavated (m <sup>3</sup> )            | 12982 | 0 | 0 |
| Area of additional peat excavated (m <sup>2</sup> )              | 11019 | 0 | 0 |

| RESULTS                                                                     |        | Total |     |
|-----------------------------------------------------------------------------|--------|-------|-----|
|                                                                             | Exp    | Min   | Max |
| Total volume of peat removed (m <sup>3</sup> ) due to windfarm construction | 114154 | 0     | 0   |
| Total area of land lost due to windfarm construction (m <sup>2</sup> )      | 242598 | 0     | 0   |

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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.

**CO<sub>2</sub> 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 |
|-----------------------------------------------------------------------------|----------|---------|---------|
| <b>CO<sub>2</sub> loss from removed peat</b>                                |          |         |         |
| C Content of dry peat (% by weight)                                         | 60       | 0       | 0       |
| Dry soil bulk density (g cm <sup>-3</sup> )                                 | 0.25     | 0.00    | 0.00    |
| % C contained in removed peat that is lost as CO <sub>2</sub>               | 100      | 100     | 100     |
| Total volume of peat removed (m <sup>3</sup> ) due to windfarm construction | 114154   | 0       | 0       |
| CO <sub>2</sub> loss from removed peat (t CO <sub>2</sub> )                 | 62791    | 0       | 0       |

Assumption: If peat is not restored, 100% of the carbon contained in the removed peat is lost as CO<sub>2</sub>

Check

|                                                                                             |       |   |   |
|---------------------------------------------------------------------------------------------|-------|---|---|
| <b>CO<sub>2</sub> loss from undrained peat left in situ</b>                                 |       |   |   |
| Total area of land lost due to windfarm construction (ha)                                   | 24    | 0 | 0 |
| CO <sub>2</sub> loss from undrained peat left in situ (t CO <sub>2</sub> ha <sup>-1</sup> ) | 689   | 0 | 0 |
| CO <sub>2</sub> loss from undrained peat left in situ (t CO <sub>2</sub> )                  | 16726 | 0 | 0 |

|                                                                                 |              |          |          |
|---------------------------------------------------------------------------------|--------------|----------|----------|
| <b>CO<sub>2</sub> loss attributable to peat removal only</b>                    |              |          |          |
| CO <sub>2</sub> loss from removed peat (t CO <sub>2</sub> )                     | 62791        | 0        | 0        |
| CO <sub>2</sub> loss from undrained peat left in situ (t CO <sub>2</sub> )      | 16726        | 0        | 0        |
| <b>RESULTS</b>                                                                  |              |          |          |
| <b>CO<sub>2</sub> loss attributable to peat removal only (t CO<sub>2</sub>)</b> | <b>46064</b> | <b>0</b> | <b>0</b> |

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**CO<sub>2</sub> 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.

| Extent of drainage around each metre of drainage ditch          | Exp | Total Min | Max |
|-----------------------------------------------------------------|-----|-----------|-----|
| Average extent of drainage around drainage features at site (m) | 0   | 0         | 0   |

| Peat affected by drainage around borrow pits                          | Exp | Total Min | Max |
|-----------------------------------------------------------------------|-----|-----------|-----|
| Number of borrow pits                                                 | 1   | 0         | 0   |
| Average length of pits (m)                                            | 468 | 0         | 0   |
| Average width of pits (m)                                             | 190 | 0         | 0   |
| Average depth of peat removed from pit (m)                            | 0.0 | 0.0       | 0.0 |
| Area affected by drainage per borrow pit (m <sup>2</sup> )            | 0   | 0         | 0   |
| Total area affected by drainage around borrowpits (m <sup>2</sup> )   | 0   | 0         | 0   |
| Total volume affected by drainage around borrowpits (m <sup>3</sup> ) | 0   | 0         | 0   |

| Peat affected by drainage around turbine foundation and hardstanding                    | Exp | Total Min | Max | 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                                                                         | 11  | 0         | 0   | 11                  | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   |
| Average length of turbine foundations at base (m)                                       |     |           |     | 28                  | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   |
| Average width of turbine foundations at base(m)                                         |     |           |     | 28                  | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   |
| Average depth of peat removed from turbine foundations (m)                              |     |           |     | 1.0                 | 0.0 | 0.0 | 0.0                 | 0.0 | 0.0 | 0.0                 | 0.0 | 0.0 | 0.0                 | 0.0 | 0.0 | 0.0                 | 0.0 | 0.0 |
| Average length of hard-standing at base (m)                                             |     |           |     | 88                  | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   |
| Average width of hard-standing at base (m)                                              |     |           |     | 30                  | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   |
| Average depth of peat removed from hard-standing (m)                                    |     |           |     | 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                 | 0.0 | 0.0 |
| Maximum depth of drains (m)                                                             |     |           |     | 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                 | 0.0 | 0.0 |
| Total length of foundation and hardstanding (m)                                         |     |           |     | 116                 | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   |
| Total width of foundation and hardstanding (m)                                          |     |           |     | 58                  | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   |
| Area affected by drainage of foundation and hardstanding area (m <sup>2</sup> )         | 0   | 0         | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   |
| Total area affected by drainage of foundation and hardstanding area (m <sup>2</sup> )   | 0   | 0         | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   |
| Total volume affected by drainage of foundation and hardstanding area (m <sup>3</sup> ) | 0   | 0         | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   | 0                   | 0   | 0   |

| Peat affected by drainage of access tracks | Exp | Total Min | Max |
|--------------------------------------------|-----|-----------|-----|
| Floating roads                             |     |           |     |

|                                                                     |       |      |      |
|---------------------------------------------------------------------|-------|------|------|
| Length of floating road that is drained (m)                         | 13350 | 0    | 0    |
| Floating road width (m)                                             | 6.0   | 0.0  | 0.0  |
| Average depth of drains associated with floating roads (m)          | 0.50  | 0.00 | 0.00 |
| Area affected by drainage of floating roads (m <sup>2</sup> )       | 80100 | 0    | 0    |
| Volume affected by drainage of floating roads (m <sup>3</sup> )     | 20025 | 0    | 0    |
| <u>Excavated Road</u>                                               |       |      |      |
| Length of access track that is excavated road (m)                   | 2100  | 0    | 0    |
| Excavated road width (m)                                            | 6     | 0    | 0    |
| Average depth of peat excavated for road (m)                        | 0.2   | 0.0  | 0.0  |
| Area affected by drainage of excavated roads (m <sup>2</sup> )      | 0     | 0    | 0    |
| Volume affected by drainage of excavated roads (m <sup>3</sup> )    | 0     | 0    | 0    |
| <u>Rock-filled roads</u>                                            |       |      |      |
| Length of rock filled road that is drained (m)                      | 2100  | 0    | 0    |
| Rock filled road width (m)                                          | 6     | 0    | 0    |
| Average depth of drains associated with rock filled roads (m)       | 0.5   | 0.0  | 0.0  |
| Area affected by drainage of rock-filled roads (m <sup>2</sup> )    | 0     | 0    | 0    |
| Volume affected by drainage of rock-filled roads (m <sup>2</sup> )  | 0     | 0    | 0    |
| Total area affected by drainage of access track (m <sup>2</sup> )   | 80100 | 0    | 0    |
| Total volume affected by drainage of access track (m <sup>3</sup> ) | 20025 | 0    | 0    |

|                                                                                                                           |            |                  |            |
|---------------------------------------------------------------------------------------------------------------------------|------------|------------------|------------|
| <b>Peat affected by drainage of cable trenches</b>                                                                        | <b>Exp</b> | <b>Total Min</b> | <b>Max</b> |
| 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)                                                                          | 1.0        | 0.0              | 0.0        |
| Total area affected by drainage of cable trenches (m <sup>2</sup> )                                                       | 0          | 0                | 0          |
| Total volume affected by drainage of cable trenches (m <sup>3</sup> )                                                     | 0.00       | 0.00             | 0.00       |

|                                                       |            |                  |            |
|-------------------------------------------------------|------------|------------------|------------|
| <b>Drainage around additional peat excavated</b>      | <b>Exp</b> | <b>Total Min</b> | <b>Max</b> |
| Volume of additional peat excavated (m <sup>3</sup> ) | 12982.0    | 0.0              | 0.0        |
| Area of additional peat excavated (m <sup>2</sup> )   | 11019.0    | 0.0              | 0.0        |
| Average depth of excavated peat (m)                   | 1          | 0                | 0          |
| Radius of area excavated (m)                          | 59         | 0                | 0          |

← Assumption: Area excavated is assumed to be a circle



|                                                     |      |      |      |
|-----------------------------------------------------|------|------|------|
| Radius of excavated and drained area (m)            | 59   | 0    | 0    |
| Total area affected by drainage (m <sup>2</sup> )   | 0    | 0    | 0    |
| Total volume affected by drainage (m <sup>3</sup> ) | 0.00 | 0.00 | 0.00 |

assumed to be a circle

| RESULTS                                                             | Exp   | Total Min | Max |
|---------------------------------------------------------------------|-------|-----------|-----|
| Total area affected by drainage due to windfarm (m <sup>2</sup> )   | 80100 | 0         | 0   |
| Total volume affected by drainage due to windfarm (m <sup>3</sup> ) | 20025 | 0         | 0   |

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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.



**CO<sub>2</sub> loss due to drainage**

Note: Note, CO<sub>2</sub> 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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|                                                                    | Expected | Minimum | Maximum |
|--------------------------------------------------------------------|----------|---------|---------|
| <b>Drained Land</b>                                                |          |         |         |
| Total area affected by drainage due to wind farm construction (ha) | 8        | 0       | 0       |
| Will the hydrology of the site be restored on decommissioning?     | Yes      | Yes     | Yes     |
| Will the habitat of the site be restored on decommissioning?       | Yes      | Yes     | Yes     |

**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 <sup>3</sup> )     | 20025 | 0    | 0    |
|       | C Content of dry peat (% by weight)                                      | 60    | 0    | 0    |
|       | Dry soil bulk density (g cm <sup>-3</sup> )                              | 0.25  | 0.00 | 0.00 |
|       | <b>Total GHG emissions from Drained Land (t CO<sub>2</sub> equiv.)</b>   | 11015 | 0    | 0    |
|       | <b>Total GHG Emissions from Undrained Land (t CO<sub>2</sub> equiv.)</b> | 5831  | 0    | 0    |

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 <sup>-1</sup> )                                                              | 0     | 0     | 0     |
|       | Lifetime of windfarm (years)                                                                           | 35    | 25    | 25    |
|       | Time required for regeneration of bog plants after restoration (years)                                 | 2     | 0     | 0     |
|       | <b>Methane Emissions from Drained Land</b>                                                             |       |       |       |
| Check | Rate of methane emission in drained soil ((t CH <sub>4</sub> -C) ha <sup>-1</sup> yr <sup>-1</sup> )   | 0.000 | 0.000 | 0.000 |
|       | Conversion factor: CH <sub>4</sub> -C to CO <sub>2</sub> equivalents                                   | 30.67 | 30.67 | 30.67 |
|       | CH <sub>4</sub> emissions from drained land (t CO <sub>2</sub> equiv.)                                 | 0     | 0     | 0     |
|       | <b>Carbon Dioxide Emissions from Drained Land</b>                                                      |       |       |       |
| Check | Rate of carbon dioxide emission in drained soil (t CO <sub>2</sub> ha <sup>-1</sup> yr <sup>-1</sup> ) | 35.20 | 35.20 | 35.20 |
|       | CO <sub>2</sub> emissions from drained land (t CO <sub>2</sub> )                                       | 10432 | 0     | 0     |
|       | <b>Total GHG emissions from Drained Land (t CO<sub>2</sub> equiv.)</b>                                 | 10432 | 0     | 0     |

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

Note: Conversion = (23 x 16/12) = 30.67 CO<sub>2</sub> equiv. (CH<sub>4</sub>-C)<sup>-1</sup>

**2. Losses if Land is Undrained**

|       |                                                                                                          |       |       |       |
|-------|----------------------------------------------------------------------------------------------------------|-------|-------|-------|
|       | Flooded period (days year <sup>-1</sup> )                                                                | 178   | 178   | 178   |
|       | Lifetime of windfarm (years)                                                                             | 35    | 25    | 25    |
|       | Time required for regeneration of bog plants after restoration (years)                                   | 2     | 0     | 0     |
|       | <b>Methane Emissions from Undrained Land</b>                                                             |       |       |       |
| Check | Rate of methane emission in undrained soil ((t CH <sub>4</sub> -C) ha <sup>-1</sup> yr <sup>-1</sup> )   | 0.04  | 0.04  | 0.04  |
|       | Conversion factor: CH <sub>4</sub> -C to CO <sub>2</sub> equivalents                                     | 30.67 | 30.67 | 30.67 |
|       | CH <sub>4</sub> emissions from undrained land (t CO <sub>2</sub> equiv.)                                 | 178   | 0     | 0     |
|       | <b>Carbon Dioxide Emissions from Undrained Land</b>                                                      |       |       |       |
| Check | Rate of carbon dioxide emission in undrained soil (t CO <sub>2</sub> ha <sup>-1</sup> yr <sup>-1</sup> ) | 0.00  | 0.00  | 0.00  |
|       | CO <sub>2</sub> emissions from undrained land (t CO <sub>2</sub> )                                       | 5345  | 0     | 0     |
|       | <b>Total GHG Emissions from Undrained Land (t CO<sub>2</sub> equiv.)</b>                                 | 5523  | 0     | 0     |

Note: Conversion = (23 x 16/12) = 30.67 CO<sub>2</sub> equiv. (CH<sub>4</sub>-C)<sup>-1</sup>

**3. CO<sub>2</sub> Losses due to Drainage**

|                                                                      |             |          |          |
|----------------------------------------------------------------------|-------------|----------|----------|
| Total GHG emissions from drained land (t CO <sub>2</sub> equiv.)     | 10432       | 0        | 0        |
| Total GHG emissions from undrained land (t CO <sub>2</sub> equiv.)   | 5523        | 0        | 0        |
| <b>RESULTS</b>                                                       |             |          |          |
| <b>Total GHG emissions due to drainage (t CO<sub>2</sub> equiv.)</b> | <b>4910</b> | <b>0</b> | <b>0</b> |

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**CO<sub>2</sub> loss due to drainage**

Note: Note, CO<sub>2</sub> 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).

### Emission rates from soils

Note: Note, CO<sub>2</sub> 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 = IPCC default**  
**Type of peatland = Acid Bog**

#### Calculations following IPCC default methodology

##### Emission characteristics of acid bogs (IPCC, 1997)

|                                                                                               | Expected | Minimum | Maximum |
|-----------------------------------------------------------------------------------------------|----------|---------|---------|
| Flooded period (days year <sup>-1</sup> )                                                     | 178      | 178     | 178     |
| Annual rate of methane emission (t CH <sub>4</sub> -C ha <sup>-1</sup> yr <sup>-1</sup> )     | 0.04015  | 0.04015 | 0.04015 |
| Annual rate of carbon dioxide emission (t CO <sub>2</sub> ha <sup>-1</sup> yr <sup>-1</sup> ) | 35.2     | 35.2    | 35.2    |

##### Emission characteristics of fens (IPCC, 1997)

|                                                                                               |       |       |       |
|-----------------------------------------------------------------------------------------------|-------|-------|-------|
| Flooded period (days year <sup>-1</sup> )                                                     | 169   | 169   | 169   |
| Annual rate of methane emission (t CH <sub>4</sub> -C ha <sup>-1</sup> yr <sup>-1</sup> )     | 0.219 | 0.219 | 0.219 |
| Annual rate of carbon dioxide emission (t CO <sub>2</sub> ha <sup>-1</sup> yr <sup>-1</sup> ) | 35.2  | 35.2  | 35.2  |

#### Selected emission characteristics (IPCC, 1997)

|                                                                                               |         |         |         |
|-----------------------------------------------------------------------------------------------|---------|---------|---------|
| Flooded period (days year <sup>-1</sup> )                                                     | 178     | 178     | 178     |
| Annual rate of methane emission (t CH <sub>4</sub> -C ha <sup>-1</sup> yr <sup>-1</sup> )     | 0.04015 | 0.04015 | 0.04015 |
| Annual rate of carbon dioxide emission (t CO <sub>2</sub> ha <sup>-1</sup> yr <sup>-1</sup> ) | 35.2    | 35.2    | 35.2    |

Assumption: The period of flooding is taken to be 178 days yr<sup>-1</sup> for acid bogs and 169 days yr<sup>-1</sup> 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 CH<sub>4</sub> emission rate provided for acid bogs is 11 (1-38) mg CH<sub>4</sub>-C m<sup>-2</sup> day<sup>-1</sup> x 365 days; and for fens is 60 (21-162) mg CH<sub>4</sub>-C m<sup>-2</sup> day<sup>-1</sup> x 365 days (Aselmann & Crutzen, 1989. J. Atm. Chem. 8, 307-358)

Assumption: CO<sub>2</sub> emissions on drainage of organic soils for upland crops (e.g., grain, vegetables) are 3.667x9.6 (7.9-11.3) t CO<sub>2</sub> ha<sup>-1</sup> yr<sup>-1</sup> in temperate climates (Armentano and Menges, 1986. J. Ecol. 74, 755-774).

#### Calculations following ECOSSE based methodology

##### Drained Land

|                                                                                   |       |   |   |
|-----------------------------------------------------------------------------------|-------|---|---|
| Total area affected by drainage due to wind farm construction (ha)                | 8     | 0 | 0 |
| Total volume affected by drainage due to wind farm construction (m <sup>3</sup> ) | 20025 | 0 | 0 |

#### Soil Characteristics that Determine Emission Rates

|                                                 |      |         |         |
|-------------------------------------------------|------|---------|---------|
| Average annual air temperature at the site (°C) | 10.7 | 0       | 0       |
| Average water table depth at site (m)           | 2.60 | 0.00    | 0.00    |
| Average water table depth of drained land (m)   | 2.60 | #DIV/0! | #DIV/0! |

#### Annual Emission Rates following site specific methodology

##### Acid bogs

|                                                                                                          |       |         |         |
|----------------------------------------------------------------------------------------------------------|-------|---------|---------|
| Rate of carbon dioxide emission in drained soil (t CO <sub>2</sub> ha <sup>-1</sup> yr <sup>-1</sup> )   | 24.48 | #DIV/0! | #DIV/0! |
| Rate of carbon dioxide emission in undrained soil (t CO <sub>2</sub> ha <sup>-1</sup> yr <sup>-1</sup> ) | 24.48 | -2.13   | -2.13   |
| Rate of methane emission in drained soil ((t CH <sub>4</sub> -C) ha <sup>-1</sup> yr <sup>-1</sup> )     | 0.001 | #DIV/0! | #DIV/0! |
| Rate of methane emission in undrained soil ((t CH <sub>4</sub> -C) ha <sup>-1</sup> yr <sup>-1</sup> )   | 0.00  | 0.46    | 0.46    |

##### Fens

|                                                                                                          |        |         |         |
|----------------------------------------------------------------------------------------------------------|--------|---------|---------|
| Rate of carbon dioxide emission in drained soil (t CO <sub>2</sub> ha <sup>-1</sup> yr <sup>-1</sup> )   | 65.58  | #DIV/0! | #DIV/0! |
| Rate of carbon dioxide emission in undrained soil (t CO <sub>2</sub> ha <sup>-1</sup> yr <sup>-1</sup> ) | 65.58  | 0.06    | 0.06    |
| Rate of methane emission in drained soil ((t CH <sub>4</sub> -C) ha <sup>-1</sup> yr <sup>-1</sup> )     | -0.003 | #DIV/0! | #DIV/0! |
| Rate of methane emission in undrained soil ((t CH <sub>4</sub> -C) ha <sup>-1</sup> yr <sup>-1</sup> )   | 0.00   | 0.55    | 0.55    |

#### Selected emission characteristics following site specific methodology

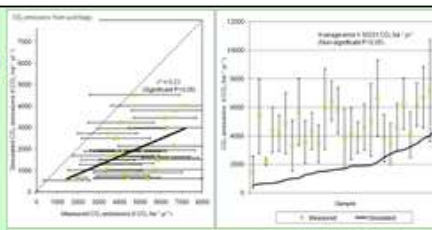
|                                                                                                          |       |         |         |
|----------------------------------------------------------------------------------------------------------|-------|---------|---------|
| Rate of carbon dioxide emission in drained soil (t CO <sub>2</sub> ha <sup>-1</sup> yr <sup>-1</sup> )   | 24.48 | #DIV/0! | #DIV/0! |
| Rate of carbon dioxide emission in undrained soil (t CO <sub>2</sub> ha <sup>-1</sup> yr <sup>-1</sup> ) | 24.48 | -2.13   | -2.13   |
| Rate of methane emission in drained soil ((t CH <sub>4</sub> -C) ha <sup>-1</sup> yr <sup>-1</sup> )     | 0.001 | #DIV/0! | #DIV/0! |
| Rate of methane emission in undrained soil ((t CH <sub>4</sub> -C) ha <sup>-1</sup> yr <sup>-1</sup> )   | 0.00  | 0.46    | 0.46    |

## RESULTS

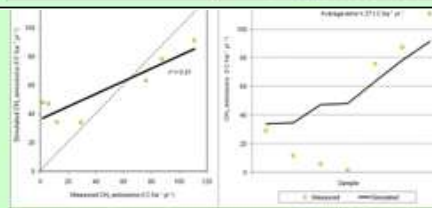
#### Selected Emission Rates

|                                                                                                          |       |       |       |
|----------------------------------------------------------------------------------------------------------|-------|-------|-------|
| Rate of carbon dioxide emission in drained soil (t CO <sub>2</sub> ha <sup>-1</sup> yr <sup>-1</sup> )   | 35.20 | 35.20 | 35.20 |
| Rate of carbon dioxide emission in undrained soil (t CO <sub>2</sub> ha <sup>-1</sup> yr <sup>-1</sup> ) | 0.00  | 0.00  | 0.00  |
| Rate of methane emission in drained soil ((t CH <sub>4</sub> -C) ha <sup>-1</sup> yr <sup>-1</sup> )     | 0.000 | 0.000 | 0.000 |
| Rate of methane emission in undrained soil ((t CH <sub>4</sub> -C) ha <sup>-1</sup> yr <sup>-1</sup> )   | 0.04  | 0.04  | 0.04  |

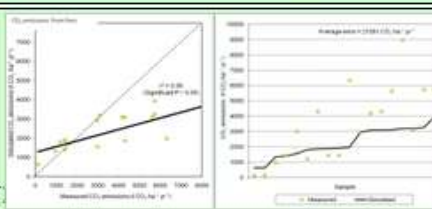
Note: Carbon dioxide emissions from acid bogs. Equation derived by regression analysis against 60 measurements (Nayak et al, 2009). The equation derived was  $R_{CO_2} = (3.667/1000) \times ((6700 \times \exp(-0.26 \times \exp(-0.0515 \times ((W \times 100) - 50)))) + ((72.54 \times T) - 800))$  where  $R_{CO_2}$  is the annual rate of CO<sub>2</sub> emissions (t CO<sub>2</sub> (ha)<sup>-1</sup> yr<sup>-1</sup>),  $T$  = 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 CO<sub>2</sub> ha<sup>-1</sup> yr<sup>-1</sup> which is non-significant ( $P < 0.05$ ) (Smith et al, 1997).



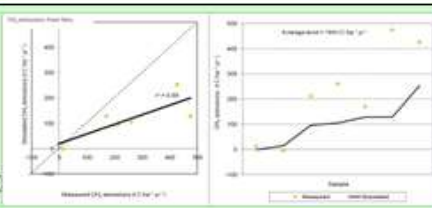
measurements (Nayak et al, 2009). The equation derived was  $R_{CH_4} = (1/1000) \times (500 \times \exp(-0.1234 \times (W \times 100))) + ((3.529 \times T) - 36.67))$  where  $R_{CH_4}$  is the annual rate of CH<sub>4</sub> emissions (t CH<sub>4</sub>-C (ha)<sup>-1</sup> yr<sup>-1</sup>),  $T$  = average 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 CH<sub>4</sub>-C ha<sup>-1</sup> yr<sup>-1</sup> (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 CO<sub>2</sub> emissions (t CO<sub>2</sub> (ha)<sup>-1</sup> yr<sup>-1</sup>),  $T$  = 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 ( $r^2 = 0.66$ ;  $P > 0.05$ ) and an average error of 2108 t CO<sub>2</sub> ha<sup>-1</sup> yr<sup>-1</sup> (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 CH<sub>4</sub> emissions (t CH<sub>4</sub>-C (ha)<sup>-1</sup> yr<sup>-1</sup>),  $T$  = 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 CH<sub>4</sub>-C ha<sup>-1</sup> yr<sup>-1</sup> (significance not defined due to lack of replicate - Smith et al, 1997).



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**Emission rates from soils**

Note: Note, CO<sub>2</sub> 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).

**Emissions due to loss of DOC and POC**

Note: Note, CO<sub>2</sub> losses from DOC and POC are calculated using a simple approach derived from generic estimates of the percentage of the total CO<sub>2</sub> 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 |
|----------------------------------------------------------------------------------|----------|---------|---------|
| <b>Total C loss</b>                                                              |          |         |         |
| Gross CO <sub>2</sub> loss from restored drained land (t CO <sub>2</sub> )       | 5087     | 0       | 0       |
| Gross CH <sub>4</sub> loss from restored drained land (t CO <sub>2</sub> equiv.) | 0        | 0       | 0       |
| Gross CO <sub>2</sub> loss from improved land (t CO <sub>2</sub> )               |          |         |         |
| Degraded Bog                                                                     | 0        | 0       | 0       |
| Felled Forestry                                                                  | 0        | 0       | 0       |
| Borrow Pits                                                                      | 0        | 0       | 0       |
| Foundations & Hardstanding                                                       | 0        | 0       | 0       |
| Gross CH <sub>4</sub> loss from improved land (t CO <sub>2</sub> equiv.)         |          |         |         |
| Degraded Bog                                                                     | 0        | 0       | 0       |
| Felled Forestry                                                                  | 0        | 0       | 0       |
| Borrow Pits                                                                      | 0        | 0       | 0       |
| Foundations & Hardstanding                                                       | 0        | 0       | 0       |
| Conversion factor: CH <sub>4</sub> -C to CO <sub>2</sub> equivalents             | 30.6667  | 30.6667 | 30.6667 |
| % total soil C losses, lost as DOC                                               | 26       | 7       | 40      |
| % DOC loss emitted as CO <sub>2</sub> over the long term                         | 100      | 100     | 100     |
| % total soil C losses, lost as POC                                               | 8        | 4       | 10      |
| % POC loss emitted as CO <sub>2</sub> over the long term                         | 100      | 100     | 100     |
| Total gaseous loss of C (t C)                                                    | 1390     | 0       | 0       |
| Total C loss as DOC (t C)                                                        | 361      | 0       | 0       |
| Total C loss as POC (t C)                                                        | 111      | 0       | 0       |

Note: Only restored drained land included because if land is not restored, the C lost has already been counted as carbon dioxide

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/KM<sup>2</sup>/yr) and not on flux at catchment outlet (i.e. 10.3 - 21.8 MgC/KM<sup>2</sup>/yr)  
Worrall, F. et al., 2009. The multi-annual carbon budget of a peat-covered catchment. *Science of The*

Assumption: In the long term, 100% of leached DOC is assumed to be lost as CO<sub>2</sub>

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/KM<sup>2</sup>/yr) (Worrall et al, 2009).

Assumption: In the long term, 100% of leached POC is assumed to be lost as CO<sub>2</sub>

|                                                                                   |             |          |          |
|-----------------------------------------------------------------------------------|-------------|----------|----------|
| <b>RESULTS</b>                                                                    |             |          |          |
| <b>Total CO<sub>2</sub> loss due to DOC leaching (t CO<sub>2</sub>)</b>           | <b>1323</b> | <b>0</b> | <b>0</b> |
| <b>Total CO<sub>2</sub> loss due to POC leaching (t CO<sub>2</sub>)</b>           | <b>407</b>  | <b>0</b> | <b>0</b> |
| <b>Total CO<sub>2</sub> loss due to DOC &amp; POC leaching (t CO<sub>2</sub>)</b> | <b>1730</b> | <b>0</b> | <b>0</b> |
| <b>Additional CO<sub>2</sub> payback time of windfarm due to DOC &amp; POC</b>    |             |          |          |
| ...coal-fired electricity generation (months)                                     | 0           | #DIV/0!  | #DIV/0!  |
| ...grid-mix of electricity generation (months)                                    | 1           | #DIV/0!  | #DIV/0!  |
| ...fossil fuel - mix of electricity generation (months)                           | 0           | #DIV/0!  | #DIV/0!  |

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**Emissions due to loss of DOC and POC**

Note: Note, CO<sub>2</sub> losses from DOC and POC are calculated using a simple approach derived from generic estimates of the percentage of the total CO<sub>2</sub> 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)

**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  |
|-----------------------------------------------------------------------------------------|----------|----------|----------|
| <b>Emissions due to forestry felling</b>                                                |          |          |          |
| Area of forestry plantation to be felled (ha)                                           | 0        | 0        | 0        |
| Carbon sequestered (tC ha <sup>-1</sup> yr <sup>-1</sup> )                              | 3.6      | 0        | 0        |
| Lifetime of windfarm (years)                                                            | 35       | 0        | 0        |
| Carbon sequestered over the lifetime of the windfarm (t C ha <sup>-1</sup> )            | 126      | 0        | 0        |
| <b>RESULTS</b>                                                                          |          |          |          |
| <b>Total carbon loss due to felling of forestry (t CO<sub>2</sub>)</b>                  | <b>0</b> | <b>0</b> | <b>0</b> |
| <b>Additional CO<sub>2</sub> payback time of windfarm due to management of forestry</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        |

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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.



|                                                                                                                                                               |  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| <p><b><u>CO<sub>2</sub> loss from forests - calculation using detailed management information</u></b></p> <p>Forest carbon calculator (Perks et al, 2009)</p> |  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------|--|

Forest carbon calculator (Perks et al, 2009)

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|                                                                                                                   |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
|-------------------------------------------------------------------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Fossil fuel-mix emission factor (t CO <sub>2</sub> MWh <sup>-1</sup> )                                            | 0.430 | 0.000 | 0.000 | 0.430 | 0.000 | 0.000 | 0.430 | 0.000 | 0.000 | 0.430 | 0.000 | 0.000 | 0.430 | 0.000 | 0.000 | 0.430 | 0.000 | 0.000 |
| Savings in CO <sub>2</sub> emissions associated with using replanted forestry as a biofuel (t CO <sub>2</sub> )   |       |       |       | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Distance to nearest biomass power plant (km)                                                                      | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| Emissions of CO <sub>2</sub> associated with transportation (t CO <sub>2</sub> km <sup>-1</sup> t <sup>-1</sup> ) | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  |
| Carbon equivalent of transportation (t CO <sub>2</sub> eq.)                                                       |       |       |       | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Fossil fuel equivalent saving (t CO <sub>2</sub> )                                                                | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |

|                                                                                   |   |         |         |   |         |         |   |         |         |   |         |         |   |         |         |   |         |         |
|-----------------------------------------------------------------------------------|---|---------|---------|---|---------|---------|---|---------|---------|---|---------|---------|---|---------|---------|---|---------|---------|
| RESULTS                                                                           |   |         |         |   |         |         |   |         |         |   |         |         |   |         |         |   |         |         |
| Total Carbon loss associated with forest management (t CO <sub>2</sub> )          | 0 | 0       | 0       | 0 | 0       | 0       | 0 | 0       | 0       | 0 | 0       | 0       | 0 | 0       | 0       | 0 | 0       | 0       |
| Additional CO <sub>2</sub> payback time of windfarm due to management of forestry |   |         |         |   |         |         |   |         |         |   |         |         |   |         |         |   |         |         |
| ...coal-fired electricity generation (months)                                     | 0 | #DIV/0! | #DIV/0! | 0 | #DIV/0! | #DIV/0! | 0 | #DIV/0! | #DIV/0! | 0 | #DIV/0! | #DIV/0! | 0 | #DIV/0! | #DIV/0! | 0 | #DIV/0! | #DIV/0! |
| ...grid-mix of electricity generation (months)                                    | 0 | #DIV/0! | #DIV/0! | 0 | #DIV/0! | #DIV/0! | 0 | #DIV/0! | #DIV/0! | 0 | #DIV/0! | #DIV/0! | 0 | #DIV/0! | #DIV/0! | 0 | #DIV/0! | #DIV/0! |
| ...fossil fuel - mix of electricity generation (months)                           | 0 | #DIV/0! | #DIV/0! | 0 | #DIV/0! | #DIV/0! | 0 | #DIV/0! | #DIV/0! | 0 | #DIV/0! | #DIV/0! | 0 | #DIV/0! | #DIV/0! | 0 | #DIV/0! | #DIV/0! |

|                                                                                       |
|---------------------------------------------------------------------------------------|
| CO <sub>2</sub> loss from forests - calculation using detailed management information |
| Forest carbon calculator (Perks et al, 2009)                                          |

Simplified version of the 3PG model (Xenakis et al, 2008). This version, doesn't require climate data as no explicit environmental modifier is calculated. Instead, it uses a factor (from 0 to 1) representing the total effect of environment on growth. The simplified model requires a value of annual incoming solar radiation, a modifier for the age-related decline in productivity, a light extinction coefficient and specific leaf area.

The model does not need temprain/solrad data: the impact of the environment at the site is included by adjusting the environmental modifier, based on site yield class and temperature. Light use efficiency (LUE), rather than quantum use efficiency (QYE) is used, making it easier to develop the model for many species even for a grouping such as "conifers" or "deciduous". Calibration for Sitka Spruce gives  $QYE = 0.08 \text{ (mol/mol)} \Rightarrow LUE = 2.21 \text{ (kJC/MJ)}$ , and for SP  $QYE = 0.05 \text{ (mol/mol)} \Rightarrow LUE = 1.37 \text{ (kJC/MJ)}$ .

| 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            |
| Accumulated temperature (day-degrees > 5°C)                   | (> 1050 deg.C) | (> 1050 deg.C) | (> 1050 deg.C) | (> 1050 deg.C)  | (> 1050 deg.C) | (> 1050 deg.C) | (> 1050 deg.C)  | (> 1050 deg.C) | (> 1050 deg.C) | (> 1050 deg.C)  | (> 1050 deg.C) | (> 1050 deg.C) | (> 1050 deg.C)  | (> 1050 deg.C) | (> 1050 deg.C) | (> 1050 deg.C)  | (> 1050 deg.C) | (> 1050 deg.C) |
| Code number                                                   | 3              | 3              | 3              | 3               | 3              | 3              | 3               | 3              | 3              | 3               | 3              | 3              | 3               | 3              | 3              | 3               | 3              | 3              |
| Major Soil Sub Group                                          | Deep Peat      |                |                | Deep Peat       | Deep Peat      | Deep Peat      | 0               | 0              | 0              | 0               | 0              | 0              | 0               | 0              | 0              | 0               | 0              | 0              |
| Code number                                                   | 2              |                |                | 2               | 2              | 2              | 0               | 0              | 0              | 0               | 0              | 0              | 0               | 0              | 0              | 0               | 0              | 0              |
| Species                                                       | Scots pine     |                |                | Scots pine      | Scots pine     | Scots pine     | 0               | 0              | 0              | 0               | 0              | 0              | 0               | 0              | 0              | 0               | 0              | 0              |
| Code number                                                   | 1              |                |                | 1               | 1              | 1              | 0               | 0              | 0              | 0               | 0              | 0              | 0               | 0              | 0              | 0               | 0              | 0              |
| Age of forestry when felled for windfarm (yr)                 | 0              |                |                | 0               | 0              | 0              | 0               | 0              | 0              | 0               | 0              | 0              | 0               | 0              | 0              | 0               | 0              | 0              |
| Lifetime of windfarm (years)                                  | 35             | 25             | 25             | 35              | 25             | 25             | 35              | 25             | 25             | 35              | 25             | 25             | 35              | 25             | 25             | 35              | 25             | 25             |
| Years after felling when replanting occurs                    | 0              |                |                | 0               | 0              | 0              | 0               | 0              | 0              | 0               | 0              | 0              | 0               | 0              | 0              | 0               | 0              | 0              |
| Age of seedlings on planting (yr)                             |                |                |                | 0               | 0              | 0              | 0               | 0              | 0              | 0               | 0              | 0              | 0               | 0              | 0              | 0               | 0              | 0              |
| Years when replanted forestry will be grown on wind farm site | 35             |                |                | 35              | 25             | 25             | 35              | 25             | 25             | 35              | 25             | 25             | 35              | 25             | 25             | 35              | 25             | 25             |

[illegible]

| Parameter                                             | Units                                    | Species    |              | Selected Value |         |         |         |         |
|-------------------------------------------------------|------------------------------------------|------------|--------------|----------------|---------|---------|---------|---------|
|                                                       |                                          | Scots Pine | Sitka Spruce | Area 1         | Area 2  | Area 3  | Area 4  | Area 5  |
| <b>3PG module</b>                                     |                                          |            |              |                |         |         |         |         |
| Average annual photosynthetically active radiation    | 2880 MJ m <sup>-2</sup> yr <sup>-1</sup> |            |              | 2880           | 2880    | 2880    | 2880    | 2880    |
| Light extinction coefficient                          | 0.5 -                                    |            |              | 0.5            | 0.5     | 0.5     | 0.5     | 0.5     |
| Specific leaf area                                    | m <sup>2</sup> kg <sup>-1</sup> C        | 6          | 8            | 6              | 8       | 8       | 8       | 8       |
| Leaf longevity                                        | 1 yrs                                    | 4          | 7            | 4              | 7       | 7       | 7       | 7       |
| Fine root longevity                                   | 1 yrs                                    |            |              | 1              | 1       | 1       | 1       | 1       |
| Maximum light-use efficiency                          | kg C MJ <sup>-1</sup> day <sup>-1</sup>  | 0.00152    | 0.00166      | 0.00152        | 0.00166 | 0.00166 | 0.00166 | 0.00166 |
| Total reduction factor for misc environmental effects | -                                        |            |              | 0.3679         | #N/A    | #N/A    | #N/A    | #N/A    |
| Ratio of NPP to GPP                                   | 0.47 -                                   |            |              | 0.47           | 0.47    | 0.47    | 0.47    | 0.47    |
| Allocation to foliage                                 | 0.25 -                                   |            |              | 0.25           | 0.25    | 0.25    | 0.25    | 0.25    |
| Coefficient for allocation response to nitrogen       | 1.00 -                                   |            |              | 1.00           | 1.00    | 1.00    | 1.00    | 1.00    |
| Age for 50% reduction in light-use efficiency         | 100 yrs                                  | 100        | 120          | 100            | 120     | 120     | 120     | 120     |
| Initial foliage biomass                               | 0.005 kg C m <sup>-2</sup>               |            |              | 0.005          | 0.005   | 0.005   | 0.005   | 0.005   |
| <b>Understorey module</b>                             |                                          |            |              |                |         |         |         |         |
| Understorey LAI                                       | 3.00 -                                   |            |              | 3.00           | 3.00    | 3.00    | 3.00    | 3.00    |

| Conversion Factors          | Quantum yield efficiency<br>( $\text{mol mol}^{-1}$ ) | to | Light use efficiency<br>( $\text{kgC MJ}^{-1}$ )      |
|-----------------------------|-------------------------------------------------------|----|-------------------------------------------------------|
|                             | 0.05                                                  |    | 0.00130                                               |
|                             | Light use efficiency<br>( $\text{kgC MJ}^{-1}$ )      | to | Quantum yield efficiency<br>( $\text{mol mol}^{-1}$ ) |
|                             | 0.00135                                               |    | 0.0489                                                |
| $\text{gDM}_{\text{mol}}$   | 24                                                    |    |                                                       |
| $\text{molPAR}_{\text{MJ}}$ | 2.3                                                   |    |                                                       |

| GPP Reduction Factor Lookup Table |      |                                      |                                    |                                      |
|-----------------------------------|------|--------------------------------------|------------------------------------|--------------------------------------|
|                                   |      | Accumulated temperature              |                                    |                                      |
|                                   |      | Less than<br>1050 °C yr <sup>1</sup> | 1050 to<br>1350 °C yr <sup>1</sup> | More than<br>1350 °C yr <sup>1</sup> |
| Soil type                         | Code | 1                                    | 2                                  | 3                                    |
| Peaty Gley                        | 1    | 0.3178                               | 0.3551                             | 0.3720                               |
| Deep Peat                         | 2    | 0.3177                               | 0.3569                             | 0.3679                               |

[illegible]

**Gains due to site improvement**

Note: Note, CO<sub>2</sub> 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).

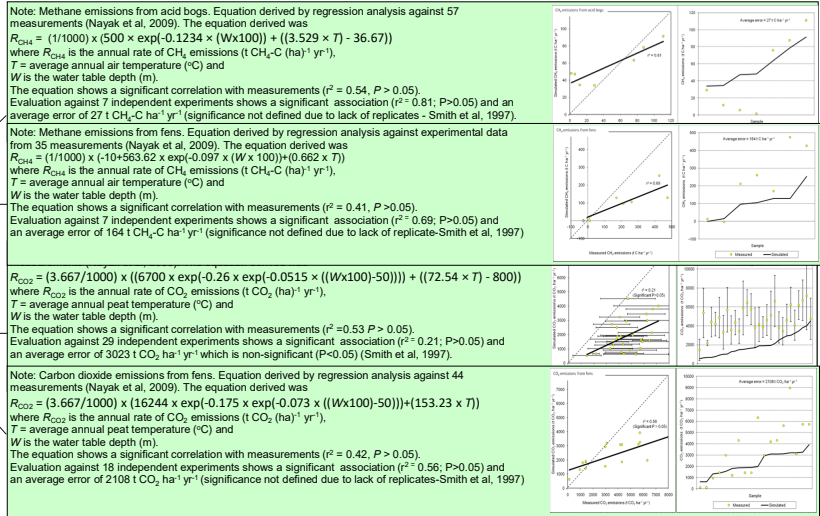
Selected Methodology = IPCC default  
Type of peatland = Acid Bog

| 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 |
| <b>1. Description of site</b>                                                                                                   |                 |                 |             |                            |                |                 |             |                            |                |                 |             |                            |
| Period of time when effectiveness of the improvement can be guaranteed (years)                                                  | 0               | 0               | 0           | 35                         | 0              | 0               | 0           | 25                         | 0              | 0               | 0           | 25                         |
| Area to be improved (ha)                                                                                                        | 0               | 0               | 0           | 0                          | 0              | 0               | 0           | 0                          | 0              | 0               | 0           | 0                          |
| Average air temperature at site (°C)                                                                                            | 10.7            | 10.7            | 10.7        | 10.7                       | 0              | 0               | 0           | 0                          | 0              | 0               | 0           | 0                          |
| Depth of peat drained (m)                                                                                                       | 1.50            | 1.50            | 0.00        | 1.50                       | 0.00           | 0.00            | 0.00        | 0.00                       | 0.00           | 0.00            | 0.00        | 0.00                       |
| 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        | 0.00                       | 0.00           | 0.00            | 0.00        | 0.00                       | 0.00           | 0.00            | 0.00        | 0.00                       |
| <b>2. Losses with improvement</b>                                                                                               |                 |                 |             |                            |                |                 |             |                            |                |                 |             |                            |
| Flooded period (days year <sup>-1</sup> )                                                                                       | 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)                                                                                                         | 0               | 0               | 0           | 35                         | 0              | 0               | 0           | 25                         | 0              | 0               | 0           | 25                         |
| <b>Methane emissions from improved land</b>                                                                                     |                 |                 |             |                            |                |                 |             |                            |                |                 |             |                            |
| Site specific methane emission from improved soil on acid bogs (t CH <sub>4</sub> -C ha <sup>-1</sup> yr <sup>-1</sup> )        | 0.501           | 0.501           | 0.501       | 0.501                      | 0.463          | 0.463           | 0.463       | 0.463                      | 0.463          | 0.463           | 0.463       | 0.463                      |
| Site specific methane emission from improved soil on fens (t CH <sub>4</sub> -C ha <sup>-1</sup> yr <sup>-1</sup> )             | 0.561           | 0.561           | 0.561       | 0.561                      | 0.554          | 0.554           | 0.554       | 0.554                      | 0.554          | 0.554           | 0.554       | 0.554                      |
| IPCC annual rate of methane emission on acid bogs (t CH <sub>4</sub> -C ha <sup>-1</sup> yr <sup>-1</sup> )                     | 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 <sub>4</sub> -C ha <sup>-1</sup> yr <sup>-1</sup> )                          | 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 <sub>4</sub> -C ha <sup>-1</sup> yr <sup>-1</sup> )                              | 0.040           | 0.040           | 0.040       | 0.040                      | 0.040          | 0.040           | 0.040       | 0.040                      | 0.040          | 0.040           | 0.040       | 0.040                      |
| CH <sub>4</sub> emissions from improved land (t CO <sub>2</sub> equiv.)                                                         | 0               | 0               | 0           | 0                          | 0              | 0               | 0           | 0                          | 0              | 0               | 0           | 0                          |
| <b>Carbon dioxide emissions from improved land</b>                                                                              |                 |                 |             |                            |                |                 |             |                            |                |                 |             |                            |
| Site specific CO <sub>2</sub> emission from improved soil on acid bogs (t CO <sub>2</sub> ha <sup>-1</sup> yr <sup>-1</sup> )   | 0.72            | 0.72            | 0.72        | 0.72                       | -2.13          | -2.13           | -2.13       | -2.13                      | -2.13          | -2.13           | -2.13       | -2.13                      |
| Site specific CO <sub>2</sub> emissions from improved soil on fens (t CO <sub>2</sub> ha <sup>-1</sup> yr <sup>-1</sup> )       | 6.07            | 6.07            | 6.07        | 6.07                       | 0.06           | 0.06            | 0.06        | 0.06                       | 0.06           | 0.06            | 0.06        | 0.06                       |
| IPCC annual rate of carbon dioxide emission on acid bogs (t CO <sub>2</sub> ha <sup>-1</sup> yr <sup>-1</sup> )                 | 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 <sub>2</sub> ha <sup>-1</sup> yr <sup>-1</sup> )                      | 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 <sub>2</sub> ha <sup>-1</sup> yr <sup>-1</sup> )                          | 0.00            | 0.00            | 0.00        | 0.00                       | 0.00           | 0.00            | 0.00        | 0.00                       | 0.00           | 0.00            | 0.00        | 0.00                       |
| CO <sub>2</sub> emissions from improved land (t CO <sub>2</sub> )                                                               | 0               | 0               | 0           | 0                          | 0              | 0               | 0           | 0                          | 0              | 0               | 0           | 0                          |
| <b>Total GHG emissions from improved land (t CO<sub>2</sub> equiv.)</b>                                                         | <b>0</b>        | <b>0</b>        | <b>0</b>    | <b>0</b>                   | <b>0</b>       | <b>0</b>        | <b>0</b>    | <b>0</b>                   | <b>0</b>       | <b>0</b>        | <b>0</b>    | <b>0</b>                   |
| <b>3. Losses without improvement</b>                                                                                            |                 |                 |             |                            |                |                 |             |                            |                |                 |             |                            |
| Flooded period (days year <sup>-1</sup> )                                                                                       | 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)                                                                                                         | 0               | 0               | 0           | 35                         | 0              | 0               | 0           | 25                         | 0              | 0               | 0           | 25                         |
| <b>Methane emissions from unimproved land</b>                                                                                   |                 |                 |             |                            |                |                 |             |                            |                |                 |             |                            |
| Site specific methane emission from unimproved soil on acid bogs (t CH <sub>4</sub> -C ha <sup>-1</sup> yr <sup>-1</sup> )      | 0.501           | 0.501           | 0.501       | 0.501                      | 0.463          | 0.463           | 0.463       | 0.463                      | 0.463          | 0.463           | 0.463       | 0.463                      |
| Site specific methane emission from unimproved soil on fens (t CH <sub>4</sub> -C ha <sup>-1</sup> yr <sup>-1</sup> )           | 0.561           | 0.561           | 0.561       | 0.561                      | 0.554          | 0.554           | 0.554       | 0.554                      | 0.554          | 0.554           | 0.554       | 0.554                      |
| IPCC annual rate of methane emission on acid bogs (t CH <sub>4</sub> -C ha <sup>-1</sup> yr <sup>-1</sup> )                     | 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 <sub>4</sub> -C ha <sup>-1</sup> yr <sup>-1</sup> )                          | 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 <sub>4</sub> -C ha <sup>-1</sup> yr <sup>-1</sup> )                              | 0.000           | 0.000           | 0.000       | 0.000                      | 0.000          | 0.000           | 0.000       | 0.000                      | 0.000          | 0.000           | 0.000       | 0.000                      |
| CH <sub>4</sub> emissions from unimproved land (t CO <sub>2</sub> equiv.)                                                       | 0               | 0               | 0           | 0                          | 0              | 0               | 0           | 0                          | 0              | 0               | 0           | 0                          |
| <b>Carbon dioxide emissions from unimproved land</b>                                                                            |                 |                 |             |                            |                |                 |             |                            |                |                 |             |                            |
| Site specific CO <sub>2</sub> emission from unimproved soil on acid bogs (t CO <sub>2</sub> ha <sup>-1</sup> yr <sup>-1</sup> ) | 0.72            | 0.72            | 0.72        | 0.72                       | -2.13          | -2.13           | -2.13       | -2.13                      | -2.13          | -2.13           | -2.13       | -2.13                      |
| Site specific CO <sub>2</sub> emissions from unimproved soil on fens (t CO <sub>2</sub> ha <sup>-1</sup> yr <sup>-1</sup> )     | 6.07            | 6.07            | 6.07        | 6.07                       | 0.06           | 0.06            | 0.06        | 0.06                       | 0.06           | 0.06            | 0.06        | 0.06                       |
| IPCC annual rate of carbon dioxide emission on acid bogs (t CO <sub>2</sub> ha <sup>-1</sup> yr <sup>-1</sup> )                 | 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 <sub>2</sub> ha <sup>-1</sup> yr <sup>-1</sup> )                      | 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 <sub>2</sub> ha <sup>-1</sup> yr <sup>-1</sup> )                          | 35.20           | 35.20           | 35.20       | 35.20                      | 35.20          | 35.20           | 35.20       | 35.20                      | 35.20          | 35.20           | 35.20       | 35.20                      |
| CO <sub>2</sub> emissions from unimproved land (t CO <sub>2</sub> )                                                             | 0               | 0               | 0           | 0                          | 0              | 0               | 0           | 0                          | 0              | 0               | 0           | 0                          |
| <b>Total GHG emissions from unimproved land (t CO<sub>2</sub> equiv.)</b>                                                       | <b>0</b>        | <b>0</b>        | <b>0</b>    | <b>0</b>                   | <b>0</b>       | <b>0</b>        | <b>0</b>    | <b>0</b>                   | <b>0</b>       | <b>0</b>        | <b>0</b>    | <b>0</b>                   |
| <b>RESULTS</b>                                                                                                                  |                 |                 |             |                            |                |                 |             |                            |                |                 |             |                            |
| <b>4. Reduction in GHG emissions due to improvement of site</b>                                                                 |                 |                 |             |                            |                |                 |             |                            |                |                 |             |                            |
| Total GHG emissions from improved land (t CO <sub>2</sub> equiv.)                                                               | 0               | 0               | 0           | 0                          | 0              | 0               | 0           | 0                          | 0              | 0               | 0           | 0                          |
| Total GHG emissions from unimproved land (t CO <sub>2</sub> equiv.)                                                             | 0               | 0               | 0           | 0                          | 0              | 0               | 0           | 0                          | 0              | 0               | 0           | 0                          |
| <b>Reduction in GHG emissions due to improvement (t CO<sub>2</sub> equiv.)</b>                                                  | <b>0</b>        | <b>0</b>        | <b>0</b>    | <b>0</b>                   | <b>0</b>       | <b>0</b>        | <b>0</b>    | <b>0</b>                   | <b>0</b>       | <b>0</b>        | <b>0</b>    | <b>0</b>                   |
| <b>Additional CO<sub>2</sub> payback time of windfarm due to site improvement</b>                                               |                 |                 |             |                            |                |                 |             |                            |                |                 |             |                            |
| ...coal-fired electricity generation (months)                                                                                   | 0               | #DIV/0!         | #DIV/0!     | 0                          | #DIV/0!        | #DIV/0!         | 0           | #DIV/0!                    | #DIV/0!        | 0               | #DIV/0!     | #DIV/0!                    |
| ...grid-mix of electricity generation (months)                                                                                  | 0               | #DIV/0!         | #DIV/0!     | 0                          | #DIV/0!        | #DIV/0!         | 0           | #DIV/0!                    | #DIV/0!        | 0               | #DIV/0!     | #DIV/0!                    |
| ...fossil fuel - mix of electricity generation (months)                                                                         | 0               | #DIV/0!         | #DIV/0!     | 0                          | #DIV/0!        | #DIV/0!         | 0           | #DIV/0!                    | #DIV/0!        | 0               | #DIV/0!     | #DIV/0!                    |

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**Gains due to site improvement**

Note: Note, CO<sub>2</sub> 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: CO<sub>2</sub> emissions from acid bogs. As above

Note: CO<sub>2</sub> emissions from fens. As above

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Frequently Asked Questions

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GENERAL

Syin Yi Phoon (Senior Hydrologist, EnviroCentre Ltd)

Comment: I could see the benefit of protected feature on the all the sheets, but it this means we cannot even copy the equations for testing sensitivity of a parameter without changing the entire sheet. The protection should be removed as it reduces the usefulness of the tool.

Response: Protection of sheets removed

Syin Yi Phoon (Senior Hydrologist, EnviroCentre Ltd)

Comment: We miss the carbon payback table that used to be at the bottom of every carbon gain/loss component. Our clients like to see how quickly they can payback C emitted due to individual components. This is useful in planning and should be replaced.

Response: This feature has been replaced

CORE INPUT DATA

Cameron Mclver (Cameron Ecology Ltd)

Question: The note on “extra capacity required for backup (%)” suggests there is a choice of % capacity or % output – I’m not clear how you know which you have chosen.

Response: The note is misleading. The number that should be entered is the percentage of the actual output of the windfarm (MWh yr<sup>-1</sup>) that is required for backup. Text has been added to the note to clarify this.

Stephen Lockett (AECOM)

Question:

Average extent of drainage around drainage features at site (m)

We have reviewed the guidance but are still unsure of what this variable means. We have used a standard input of 100m but the sheet appears to be extremely sensitive to this variable and we have limited confidence on the value chosen. The note in the cell refers to obtaining data on the ground water level but I am unsure how this relates to extent of drainage around drainage features.

Response: Average extent of drainage around each drainage feature can be measured following the method by Stewart and Lance (1991). In order to determine the extent of drainage, the undrained water table depth, and the 95% confidence interval of the measurements are needed.

Possible approach:

1. Install a series of dipwells or boreholes both upslope and downslope from the drainage feature.
2. In the first instance, assume that all dipwells are from undrained areas of the site. This incorrect assumption is used to initialise the iterative process that calculated the water table depth of the undrained soil.
3. For a particular sampling occasion, calculate the mean water table depth and 95% confidence interval from all the available data.
4. Assume all dipwells with water table depths deeper than the calculated mean water table depth plus the 95% confidence interval are within the area that is drained by a ditch and so exclude these from the calculation.
5. Calculate a new mean water table depth and 95% confidence interval using only data from undrained area.
6. Repeat the process until the calculation of the mean water table depth and 95% confidence interval has stabilised, and no further data points need to be excluded. This gives the water table depth of the undrained soil.
7. The distance from the drain to the first dipwell where the water table depth of the undrained soil occurred (to within the 95% confidence interval) can then be assumed to be the total extent of the drainage impact.

Question: Our drainage strategy is to mimic the existing drainage patterns as closely as possible by intercepting surface run-off and discharging at regular intervals downstream of the tracks back onto natural ground. As such, is there an argument this value could be effectively zero?

Response: No – removing water increases the drainage of the site, and this needs to be accounted for. However, if you are following existing drainage patters, it will be easier to determine the extent of drainage because the drains are already established.

Question: For our example site there is a significant difference in pay back when using site specific and IPCC default values (ranging from 3 to 15 years). Would you be able to provide a brief description of what is being ignored when selecting IPCC default?

Response: The IPCC default takes no account of the previous condition of the site. It provides the result for a typical acid bog or fen across Europe. Therefore, if you are working with an unusually pristine peat or a badly drained peat, you would expect the result to be very different to the average.

Tanya Ogilvy (SEPA)

Question:

Response:

5c. Volume of peat drained

Stephen Lockett (AECOM)

Question: Our new drainage will be surface swales above the ground water table so should not have any effect on the ground water table.

Response: If the surface swales will just convey storm water that would not otherwise have percolated into the soil, these swales will have no impact on the water table of the soil profile, but will only impact the water that would have runoff the surface, causing erosion. However, if the swales also reduce the amount of water entering the soil profile, then they could have an impact on the wetness of the soil. This should really be accounted for in the calculation. However, there is nothing to describe this in the carbon calculator, so you would be justified in neglecting this effect but need to indicate this in the notes.

5e. Emission rates from soils

Stephen Lockett (AECOM)

Question:

Rate of carbon dioxide emission

Response:

We would expect the rate of emission in undrained soil to be worse than the rate in drained soil. This is only the case when the ground water level is very shallow. Does the output define ‘drained soil’ as soil which is being drained by our engineering activities and ‘undrained soil’ as excavated soil which was dry to start with?

I think the confusion comes about due to the definition of terms.

The “drained soil” refers to the soil after it has been drained for the windfarm development. The “undrained soil” refers to the soil before it was drained for the development. This doesn’t refer to the status of the site before the development. Agreed, where a “drained site” refers to a site that has already been drained for a number of years, much of the labile carbon would already have been lost, and so losses due to the windfarm construction would be much less than the losses from an “undrained site” where the peat was still in pristine condition.

Worksheet 5e calculates the rate of emissions of CO2 and CH4 for the soil

1. when drained (ie dry soil);
2. when undrained (ie wet soil).

In a drained (dry) soil, we expect high rates of CO2 emissions and low rates of CH4 emissions.

In an undrained (wet) soil, we expect high rates of CH4 emissions and low rates of CO2 emissions.

These rates are then used in sheet 5d to calculate the net GHG emissions (in CO2 equivalents) attributable to the windfarm development. This is taken as the difference between the losses following drainage for the development and the losses that were occurring before the soil was drained for the development. Because the net emissions are usually higher in the drained (dry) soil than in the undrained (wet) soil, the net emissions due to draining the site usually come out as positive. If we were to compare a “drained site” and an “undrained site” in sheet 5d, the net CO2 emissions calculated for the drained site would be much less than for the undrained site because a smaller volume of soil is being further drained by the development.

| CHANGES IN VERSION 2.1.0         |               |                                          |                             |
|----------------------------------|---------------|------------------------------------------|-----------------------------|
| Worksheet                        | Cells         | Change                                   | Thanks to...                |
| Core input data                  | C31, E31, F31 | Redundant input for soil pH removed      | Ffion Causer, Natural Power |
| Forestry input data              |               | Different areas of forestry included     | N/A                         |
| Construction input data          |               | Different areas of construction included |                             |
| 1. Windfarm CO2 emission savings |               | Different areas of forestry included     |                             |
| 2. CO2 loss due to turbine life  |               | Different areas of construction included |                             |
| 5a. Volume of peat removed       |               | Different areas of construction included |                             |
| 7ii. Forestry CO2 loss - detail  |               | Different areas of forestry included     |                             |
| 7a. C sequest. in trees (3PG)    |               | Different areas of forestry included     |                             |
| 7d. Wind speed ratios            |               | Different areas of forestry included     |                             |

| CHANGES IN VERSION 2.2.0        |              |                                                                                                                                     |                                                          |
|---------------------------------|--------------|-------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|
| Worksheet                       | Cells        | Change                                                                                                                              | Thanks to...                                             |
| Construction input data         | C28, C29.... | "Volume cement..." changed to "Volume concrete..."                                                                                  | Marianne Brownlee, Arcus Renewable Energy Consulting Ltd |
| 1. Windfarm CO2 emission saving | F49          | =IF(F19=1,365*24*F11*F10*G21/100,SUM(I49,L49,O49,R49,U49)) changed to<br>=IF(D19=1,365*24*F11*F10*G21/100,SUM(I49,L49,O49,R49,U49)) | Cameron Mclver, Cameron Ecology Ltd                      |

| CHANGES IN VERSION 2.3.0   |         |                                                                                                                                                                                 |                                   |
|----------------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
| Worksheet                  | Cells   | Change                                                                                                                                                                          | Thanks to...                      |
| 5a. Volume of peat removed | F23     | =IF('Core input data'!C48=1,'Core input data'!C51,'Construction input data'!D17) changed to<br>=IF('Core input data'!C48=1,'Core input data'!C49,'Construction input data'!D17) | Stuart McGowan, Golder Associates |
| 5a. Volume of peat removed | G23,H23 | Similar to above                                                                                                                                                                |                                   |
| 5a. Volume of peat removed | F24     | =IF('Core input data'!C48=1,'Core input data'!C52,'Construction input data'!D18) changed to<br>=IF('Core input data'!C48=1,'Core input data'!C50,'Construction input data'!D18) |                                   |
| 5a. Volume of peat removed | G24,H24 | Similar to above                                                                                                                                                                |                                   |

| CHANGES IN VERSION 2.4.0   |         |                                                                                                 |                                   |
|----------------------------|---------|-------------------------------------------------------------------------------------------------|-----------------------------------|
| Worksheet                  | Cells   | Change                                                                                          | Thanks to...                      |
| 5c. Volume of peat drained | F33     | =(C9+F31+C9)*(C9+F32+C9)-(F31*F32) changed to<br>=IF(F23>0,(C9+F31+C9)*(C9+F32+C9)-(F31*F32),0) | Stuart McGowan, Golder Associates |
| 5c. Volume of peat drained | G33-T33 | Similar to above                                                                                |                                   |

| CHANGES IN VERSION 2.5.0        |                         |                                                                                              |                     |
|---------------------------------|-------------------------|----------------------------------------------------------------------------------------------|---------------------|
| Worksheet                       | Cells                   | Change                                                                                       | Thanks to...        |
| 7ii. Forestry CO2 loss - detail | F55                     | =F50*F53/F54 changed to =IF(F50>0,F50*F53/F54,0)                                             | Jenny Sneddon, AMEC |
| 7ii. Forestry CO2 loss - detail | G55-T55                 | Similar to above                                                                             |                     |
| 7ii. Forestry CO2 loss - detail | F46                     | =IF(F35="Yes", F44*F45, 0) changed to =IF(F35="Yes",IF(F39>0, F44*F45, 0),0)                 |                     |
| 7ii. Forestry CO2 loss - detail | G46-T46                 | Similar to above                                                                             |                     |
| 7ii. Forestry CO2 loss - detail | F63                     | =(F57*'Core input data'!\$E41)-F62 changed to =IF(F55>0,(F57*'Core input data'!\$C41)-F62,0) |                     |
| 7ii. Forestry CO2 loss - detail | G63-T63                 | Similar to above                                                                             |                     |
| 7ii. Forestry CO2 loss - detail | G38                     | ='Forestry input data'!\$F39 changed to ='Forestry input data'!\$H39                         |                     |
| 7ii. Forestry CO2 loss - detail | J38,M38,P38,S38         | Similar to above                                                                             |                     |
| 7ii. Forestry CO2 loss - detail | H38                     | ='Forestry input data'!\$H39 changed to ='Forestry input data'!\$F39                         |                     |
| 7ii. Forestry CO2 loss - detail | K38,N38,Q38,T38         | Similar to above                                                                             |                     |
| 7ii. Forestry CO2 loss - detail | D66                     | =D17+D24+D32-D47-D63 changed to =D17+D24+D32-E47-E63                                         |                     |
| 7ii. Forestry CO2 loss - detail | G66, J66, M66, P66, S66 | Similar to above                                                                             |                     |
| 7ii. Forestry CO2 loss - detail | E66                     | =E17+E24+E32-E47-E63 changed to =E17+E24+E32-D47-D63                                         |                     |
| 7ii. Forestry CO2 loss - detail | H66, K66, N66, Q66, T66 | Similar to above                                                                             |                     |
| 5c. Volume of peat drained      | C54                     | = 'Core input data'!C68 changed to = 'Core input data'!C70                                   | SEPA                |

|                            |                 |                                                                                                                             |
|----------------------------|-----------------|-----------------------------------------------------------------------------------------------------------------------------|
| 5c. Volume of peat drained | D54, E54        | Similar to above                                                                                                            |
| 5c. Volume of peat drained | D48             | =Core input data!C\$65 changed to =Core input data!E\$65                                                                    |
| 5c. Volume of peat drained | E48             | Similar to above                                                                                                            |
| 5c. Volume of peat drained | G33             | =IF(G23>0,(\$C9+G31+\$C9)*(\$C9+G32+\$C9)-(G31*G32),0) changed to<br>=IF(G23>0,(\$d9+G31+\$d9)*(\$d9+G32+\$d9)-(G31*G32),0) |
| 5c. Volume of peat drained | J33,M33,P33,S33 | Similar to above                                                                                                            |
| 5c. Volume of peat drained | H33             | =IF(H23>0,(\$C9+H31+\$C9)*(\$C9+H32+\$C9)-(H31*H32),0) changed to<br>=IF(H23>0,(\$eg+H31+\$eg)*(\$eg+H32+\$eg)-(H31*H32),0) |
| 5c. Volume of peat drained | J33,M33,P33,S33 | Similar to above                                                                                                            |

CHANGES IN VERSION 2.6.0

| Worksheet                       | Cells    | Change                                                                                                                                                    | Thanks to...                |
|---------------------------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|
| Payback Time and CO2 emissions  | D33      | =D\$31/D9 changed to =D\$31/E9                                                                                                                            | Sarah Lister, Natural Power |
| Payback Time and CO2 emissions  | D34, D35 | Similar to above                                                                                                                                          |                             |
| Payback Time and CO2 emissions  | E33      | =E\$31/E9 changed to =E\$31/D9                                                                                                                            |                             |
| Payback Time and CO2 emissions  | E34, E35 | Similar to above                                                                                                                                          |                             |
| Payback Time and CO2 emissions  | D31      | =D19+D25 changed to =D19+E25                                                                                                                              |                             |
| Payback Time and CO2 emissions  | E31      | =E19+E25 changed to =E19+D25                                                                                                                              |                             |
| 6. CO2 loss by DOC & POC loss   | C11      | Contents deleted                                                                                                                                          | Ffion Causer, Natural Power |
| 6. CO2 loss by DOC & POC loss   | D11, E11 | Similar to above                                                                                                                                          |                             |
| 6. CO2 loss by DOC & POC loss   | C26      | =(C9+C12+C13+C14+C15+(C10+C17+C18+C19+C20)/C21)/3.66 changed to<br>=((C9+C12+C13+C14+C15)/3.66)+(((C10+C17+C18+C19+C20)/C21)*(12/16))                     |                             |
| 6. CO2 loss by DOC & POC loss   | D26, E26 | Similar to above                                                                                                                                          | SEPA                        |
| Do I need to use this tool      |          | Wording changed to clarify that the tool SHOULD be used with highly organic soils, but COULD also be used with sites undergoing drainage or deforestation |                             |
| Core input data                 | C12      | Set to 25 and fixed to comply with planning applications for Section 36 (planning period = 25 years)                                                      |                             |
| Core input data                 | Row 25   | Average depth of peat at site not used - therefore removed                                                                                                |                             |
| 1. Windfarm CO2 emission saving | D48      | Set to AVERAGE(G48,J48,M48,P48,S48) to ensure a value is provided                                                                                         | Sarah Lister, Natural Power |
| 1. Windfarm CO2 emission saving | E37      | 24*365*\$D11 changed to 24*365*E11                                                                                                                        |                             |
| 1. Windfarm CO2 emission saving | F37-U37  | Similar to above                                                                                                                                          |                             |
| 5e. Emission rates from soils   | C34      | =C28/(C27*10000) changed to =MAX(C28/(C27*10000),C33)                                                                                                     | Ffion Causer, Natural Power |
| 5e. Emission rates from soils   | D34, E34 | Similar to above                                                                                                                                          |                             |

CHANGES IN VERSION 2.7.0

| Worksheet                      | Cells                | Change                                                                                                                                                             | Thanks to...                              |
|--------------------------------|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|
| 8. CO2 gain - site improvement | C63                  | =-12*C61/'1. Windfarm CO2 emission saving!\$D54 changed to =-12*C60/'1. Windfarm CO2 emission saving!\$D54                                                         | Sarah Lister, Natural Power               |
|                                | D63-N63              | Similar to above                                                                                                                                                   |                                           |
|                                | C64                  | =-12*C62/'1. Windfarm CO2 emission saving!\$D54 changed to =-12*C60/'1. Windfarm CO2 emission saving!\$D54                                                         |                                           |
|                                | D64-N64              | Similar to above                                                                                                                                                   |                                           |
| Core input data                | C74                  | Volume of additional peat excavated added to make the calculation more generalised                                                                                 | Rob McCall, Countryside Council for Wales |
|                                | E74, G74             | Similar to above                                                                                                                                                   |                                           |
|                                | C75                  | Area of additional peat excavated added to make the calculation more generalised                                                                                   |                                           |
|                                | E75, G75             | Similar to above                                                                                                                                                   |                                           |
| 5a. Volume of peat removed     | Row 64 - 67          | Extra lines added to show the additional peat excavated in this sheet                                                                                              |                                           |
|                                | C70                  | =C14+C27+C39+C62 changed to =C14+C27+C39+C62+C65                                                                                                                   |                                           |
|                                | D70, E70             | Similar to above                                                                                                                                                   |                                           |
| Core input data                | C71                  | =C13+F26+F38+C61 changed to =C13+F26+F38+C61+C66                                                                                                                   | Sarah Lister, Natural Power               |
|                                | B72                  | "Depth of cable trenches" change to "Average depth of peat cut for cable trenches (m)" to avoid overestimation of peat affected by cable trenches in shallow peats |                                           |
| Core input data                | Row 91               | New input: Water table depth in borrow pit before restoration                                                                                                      |                                           |
|                                | Row 95               | New input: Water table depth around foundations and hardstanding before restoration                                                                                |                                           |
| 8. CO2 gain - site improvement | Row 15               | Deleted                                                                                                                                                            |                                           |
|                                | C15 (previously C16) | =Core input data!C45 changed to =Core input data!C91                                                                                                               |                                           |
|                                | I15, M15             | Similar to above                                                                                                                                                   |                                           |
|                                | D15 (previously D16) | =Core input data!C50 changed to =Core input data!C95                                                                                                               |                                           |



|                                |          |                                                                              |                        |
|--------------------------------|----------|------------------------------------------------------------------------------|------------------------|
| 5d. CO2 loss from drained peat | J15, N15 | Similar to above                                                             | University of Aberdeen |
|                                | C43      | =C8*(C35+C36)*((C42*C34))/365 changed to =C8*(C35+C36)*((C42*(365-C34)))/365 |                        |
|                                | D43, E43 | Similar to above                                                             |                        |

CHANGES IN VERSION 2.7.2

| Worksheet                      | Cells    | Change                                                                                                                                  | Comment | Thanks to...                |
|--------------------------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------|---------|-----------------------------|
| 8. CO2 gain - site improvement | C13      | =Core input data!C8o changed to =IF('Core input data!C81>'Core input data!C82,'Core input data!C8o,o)                                   |         | Ffion Causer, Natural Power |
|                                | G13, K13 | Similar to above                                                                                                                        |         |                             |
|                                | D13      | =Core input data!C85 changed to =IF('Core input data!C86>'Core input data!C87,'Core input data!C85,o)                                   |         |                             |
|                                | H13,L13  | Similar to above                                                                                                                        |         |                             |
|                                | E13      | =Core input data!C9o changed to =IF('Core input data!C91>'Core input data!C92,'Core input data!C9o,o)                                   |         |                             |
|                                | I13, M13 | Similar to above                                                                                                                        |         |                             |
|                                | F13      | =5c. Volume of peat drained!C34/10000 changed to =IF('Core input data!C95>'Core input data!C96,'5c. Volume of peat drained!C34/10000,o) |         |                             |
|                                | J13, N13 | Similar to above                                                                                                                        |         |                             |

CHANGES IN VERSION 2.8.0

| Worksheet                       | Cells                          | Change                                                                                | Comment                                                                                                                   | Thanks to...           |
|---------------------------------|--------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|------------------------|
| 5c. Volume of peat drained      | Rows 67 - 76                   | Inserted rows to included additional excavated peat in volume of peat drained         | Include additional excavated peat in volume of peat drained                                                               | Susana Sebastian, SEPA |
|                                 | C67-C68; D67-D68; E67-E68      | Title lines                                                                           |                                                                                                                           |                        |
|                                 | C69                            | =Core input data!C74                                                                  |                                                                                                                           |                        |
|                                 | D69,E69                        | Similar to above                                                                      |                                                                                                                           |                        |
|                                 | C70                            | =Core input data!C75                                                                  |                                                                                                                           |                        |
|                                 | D70,E70                        | Similar to above                                                                      |                                                                                                                           |                        |
|                                 | C71                            | =IF(C70>0,C69/C70,o)                                                                  |                                                                                                                           |                        |
|                                 | D71,E71                        | Similar to above                                                                      |                                                                                                                           |                        |
|                                 | C72                            | =SQRT(C70/PI())                                                                       |                                                                                                                           |                        |
|                                 | D72,E72                        | Similar to above                                                                      |                                                                                                                           |                        |
|                                 | C73                            | =C72+C9                                                                               |                                                                                                                           |                        |
|                                 | D73,E73                        | Similar to above                                                                      |                                                                                                                           |                        |
|                                 | C74                            | =(PI()*C73*C73)-C7o                                                                   |                                                                                                                           |                        |
|                                 | D74,E74                        | Similar to above                                                                      |                                                                                                                           |                        |
|                                 | C75                            | =C74*C71                                                                              |                                                                                                                           |                        |
|                                 | D75,E75                        | Similar to above                                                                      |                                                                                                                           |                        |
|                                 | C79                            | =C18+C34+C57+C64 changed to =C18+C34+C57+C64+C74                                      |                                                                                                                           |                        |
|                                 | D79,E79                        | Similar to above                                                                      |                                                                                                                           |                        |
|                                 | C8o                            | =C19+C35+C58+C65 changed to =C19+C35+C58+C65+C75                                      |                                                                                                                           |                        |
|                                 | D8o,E8o                        | Similar to above                                                                      |                                                                                                                           |                        |
| 7ii. Forestry CO2 loss - detail | F62                            | =F6o*F61 changed to =F6o*F61*F55                                                      | Calculation of emissions associated to the transport of wood to biomass plant should account for number of trips to plant | Susana Sebastian, SEPA |
| Forestry input data             | G62-T62                        | Similar to above                                                                      |                                                                                                                           |                        |
| Core input data                 | C23                            | Units changed from g CO2 km <sup>-1</sup> to g CO2 km <sup>-1</sup> t <sup>-1</sup>   |                                                                                                                           |                        |
| 8. CO2 gain - site improvement  | Row 25                         | Insert input for average depth of peat at site                                        | Limit improvements following restoration to the depth of the peat                                                         | Susana Sebastian, SEPA |
|                                 | Row 15                         | Insert average depth of peat at site                                                  |                                                                                                                           |                        |
|                                 | C15                            | =Core input data!C25                                                                  |                                                                                                                           |                        |
|                                 | D15-N15 (excl. E15, I15 & M15) | Similar to above                                                                      |                                                                                                                           |                        |
|                                 | E15                            | =Core input data!C46                                                                  |                                                                                                                           |                        |
|                                 | I15,M15                        | Similar to above                                                                      |                                                                                                                           |                        |
|                                 | C16                            | Core input data!C82 changed to =IF('Core input data!C82<C15,'Core input data!C82,C15) |                                                                                                                           |                        |

|                                                      |                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                   |                                            |
|------------------------------------------------------|----------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|--------------------------------------------|
|                                                      | D16-N16<br>C17<br>D17-N17<br>C21<br>D21-N21              | Similar to above<br>='Core input data'!C83 changed to =IF('Core input data'!C83<C15,'Core input data'!C83,C15)<br>Similar to above<br>C12-C20 changed to =IF(C12-C20>0,C12-C20,0)<br>Similar to above                                                                                                                                                                                                                                                                                                                        |                                                                                                   |                                            |
| Core input data<br>8. CO2 gain - site improvement    | Rows 85, 91, 97<br>C12<br>D12-N12 (excl. E12, I12 & M12) | Insert period of time when the improvement can be guaranteed to work (years)<br>='Core input data'!C12 changed to =IF('Core input data'!C85<br>Similar to above                                                                                                                                                                                                                                                                                                                                                              | Improvements in C sequestration should continue for as long as the improvement can be guaranteed. | Rob McCall, NRW                            |
| Payback Time and CO2 emissions                       | Row 37<br>C37<br>D637,E37                                | Insert ratio of soil carbon loss to gain by restoration<br>=IF(C26<0,-(C17+C18)/C26,0)<br>Similar to above                                                                                                                                                                                                                                                                                                                                                                                                                   | Include calculation of ratio of soil losses to gains                                              | Rob McCall, NRW                            |
| Payback Time and CO2 emissions                       | Row 38<br>C38<br>D637,E37                                | Insert ratio of C emissions to power generation<br>=((C20+C26)*1000000)/(C12*1000)<br>Similar to above                                                                                                                                                                                                                                                                                                                                                                                                                       | Include calculation of C emissions to power generation                                            | Susana Sebastian, SEPA                     |
| 5. Loss of soil CO2<br>5e. Emission rates from soils | D11<br>E11<br>D31<br>E31<br>D33<br>E33                   | =D8+D9 changed to =MIN(D8+D9,E8+E9)<br>=E8+E9 changed to =MAX(D8+D9,E8+E9)<br>='Core input data'!E24 changed to =IF('Core input data'!G24<br>='Core input data'!G24 changed to =IF('Core input data'!E24<br>='Core input data'!E28 changed to =IF('Core input data'!G28<br>='Core input data'!G28 changed to =IF('Core input data'!E28                                                                                                                                                                                       | Correct use of minimum and maximum wrt water table depth at very low depths                       | Peter Batten                               |
| 8. CO2 gain - site improvement                       | G17<br><br>H17-J17<br>K17<br><br>L17-N17                 | =IF('Core input data'!E83<G15,'Core input data'!E83,G15) changed to =IF('Core input data'!G83<G15,'Core input data'!G83,G15)<br>Similar to above<br>=IF('Core input data'!G83<K15,'Core input data'!G83,K15) changed to =IF('Core input data'!E83<K15,'Core input data'!E83,K15)<br>Similar to above                                                                                                                                                                                                                         | Correct use of minimum and maximum depth of water table after restoration                         | Jo Smith, University of Aberdeen           |
| 8. CO2 gain - site improvement                       | G12<br>H12-J12<br>K12<br>L12-N12                         | =IF('Core input data'!E85 changed to =IF('Core input data'!G85<br>Similar to above<br>='Core input data'!G85 changed to =IF('Core input data'!E85<br>Similar to above                                                                                                                                                                                                                                                                                                                                                        | Correct use of min/max period when restoration can be restored                                    | Jo Smith, University of Aberdeen           |
| 8. CO2 gain - site improvement                       | C34<br><br>D34-N34<br>C53<br><br>D53-N53                 | =IF('Core input data'!\$C\$112=2,'8. CO2 gain - site improvement'!C30,'8. CO2 gain - site improvement'!C32) changed to =IF('Core input data'!\$C\$112=2,IF('Core input data'!\$C\$23=1,C30,C31),IF('Core input data'!\$C\$23=1,C32,C33))<br>Similar to above<br>=IF('Core input data'!\$C\$112=2,'8. CO2 gain - site improvement'!C49,'8. CO2 gain - site improvement'!C51) changed to =IF('Core input data'!\$C\$112=2,IF('Core input data'!\$C\$23=1,C49,C50),IF('Core input data'!\$C\$23=1,C51,C52))<br>Similar to above | Correct selection of emission factor when soil type is fen                                        | Elizabeth Keen, Peter Brett Associates LLP |

CHANGES IN VERSION 2.9.0

| Worksheet                       | Cells                         | Change                                                                                                                                                                                                                                                                                                                                     | Comment                                                                                     | Thanks to...                            |
|---------------------------------|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|-----------------------------------------|
| Core input data                 | B94<br><br>B95                | "Water table depth in borrow pit before restoration (m)" changed to "Depth of water table in borrow pit before restoration with respect to the restored surface (m)"<br>"Water table depth in borrow pit after restoration (m)" changed to "Depth of water table in borrow pit after restoration with respect to the restored surface (m)" | Confusing wording as water table depth may always be entered as zero.                       | Clare Wharmby - Carbon Forecast         |
| 8. CO2 gain - site improvement  | C47<br><br>D47-N47            | =(23*16/12)*C13*C40*C46*(C19/365) changed to =(23*16/12)*C13*C40*C46*(C38/365)<br>Similar to above                                                                                                                                                                                                                                         | Error in formula using the improved flooded period instead of the unimproved flooded period | Elizabeth Keen - Peter Brett Associates |
| 7c. Average stand data          | Rows 13-29<br><br>Rows 168-86 | Stand data extended from 17 year to 0 years<br>Similar to above                                                                                                                                                                                                                                                                            | If forest stand is less than 17 years old, the calculations fail                            | Brenda Park - AMEC                      |
| 7ii. Forestry CO2 loss - detail | F31                           | =IF (F29>0,IF(F27="Deep Peat",(VLOOKUP(F29,7c. Average stand data'!\$D\$87:\$G\$118,3)),(VLOOKUP(F29,7c. Average stand data'!\$D\$30:\$G\$63,3))))),0) changed to =IF(F29>0,IF(F27="Deep Peat",(VLOOKUP(F29,7c. Average stand data'!\$D\$68:\$G\$118,3)),                                                                                  |                                                                                             |                                         |

|                                 |                                                  |                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                              |                                   |
|---------------------------------|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|-----------------------------------|
| 7ii. Forestry CO2 loss - detail | G31-T31                                          | Similar to above                                                                                                                                                                                                                                                                                                                                                                                    |                                                                              |                                   |
|                                 | G35                                              | =IF('Forestry input data'!\$F\$33=1,"Yes", "No") changed to =IF('Forestry input data'!\$D\$33=1,"Yes", "No")                                                                                                                                                                                                                                                                                        | Use of felled wood as biofuel not correctly read in min and max calculations | Jo Smith - University of Aberdeen |
|                                 | H35,J35,K35,M35,N35,P35,Q35,S35,T35              | Similar to above                                                                                                                                                                                                                                                                                                                                                                                    |                                                                              |                                   |
| 7ii. Forestry CO2 loss - detail | F16                                              | =7a. C sequest. in trees (3PG)!\$F\$24 changed to =IF(F12>0,7a. C sequest. in trees (3PG)!\$F\$24,0)                                                                                                                                                                                                                                                                                                | Avoid #NA                                                                    | Claire Frost - AECOM              |
|                                 | G16-T16                                          | Similar to above                                                                                                                                                                                                                                                                                                                                                                                    |                                                                              |                                   |
| Forestry input data             | Note: Emissions from felling and timber removal. | "the emissions are 6657 g CO <sub>2</sub> m <sup>-3</sup> " changed to "the emissions are 6675 g CO <sub>2</sub> m <sup>-3</sup> "                                                                                                                                                                                                                                                                  |                                                                              | Jonathon Davison - Mott MacDonald |
| Forestry input data             | Note: Emissions associated with transportation   | "3933000 g CO <sub>2</sub> km <sup>-1</sup> (range 3850000 – 4015000 g CO <sub>2</sub> km <sup>-1</sup> - average = 39.33 g CO <sub>2</sub> km <sup>-1</sup> t <sup>-1</sup> )" changed to "39.33 g CO <sub>2</sub> km <sup>-1</sup> t <sup>-1</sup> (range 38.5 – 40.15 g CO <sub>2</sub> km <sup>-1</sup> t <sup>-1</sup> - average = 39.33 g CO <sub>2</sub> km <sup>-1</sup> t <sup>-1</sup> )" |                                                                              | Jonathon Davison - Mott MacDonald |
| Payback Time and CO2 emissions  | C37<br>D637,E37                                  | =IF(C26<0,-(C17+C18)/C26,"No gains!")<br>Similar to above                                                                                                                                                                                                                                                                                                                                           | Ensure no restoration is highlighted as no gains rather than appearing       | Sarah Lister, Natural Power       |
| Payback Time and CO2 emissions  | C38<br>D637,E37                                  | =((12/44)*(C20+C26)*1000000)/(C12*1000)<br>Similar to above                                                                                                                                                                                                                                                                                                                                         | Express ratio as CO2 rather than C emissions to power generation             | Sarah Lister, Natural Power       |

CHANGES IN VERSION 2.10.0

| Worksheet                       | Cells                        | Change                                                                                                                                                                           | Comment                                                                                                                                                                                     | Thanks to...                |
|---------------------------------|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|
| 8. CO2 gain - site improvement  | K13                          | =IF('Core input data'!G82>'Core input data'!G83,'Core input data'!G81,0) changed to =IF('Core input data'!G82>'Core input data'!E83,'Core input data'!G81,0)                     | Change to correct test for improvement in restored area.                                                                                                                                    | Sarah Lister, Natural Power |
|                                 | L13-N13<br>G13               | Similar to above<br>=IF('Core input data'!E82>'Core input data'!E83,'Core input data'!E81,0) changed to =IF('Core input data'!E82>'Core input data'!G83,'Core input data'!E81,0) |                                                                                                                                                                                             |                             |
|                                 | H13-J13                      | Similar to above                                                                                                                                                                 |                                                                                                                                                                                             |                             |
| Payback Time and CO2 emissions  | B22                          | "8a. Gains due to improvement of degraded bogs" changed to "8a. Change in emissions due to improvement of degraded bogs"                                                         | Confusion over labelling of "gains" due to restoration and improvement                                                                                                                      | Sarah Lister, Natural Power |
|                                 | B23 - B26<br>D38<br>C38, E38 | Similar to above<br>=((D20+D26)*1000000)/(D12*1000) changed to =(D32*1000)/(E12)<br>Similar to above                                                                             | Error in min / max calculation                                                                                                                                                              | Peter Batten                |
| 1. Windfarm CO2 emission saving | H39                          | =('Forestry input data'!\$F28 changed to =G39                                                                                                                                    | The power curve code for Min and Max were not correctly retrieved, because the dropdowns located in the tab Forestry Input Data cells F28 and H28 do not have any value associated to them. | Carlos Ruiz, SEPA           |
|                                 | I39-U39                      | Similar to above                                                                                                                                                                 |                                                                                                                                                                                             |                             |
|                                 | H40<br>I40-U40               | =OFFSET(\$D\$24,H39,1) changed to =OFFSET(\$D\$24,H39,2)<br>Similar to above                                                                                                     | Column in offset incorrectly specified                                                                                                                                                      |                             |
|                                 | H44<br>I40-U40               | =OFFSET(\$D\$24,H39,4) changed to =OFFSET(\$D\$24,H39,5)<br>Similar to above                                                                                                     | Column in offset incorrectly specified                                                                                                                                                      |                             |
|                                 | G49                          | =24*365*G11*G10*G48/100 changed to =IF(G10<=0,0,24*365*G11*G10*G48/100)                                                                                                          |                                                                                                                                                                                             |                             |
|                                 | H48-U49                      | Similar to above                                                                                                                                                                 | Incorrect calculation of annual energy output when less than 5 areas of forestry included.                                                                                                  |                             |

|                                 |                                      |                                                                                                                                                                                |                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                   |
|---------------------------------|--------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| 2. CO2 loss due to turbine life | C19-T19                              | 0.173 changed to 0.316                                                                                                                                                         |                                                                                                   | The emission rate of 173kg/m3 is the rate for "mass foundations". However foundations for wind turbines are reinforced, so the rate is changed to that for Reinforced Foundations, and revised to the new emission rate, from the Table 7 in <a href="http://www.concretecentre.com/sustainability/energy_efficiency/embodied_co2.aspx">http://www.concretecentre.com/sustainability/energy_efficiency/embodied_co2.aspx</a><br>Direct input of emissions includes cement already | Carlos Ruiz, SEPA |
|                                 | C23                                  | =IF('Core input data'!\$C\$20=1,\$C9+C20,\$C13+C20) changed to =IF('Core input data'!\$C\$20=1,\$C9,\$C13+C20)                                                                 |                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                   |
|                                 | D23-E23                              | Similar to above                                                                                                                                                               |                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                   |
| 5a. Volume of peat removed      | F26                                  | =F20*((F23*F24)+(F22*(F21-F23)/2)+(F21*(F22-F24)/2)+((F21-F23)*(F22-F24))/2) changed to =IF(F25>0,(F20*(F25/3 * (F21*F22 + F23*F24 + SQRT(F21*F22*F23*F24))))/F25,0)           | Error in formula                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Carlos Ruiz, SEPA |
| 5c. Volume of peat drained      | G26-T26                              | Similar to above                                                                                                                                                               |                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Carlos Ruiz, SEPA |
|                                 | C34                                  | =C33*C23 changed to =F34+I34+L34+O34+R34                                                                                                                                       |                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                   |
|                                 | D34-T34                              | Similar to above                                                                                                                                                               |                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                   |
|                                 | C55                                  | =('Core input data'!C70 changed to =C52*(C9+C9)                                                                                                                                |                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                   |
|                                 | D55-E55                              | Similar to above                                                                                                                                                               |                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                   |
|                                 | C73<br>D73-E73                       | =C72+C9 changed to =IF(C70>0,C72+C9,0)<br>Similar to above                                                                                                                     |                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                   |
| 5d. CO2 loss from drained peat  | C43                                  | =C8*(C35+C36)*((C42*(365-C34))/365 changed to =C8*(C35+C36)*(((C42*C34)/365)+(C29*(365-C34)/365))                                                                              | Accounts for emissions during both flooded and unflooded times of the year in an undrained soil   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Carlos Ruiz, SEPA |
|                                 | D43,E43<br>C40                       | Similar to above<br>=C8*(C35+C36)*C39*((C38*C34))/365 changed to<br>=C8*(C35+C36)*C39*(((C38*C34)/365)+(C25*(365-C34)/365))                                                    |                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Carlos Ruiz, SEPA |
|                                 | D40,E40<br>D50                       | Similar to above<br>=D47-D48 changed to =IF(D47-D48<E47-E48,D47-D48,E47-E48)                                                                                                   | Protection against unusual conditions that result in incorrect order for min and max calculations |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                   |
|                                 | E50                                  | Similar to above                                                                                                                                                               |                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                   |
|                                 | D31                                  | =('Core input data'!G24 changed to =('Core input data'!E24                                                                                                                     |                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                   |
| 5e. Emission rates from soils   | E31                                  | =('Core input data'!E24 changed to =('Core input data'!G24                                                                                                                     | Correction from previous min/max change                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Carlos Ruiz, SEPA |
| Core input data                 | C103<br>E103, G103, C107, E107, G107 | =IF(C105=2,IF(C106=2,2,1),1) changed to =IF(C105>1,IF(C106>1,2,1),1)<br>Similar to above                                                                                       |                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Carlos Ruiz, SEPA |
| 7a. C sequest. in trees (3PG)   | E24                                  | =AVERAGE(F24,I24,L24,O24,R24) changed to =AGGREGATE(1,6,F24,I24,L24,O24,R24)                                                                                                   | Correction to avoid error when some areas of foresttry are not filled.                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Carlos Ruiz, SEPA |
|                                 | F24, G24, E25-G25, E26-G26           | Similar to above                                                                                                                                                               |                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                   |
|                                 | F25<br>G25-T25                       | =VLOOKUP(F15,\$C62:\$AQ212,9,TRUE) changed to =VLOOKUP(F15,\$B62:\$AQ212,10,TRUE)<br>Similar to above                                                                          | Correction to formula so that it looks in the age column                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                   |
|                                 | F26                                  | =SUM(OFFSET(((INDIRECT(ADDRESS(MATCH(F19,\$B62:\$B112,0)+61,9,4))))),0,1, F19,1)) changed to =SUM(OFFSET(((INDIRECT(ADDRESS(MATCH(F18,\$B62:\$B112,0)+61,9,4))))),0,1, F19,1)) | Change to correct lookup of net primary production of replanted forestry                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                   |
|                                 | G26-T26                              | Similar to above                                                                                                                                                               |                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                   |
| 7d. Wind speed ratios           | Insert row 9                         | Years after planting when felling occurs                                                                                                                                       | Changes to calculate final height of                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Carlos Ruiz, SEPA |

|                                 |                                              |                                                                                                                                                                                                                                                                                          |                                                                                                                                                                              |                                                                                                                                                                                            |
|---------------------------------|----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                 | C9                                           | =Forestry input data!D41                                                                                                                                                                                                                                                                 |                                                                                                                                                                              |                                                                                                                                                                                            |
|                                 | D9-Q9                                        | Similar to above                                                                                                                                                                                                                                                                         |                                                                                                                                                                              | replanted forestry by accounting for years after felling when replanting occurs and age of seedlings as well as lifetime of windfarm - previously only accounted for lifetime of windfarm. |
|                                 | Insert row 10                                | Age of seedlings on plant (yr)                                                                                                                                                                                                                                                           |                                                                                                                                                                              |                                                                                                                                                                                            |
|                                 | C10                                          | =Forestry input data!D42                                                                                                                                                                                                                                                                 |                                                                                                                                                                              |                                                                                                                                                                                            |
|                                 | D10-Q10                                      | Similar to above                                                                                                                                                                                                                                                                         |                                                                                                                                                                              |                                                                                                                                                                                            |
|                                 | C21                                          | =VLOOKUP(C11,'7c. Average stand data'!\$D\$30:\$H\$63,2,TRUE) changed to =VLOOKUP(C11-C9+C10,'7c. Average stand data'!\$D\$30:\$H\$63,2,TRUE)                                                                                                                                            |                                                                                                                                                                              |                                                                                                                                                                                            |
|                                 | D21-Q21                                      | Similar to above                                                                                                                                                                                                                                                                         |                                                                                                                                                                              |                                                                                                                                                                                            |
|                                 | C22                                          | =OFFSET('7c. Average stand data'!\$D30,C8-'7c. Average stand data'!\$D30+C11,1,1) changed to =IF(C8+C11<=50,OFFSET('7c. Average stand data'!\$D30,C8-'7c. Average stand data'!\$D30+C11,1,1),OFFSET('7c. Average stand data'!\$D30,C8-'7c. Average stand data'!\$D30+C11-50+C10-C9,1,1)) | Change to allow for normal harvesting of forestry during the lifetime of the windfarm                                                                                        |                                                                                                                                                                                            |
|                                 | D22-Q22                                      | Similar to above                                                                                                                                                                                                                                                                         |                                                                                                                                                                              |                                                                                                                                                                                            |
|                                 | C52                                          | =IF((0.75+0.03*(LN(C43/C44)))*C44*POWER(C18/C44,0.8)+C46<C49,(0.75+0.03*(LN(C43/C44)))*C44*POWER(C18/C44,0.8)+C46,C49) changed to =IF((0.75+0.03*(LN(C42/C44)))*C44*POWER(C18/C44,0.8)+C46<C49,(0.75+0.03*(LN(C42/C44)))*C44*POWER(C18/C44,0.8)+C46,C49)                                 | Changes to correct formula for height of new internal boundary layer over forest - previously used roughness of group in gap instead of roughness of ground in forested area |                                                                                                                                                                                            |
|                                 | D52-Q52                                      | Similar to above                                                                                                                                                                                                                                                                         |                                                                                                                                                                              |                                                                                                                                                                                            |
|                                 | C54                                          | =IF((0.75+0.03*LN(C44/C43))*C45*POWER(C19/C21,0.8)+C47<C49,(0.75+0.03*LN(C44/C45))*C45*POWER(C19/C45,0.8)+C47,C49) changed to =IF((0.75+0.03*LN(C44/C45))*C45*POWER(C19/C45,0.8)+C47<C49,(0.75+0.03*LN(C44/C45))*C45*POWER(C19/C45,0.8)+C47,C49)                                         | Changes to correct the calculation of height of boundary layer in replanted area                                                                                             |                                                                                                                                                                                            |
|                                 | D54-Q54                                      | Similar to above                                                                                                                                                                                                                                                                         |                                                                                                                                                                              |                                                                                                                                                                                            |
| Construction input data         | C13                                          | "Depth of hole dug when constructing foundations (m)" changed to "Average depth of peat removed when constructing foundations (m)"                                                                                                                                                       | Changes in wording to improve clarity of input data                                                                                                                          | Carlos Ruiz, SEPA                                                                                                                                                                          |
|                                 | C20, C34, C41, C55, C62, C76, C83, C97, C104 | Similar to above                                                                                                                                                                                                                                                                         |                                                                                                                                                                              |                                                                                                                                                                                            |
| 1. Windfarm CO2 emission saving | H17                                          | =Core input data!\$C\$41 changed to =Core input data!\$E\$41                                                                                                                                                                                                                             | Correction of error                                                                                                                                                          | Carlos Ruiz, SEPA                                                                                                                                                                          |
|                                 | D48                                          | =AVERAGE(G48,J48,M48,P48,S48) changed to =AGGREGATE(1,6,G48,J48,M48,P48,S48)                                                                                                                                                                                                             | Changes to average capacity factor only over forestry areas that have valid data                                                                                             | Jo Smith, University of Aberdeen                                                                                                                                                           |
|                                 | E48,F48                                      | Similar to above                                                                                                                                                                                                                                                                         |                                                                                                                                                                              |                                                                                                                                                                                            |
| 2. CO2 loss due to turbine life | D9                                           | =Core input data!E21*D12*Core input data!E14*1. Windfarm CO2 emission saving!D48/100 changed to =Core input data!E21*D12*Core input data!E14*1. Windfarm CO2 emission saving!E48/100                                                                                                     | Changed so that minimum and maximum emission factors are used                                                                                                                | Carlos Ruiz, SEPA                                                                                                                                                                          |
|                                 | E9                                           | Similar to above                                                                                                                                                                                                                                                                         |                                                                                                                                                                              |                                                                                                                                                                                            |
| Forestry input data             | F31                                          | Dropdown menu linked to cell D31                                                                                                                                                                                                                                                         | Change to set soil type in forestry areas of exp., min and max to same value                                                                                                 | Carlos Ruiz, SEPA                                                                                                                                                                          |
|                                 | H31                                          | Similar to above                                                                                                                                                                                                                                                                         |                                                                                                                                                                              |                                                                                                                                                                                            |
|                                 | F50                                          | Dropdown menu linked to cell D50                                                                                                                                                                                                                                                         |                                                                                                                                                                              |                                                                                                                                                                                            |
|                                 | H50                                          | Similar to above                                                                                                                                                                                                                                                                         |                                                                                                                                                                              |                                                                                                                                                                                            |
|                                 | F69                                          | Dropdown menu linked to cell D69                                                                                                                                                                                                                                                         |                                                                                                                                                                              |                                                                                                                                                                                            |
|                                 | H69                                          | Similar to above                                                                                                                                                                                                                                                                         |                                                                                                                                                                              |                                                                                                                                                                                            |
|                                 | F88                                          | Dropdown menu linked to cell D88                                                                                                                                                                                                                                                         |                                                                                                                                                                              |                                                                                                                                                                                            |
|                                 | H88                                          | Similar to above                                                                                                                                                                                                                                                                         |                                                                                                                                                                              |                                                                                                                                                                                            |
|                                 | F107                                         | Dropdown menu linked to cell D107                                                                                                                                                                                                                                                        |                                                                                                                                                                              |                                                                                                                                                                                            |
|                                 | H107                                         | Similar to above                                                                                                                                                                                                                                                                         |                                                                                                                                                                              |                                                                                                                                                                                            |
| 7ii. Forestry CO2 loss - detail | F37                                          | =7a. C sequest. in trees (3PG)!\$F\$25 changed to =7a. C sequest. in trees (3PG)!F\$25                                                                                                                                                                                                   | Change to correctly reference different forestry areas                                                                                                                       | Carlos Ruiz, SEPA                                                                                                                                                                          |
|                                 | G37-T37                                      | Similar to above                                                                                                                                                                                                                                                                         |                                                                                                                                                                              |                                                                                                                                                                                            |
|                                 | F52                                          | =7a. C sequest. in trees (3PG)!\$F19 changed to =7a. C sequest. in trees (3PG)!F19                                                                                                                                                                                                       |                                                                                                                                                                              |                                                                                                                                                                                            |
|                                 | G52-T52                                      | Similar to above                                                                                                                                                                                                                                                                         |                                                                                                                                                                              |                                                                                                                                                                                            |
|                                 | F53                                          | =7a. C sequest. in trees (3PG)!F26 changed to =7a. C sequest. in trees (3PG)!\$F26                                                                                                                                                                                                       |                                                                                                                                                                              |                                                                                                                                                                                            |
|                                 | G53-T53                                      | Similar to above                                                                                                                                                                                                                                                                         |                                                                                                                                                                              |                                                                                                                                                                                            |
|                                 | I38                                          | =Forestry input data!\$D39 changed to =Forestry input data!\$D58                                                                                                                                                                                                                         | Change to refer to different forestry areas                                                                                                                                  |                                                                                                                                                                                            |
|                                 | J38-T38                                      | Similar to above                                                                                                                                                                                                                                                                         |                                                                                                                                                                              |                                                                                                                                                                                            |
|                                 | D61                                          | =Forestry input data!\$D23/1000000 changed to =Forestry input data!\$F23/1000000                                                                                                                                                                                                         | Change to reference the correct cell                                                                                                                                         |                                                                                                                                                                                            |

|                                |                                                                     |                                                                                                                                                                                                                                                          |                                                                  |                   |
|--------------------------------|---------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------|
|                                | G61,J61,M61,P61,S61<br>E61<br>H61,K61,N61,Q61,T61<br>G63<br>H83-T63 | Similar to above<br>='Forestry input data!\$D23/1000000 changed to ='Forestry input data!\$H23/1000000<br>Similar to above<br>=IF(G55>0,(G57*'Core input data!\$C41)-G62,o) changed to =IF(G55>0,(G57*'Core input data!\$E41)-G62,o)<br>Similar to above |                                                                  |                   |
| Core input data                | E23<br>G23                                                          | Menu linked to cell C23<br>Similar to above                                                                                                                                                                                                              | Change to allow only one soil type                               | Carlos Ruiz, SEPA |
| 8. CO2 gain - site improvement | D62<br><br>E62-N62;D63-N63;D64-N64                                  | =-12*D60/'1. Windfarm CO2 emission saving!\$D53 changed to =-12*D60/'1. Windfarm CO2 emission saving!\$E53<br>Similar to above                                                                                                                           | Change to allow use of different counterfactual emission factors | Carlos Ruiz, SEPA |

CHANGES IN VERSION 2.11.0

| Worksheet                     | Cells                         | Change                                                                                                                                                                                       | Comment | Thanks to... |
|-------------------------------|-------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|--------------|
| 5e. Emission rates from soils | D21<br>E21<br>D22,E22,D23,E23 | =IF('Core input data!D23=1,D11,D16) changed to =IF('Core input data!C23=1,D11,D16)<br>=IF('Core input data!E23=1,D11,D16) changed to =IF('Core input data!C23=1,D11,D16)<br>Similar to above |         | Peter Batten |

CHANGES IN VERSION 2.12.0

| Worksheet                       | Cells                     | Change                                                                                                                                                             | Comment                                                                                                                                         | Thanks to...                 |
|---------------------------------|---------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
| Core input data                 | C27,E27,G27               | Cell validated to be between 0.01 and 1000                                                                                                                         | Avoids incorrect entry of zero for extent of drainage                                                                                           | Carlos Ruiz, SEPA            |
| Payback and CO2 emissions       | C37<br><br>D37<br><br>E37 | =IF(C26>0,(C17+C18)/C26,"No gains!") changed to =IF(C26>0,(C17+C18)/C26,"No gains!")<br><br>=IF(D26<0,-(D17+D18)/D26,"No gains!") changed to<br><br>Similar to D37 | Error introduced by change in sign of C26<br><br>Error introduced by change in sign of D26 plus correction in use of minimum and maximum values | <br><br>Alexa Morrison, RSPB |
| 2. CO2 loss due to turbine life | C9,D9,E9                  | ='Core input data!C21*C12*'Core input data!C14*'1. Windfarm CO2 emission saving!D48/100 to = 'Core input data!C21*C12*'Core input data!C14                         | Corrected to remove dependence on capacity factor                                                                                               | Clare Wharmby                |

CHANGES IN VERSION 2.13.0

CHANGES MADE BY SEPA - REPLICATED IN VERSION 2.14

CHANGES IN VERSION 2.14.0

| Worksheet                  | Cells                                  | Change                                                                                                                                                                                                                                                                           | Comment                                                                 | Thanks to...                    |
|----------------------------|----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|---------------------------------|
| 5a. Volume of peat removed | F37<br><br>G37,H37<br>I37<br>J37 - T37 | =IF(\$C\$31=1,'Core input data!C54,'Construction input data!D13) -> =IF(\$C\$31=1,'Core input data!C54,'Construction input data!D20)<br>Similar to above<br>=IF(\$C\$31=1,0,'Construction input data!\$D34) -> =IF(\$C\$31=1,0,'Construction input data!D41)<br>Similar to above | Correction to use depth of hardstanding instead of depth of foundations | Clare Wharmby - Carbon Forecast |