

Payback Time and CO₂ emissions • UIRC-LUK8-7CN3 v4

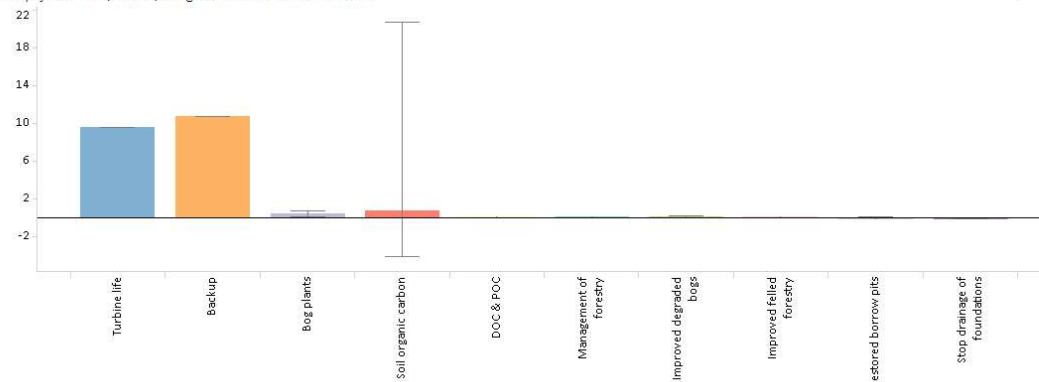
| 1. Windfarm CO ₂ emission saving over... | Exp. | Min. | Max. |
|---|-----------|-----------|------------|
| ...coal-fired electricity generation (t CO ₂ / yr) | 174,659 | 162,183 | 187,135 |
| ...grid-mix of electricity generation (t CO ₂ / yr) | 48,141 | 44,703 | 51,580 |
| ...fossil fuel-mix of electricity generation (t CO ₂ / yr) | 85,431 | 79,329 | 91,533 |
| Energy output from windfarm over lifetime (MWh) | 9,492,336 | 8,814,312 | 10,170,360 |

| Total CO ₂ losses due to wind farm (tCO ₂ eq.) | Exp. | Min. | Max. |
|--|---------|---------|---------|
| 2. Losses due to turbine life (eg. manufacture, construction, decommissioning) | 68,327 | 68,327 | 68,327 |
| 3. Losses due to backup | 76,278 | 76,278 | 76,278 |
| 4. Losses due to reduced carbon fixing potential | 3,208 | 797 | 5,224 |
| 5. Losses from soil organic matter | 5,524 | -26,751 | 157,407 |
| 6. Losses due to DOC & POC leaching | 10 | 0 | 103 |
| 7. Losses due to felling forestry | 0 | 0 | 0 |
| Total losses of carbon dioxide | 153,346 | 118,650 | 307,338 |

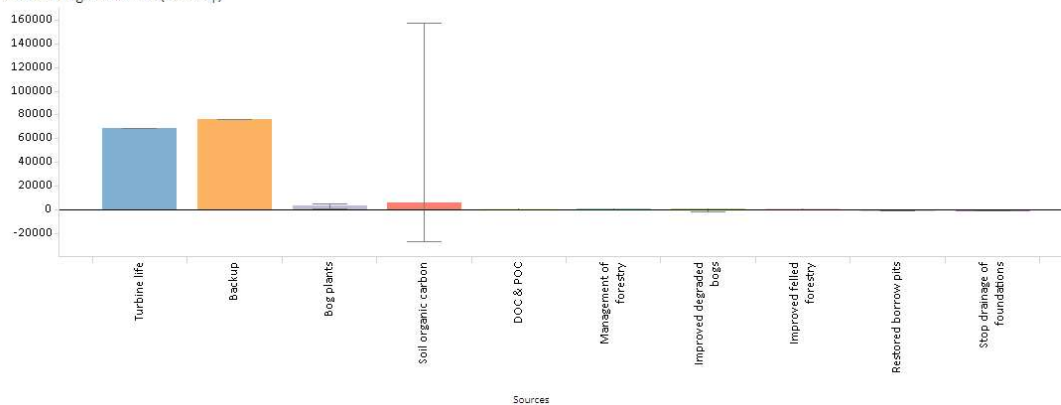
| 8. Total CO ₂ gains due to improvement of site (t CO ₂ eq.) | Exp. | Min. | Max. |
|--|------|------|--------|
| 8a. Change in emissions due to improvement of degraded bogs | 0 | 0 | -1,746 |
| 8b. Change in emissions due to improvement of felled forestry | 0 | 0 | 0 |
| 8c. Change in emissions due to restoration of peat from borrow pits | -154 | 0 | -1,094 |
| 8d. Change in emissions due to removal of drainage from foundations & hardstanding | -433 | 0 | -715 |
| Total change in emissions due to improvements | -587 | 0 | -3,555 |

| RESULTS | Exp. | Min. | Max. |
|--|---------|---------|-----------|
| Net emissions of carbon dioxide (t CO ₂ eq.) | 152,759 | 115,095 | 307,338 |
| Carbon Payback Time | | | |
| ...coal-fired electricity generation (years) | 0.9 | 0.6 | 1.9 |
| ...grid-mix of electricity generation (years) | 3.2 | 2.2 | 6.9 |
| ...fossil fuel-mix of electricity generation (years) | 1.8 | 1.3 | 3.9 |
| Ratio of soil carbon loss to gain by restoration (not used in Scottish applications) | 9.43 | -7.52 | No gains! |
| Ratio of CO ₂ eq. emissions to power generation (g/kWh) (for info. only) | 16.09 | 11.32 | 34.87 |

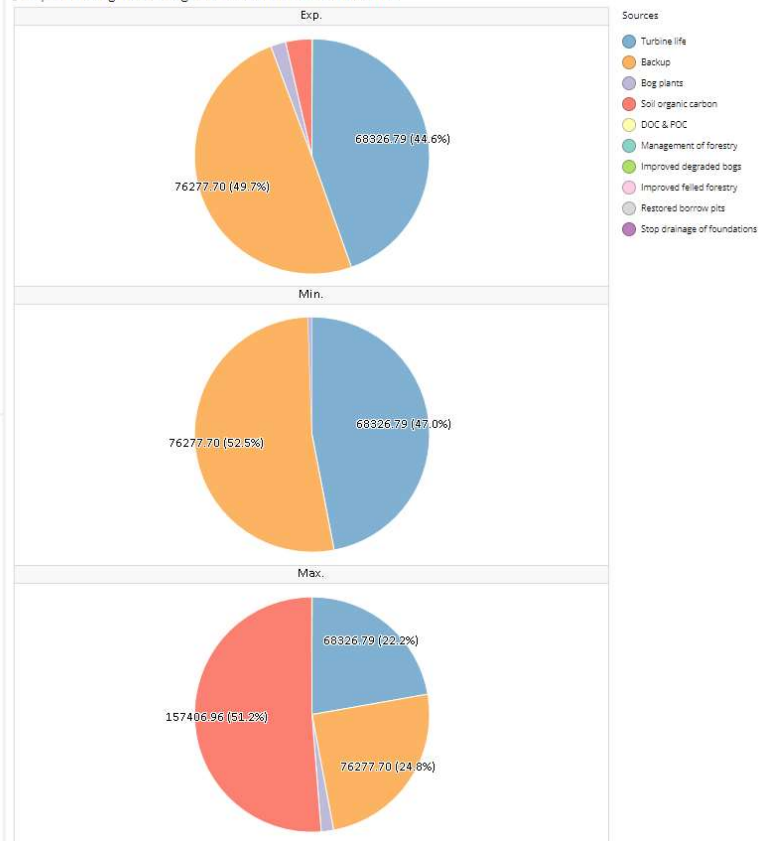
Carbon payback time (months) using fossil-fuel mix as counterfactual



Greenhouse gas emissions (t CO₂ eq.)



Proportions of greenhouse gas emissions from different sources



Carbon Calculator v1.6.1

Achany Extension Wind Farm V2 Location: 58.045629 -4.624451

SSEN

Core input data

| Input data | Expected value | Minimum value | Maximum value | Source of data |
|--|----------------------------------|----------------------------------|----------------------------------|--|
| Windfarm characteristics | | | | |
| <u>Dimensions</u> | | | | |
| No. of turbines | 18 | 18 | 18 | Chapter 3: Description of Development. Section 3.3 |
| Duration of consent (years) | 50 | 50 | 50 | Chapter 3: Description of Development. Section 3.6. |
| <u>Performance</u> | | | | |
| Power rating of 1 turbine (MW) | 4.3 | 4.3 | 4.3 | Chapter 3: Description of Development. Section 3.3. |
| Capacity factor | 28 | 26 | 30 | raw data |
| <u>Backup</u> | | | | |
| Fraction of output to backup (%) | 5 | 5 | 5 | Conservative factor based on guidance |
| Additional emissions due to reduced thermal efficiency of the reserve generation (%) | 10 | 10 | 10 | Fixed |
| Total CO2 emission from turbine life (tCO ₂ MW ⁻¹) (eg. manufacture, construction, decommissioning) | Calculate wrt installed capacity | Calculate wrt installed capacity | Calculate wrt installed capacity | |
| Characteristics of peatland before windfarm development | | | | |
| Type of peatland | Acid bog | Acid bog | Acid bog | Volume 2, Chapter 8, Section 8.6 |
| Average annual air temperature at site (°C) | 10 | 8 | 12 | Raw Data |
| Average depth of peat at site (m) | 0.6 | 0 | 5.8 | Volume 4, Appendix 11.2 |
| C Content of dry peat (% by weight) | 53 | 19 | 65 | Assumed Blanket Peat value |
| Average extent of drainage around drainage features at site (m) | 5 | 2 | 6 | Raw Data |
| Average water table depth at site (m) | 0.5 | 0.1 | 1 | Raw Data |
| Dry soil bulk density (g cm ⁻³) | 0.15 | 0.09 | 0.25 | Based on past experience |
| Characteristics of bog plants | | | | |
| Time required for regeneration of bog plants after restoration (years) | 15 | 10 | 20 | Raw Data |
| Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha ⁻¹ yr ⁻¹) | 0.25 | 0.12 | 0.31 | SNH recommended value, Calculating carbon savings from wind farms on Scottish peat lands: a new approach |
| Forestry Plantation Characteristics | | | | |
| Area of forestry plantation to be felled (ha) | 0 | 0 | 0 | No Trees Felled |
| Average rate of carbon sequestration in timber (tC ha ⁻¹ yr ⁻¹) | 0 | 0 | 0 | No Trees Felled |
| Counterfactual emission factors | | | | |

| Input data | Expected value | Minimum value | Maximum value | Source of data |
|---|----------------|---------------|---------------|---|
| Coal-fired plant emission factor (t CO ₂ MWh ⁻¹) | 0.92 | 0.92 | 0.92 | |
| Grid-mix emission factor (t CO ₂ MWh ⁻¹) | 0.25358 | 0.25358 | 0.25358 | |
| Fossil fuel-mix emission factor (t CO ₂ MWh ⁻¹) | 0.45 | 0.45 | 0.45 | |
| Borrow pits | | | | |
| Number of borrow pits | 2 | 1 | 2 | Volume 4, Appendix 11.1 |
| Average length of pits (m) | 255 | 191 | 330 | Raw Data |
| Average width of pits (m) | 205 | 175 | 238 | Raw Data |
| Average depth of peat removed from pit (m) | 0.62 | 0.41 | 0.94 | Volume 4, Appendix 11.2 |
| Access tracks | | | | |
| Total length of access track (m) | 23732 | 23701 | 23803 | Raw data |
| Existing track length (m) | 6600 | 6600 | 6600 | Volume 2, Chapter 3, Section 3.1 |
| <u>Length of access track that is floating road (m)</u> | 2002 | 2001 | 2003 | Volume 2, Chapter 3, Section 3.1 |
| Floating road width (m) | 7 | 5.5 | 7 | Volume 3, Figure 3.4 |
| Floating road depth (m) | 0.6 | 0.59 | 0.7 | Volume 3, Figure 3.4 |
| Length of floating road that is drained (m) | 1000 | 0 | 1500 | estimate |
| Average depth of drains associated with floating roads (m) | 0.5 | 0.5 | 1 | estimate |
| <u>Length of access track that is excavated road (m)</u> | 15130 | 15100 | 15200 | Volume 2, Chapter 3, Section 3.1 |
| Excavated road width (m) | 7 | 5.5 | 7 | Volume 3, Figure 3.4 |
| Average depth of peat excavated for road (m) | 0.37 | 0.37 | 0.37 | Raw Data |
| <u>Length of access track that is rock filled road (m)</u> | 0 | 0 | 0 | - |
| Rock filled road width (m) | 5 | 5 | 5 | Input required but not used |
| Rock filled road depth (m) | 0 | 0 | 0 | - |
| Length of rock filled road that is drained (m) | 0 | 0 | 0 | - |
| Average depth of drains associated with rock filled roads (m) | 0 | 0 | 0 | - |
| 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 | 0 | 0 | - |
| Average depth of peat cut for cable trenches (m) | 0 | 0 | 0 | - |
| Additional peat excavated (not already accounted for above) | | | | |
| Volume of additional peat excavated (m ³) | 20400 | 20300 | 20500 | Raw Data (Welfare, construction compounds, batch plants, temp hardstands and turning heads) |
| Area of additional peat excavated (m ²) | 64000 | 63000 | 65000 | Raw Data (Welfare, construction compounds, batch plants, temp hardstands and turning heads) |
| Peat Landslide Hazard | | | | |
| Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments | negligible | negligible | negligible | Fixed |
| Improvement of C sequestration at site by blocking drains, restoration of habitat etc | | | | |
| <u>Improvement of degraded bog</u> | | | | |

| Input data | Expected value | Minimum value | Maximum value | Source of data |
|---|----------------|---------------|---------------|--|
| Area of degraded bog to be improved (ha) | 11.6 | 11.6 | 11.6 | Volume 2, Chapter 3, Section 8.13 |
| Water table depth in degraded bog before improvement (m) | 0.3 | 0.1 | 0.5 | Based on The Hydrology of Peat, Uni. Birmingham 2016 |
| Water table depth in degraded bog after improvement (m) | 0.25 | 0.09 | 0.4 | Based on The Hydrology of Peat, Uni. Birmingham 2016 |
| Time required for hydrology and habitat of bog to return to its previous state on improvement (years) | 10 | 5 | 15 | Raw data |
| Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years) | 10 | 5 | 15 | Raw data |
| <u>Improvement of felled plantation land</u> | | | | |
| Area of felled plantation to be improved (ha) | 0 | 0 | 0 | Not required |
| Water table depth in felled area before improvement (m) | 0 | 0 | 0 | Not required |
| Water table depth in felled area after improvement (m) | 0 | 0 | 0 | Not required |
| Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years) | 2 | 2 | 2 | Input required but not considered |
| Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years) | 2 | 2 | 2 | Input required but not considered |
| <u>Restoration of peat removed from borrow pits</u> | | | | |
| Area of borrow pits to be restored (ha) | 5.2275 | 3.3425 | 7.854 | Raw data |
| Depth of water table in borrow pit before restoration with respect to the restored surface (m) | 0.2 | 0.1 | 0.3 | Raw data |
| Depth of water table in borrow pit after restoration with respect to the restored surface (m) | 0.19 | 0.05 | 0.25 | Raw data |
| Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years) | 10 | 5 | 20 | estimate |
| Period of time when effectiveness of the restoration of peat removed from borrow pits can be guaranteed (years) | 20 | 15 | 25 | estimate |
| <u>Early removal of drainage from foundations and hardstanding</u> | | | | |
| Water table depth around foundations and hardstanding before restoration (m) | 0.2 | 0.1 | 0.3 | Raw data |
| Water table depth around foundations and hardstanding after restoration (m) | 0.1 | 0 | 0.2 | Raw data |
| Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years) | 3 | 3 | 3 | estimate |
| <u>Restoration of site after decommissioning</u> | | | | |
| <u>Will the hydrology of the site be restored on decommissioning?</u> | No | No | No | |
| Will you attempt to block any gullies that have formed due to the windfarm? | Yes | Yes | Yes | Volume 4, Appendix 8.6 |
| Will you attempt to block all artificial ditches and facilitate rewetting? | No | No | No | Volume 4, Appendix 8.6 |
| <u>Will the habitat of the site be restored on decommissioning?</u> | No | No | No | |

| Input data | Expected value | Minimum value | Maximum value | Source of data |
|---|--|---------------|---------------|---------------------|
| Will you control grazing on degraded areas? | No | No | No | Volume 2, Chapter 3 |
| Will you manage areas to favour reintroduction of species | No | No | No | Volume 2, Chapter 3 |
| Methodology | | | | |
| Choice of methodology for calculating emission factors | Site specific (required for planning applications) | | | |

Forestry input data

N/A

Construction input data

| Input data | Expected value | Minimum value | Maximum value | Source of data |
|--|----------------|---------------|---------------|----------------------------------|
| Achany Extension Wind Farm | | | | |
| Number of turbines in this area | 18 | 18 | 18 | Revised Turbine layout |
| Turbine foundations | | | | |
| Depth of hole dug when constructing foundations (m) | 0.57 | 0.13 | 1.73 | Raw Data |
| Aproximate geometric shape of whole dug when constructing foundations | Circular | Circular | Circular | Volume 2, Chapter 3, Section 3.3 |
| Diameter at bottom | 30 | 26 | 38.8 | |
| Diameter at surface | 25 | 25 | 25 | |
| Hardstanding | | | | |
| Depth of hole dug when constructing hardstanding (m) | 0.57 | 0.13 | 1.73 | Raw Data |
| Aproximate geometric shape of whole dug when constructing hardstanding | Rectangular | Rectangular | Rectangular | Volume 2, Chapter 3, Section 3.3 |
| Length at surface | 63 | 63 | 63 | |
| Width at surface | 25 | 25 | 25 | |
| Length at bottom | 64.14 | 63.26 | 66.46 | |
| Width at bottom | 26.14 | 25.26 | 28.46 | |
| Piling | | | | |
| Is piling used? | No | No | No | Not Required |
| Volume of Concrete | | | | |
| Volume of concrete used (m ³) in the entire area | 14000 | 14000 | 14000 | Volume 2, Chapter 3, Section 3.3 |