Appendix 3.3 – Carbon Calculator

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Appendix 3.3 – Carbon Calculator

Introduction

The Scottish Government Carbon Calculator Online Tool Version 1.6.1 was used to assess the carbon impact of the Proposed Development. The input parameters and the calculator outputs are outlined below.

The project reference code of this calculation is BMI1-Y282-H7DF. This project reference code can be used to view the calculator input parameters and calculator output online through the Carbon Calculator Tool at the following web address:

https://informatics.sepa.org.uk/CarbonCalculator/index.jsp

Carbon Calculator Input Parameters

Carbon Calculator v1.6.1
Strath Tirry Wind Farm Location: 58.096774 -4.4128
Strath Tirry Wind Energy Limited

Core input data

Input data	Expected value	Minimum value	Maximum value	Source of data
Windfarm characteristics				
Dimensions				
No. of turbines	4	4	4	EIA Chapter 3
Duration of consent (years)	30	30	30	EIA Chapter 3
Performance				
Power rating of 1 turbine (MW)	4.2	4.2	4.2	EIA Chapter 3
Capacity factor	26.62	23.96	29.28	BEIS July 2020 Onshore Wind Value
Backup				
Fraction of output to backup (%)	5	5	5	standard value
Additional emissions due to reduced thermal efficiency of the reserve generation (%)	10	10	10	Fixed
Total CO2 emission from turbine life (tCO2 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	EIA Chapter 11
Average annual air temperature at site (°C)	11.7	10.53	12.87	Annual met station data
Average depth of peat at site (m)	0.56	0.504	0.616	EIA Chapter 11
C Content of dry peat (% by weight)	33	19	44.88	Lab data from survey samples
Average extent of drainage around drainage features at site (m)	10	9	11	EIA Chapter 7
Average water table depth at site (m)	0.1	0.05	0.3	observed during survey
Dry soil bulk density (g cm^{-3})	0.3	0.29	0.3	maximum value allowed
Characteristics of bog plants				
Time required for regeneration of bog plants after restoration (years)	10	5	15	standard
Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha^{-1} yr^{-1})	0.25	0.12	0.31	SNH guidance
Forestry Plantation Characteristics				
Area of forestry plantation to be felled (ha)	14.42	12.978	15.862	EIA Chapter 16
Average rate of carbon sequestration in timber (tC ha^{-1} yr^{-1})	3.6	3.24	3.96	SNH guidance
Counterfactual emission factors				
Coal-fired plant emission factor (t CO2 MWh^{-1})	0.92	0.92	0.92	
Grid-mix emission factor (t CO2 MWh^{-1})	0.25358	0.25358	0.25358	
Fossil fuel-mix emission factor (t CO2 MWh^{-1})	0.45	0.45	0.45	
Borrow pits				
Number of borrow pits	3	1	3	EIA Chapter 3
Average length of pits (m)	40	36	44	EIA Chapter 3
Average width of pits (m)	40	36	44	EIA Chapter 3
Average depth of peat removed from pit (m)	0.34	0.32	0.35	EIA Chapter 3
Access tracks				
Total length of access track (m)	1925	1732.5	2117.5	EIA Chapter 3
Existing track length (m)	0	0	0	EIA Chapter 3

Input data	Expected value	Minimum value	Maximum value	Source of data
Length of access track that is floating road (m)	0	0	0	EIA Chapter 3
Floating road width (m)	5	5	5	EIA Chapter 3
Floating road depth (m)	0	0	0	EIA Chapter 3
Length of floating road that is drained (m)	0	0	0	EIA Chapter 3
Average depth of drains associated with floating roads (m)	0	0	0	EIA Chapter 3
Length of access track that is excavated road (m)	1925	1732.5	2117.5	EIA Chapter 3
Excavated road width (m)	5	5	5	EIA Chapter 3
Average depth of peat excavated for road (m)	0.41	0.369	0.451	EIA Chapter 11
Length of access track that is rock filled road (m)	0	0	0	EIA Chapter 3
Rock filled road width (m)	5	5	5	EIA Chapter 3
Rock filled road depth (m)	0	0	0	EIA Chapter 3
Length of rock filled road that is drained (m)	0	0	0	EIA Chapter 3
Average depth of drains associated with rock filled roads (m)	0	0	0	EIA Chapter 3
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	EIA Chapter 3
Average depth of peat cut for cable trenches (m)	0.5	0	0.51	EIA Chapter 3
Additional peat excavated (not already accounted for above)				
Volume of additional peat excavated (m^3)	527.2	474.48	579.92	EIA Chapter 11
Area of additional peat excavated (m^2)	2016	1814.4	2217.6	EIA Chapter 3
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				
Improvement of degraded bog				
Area of degraded bog to be improved (ha)	0.49	0.441	0.539	EIA Chapter 8
Water table depth in degraded bog before improvement (m)	0.1	0.05	0.3	observed in site survey
Water table depth in degraded bog after improvement (m)	0.09	0.04	0.29	EIA Chapter 7
Time required for hydrology and habitat of bog to return to its previous state on improvement (years)	10	5	15	standard value
Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years)	30	30	30	EIA Chapter 3
Improvement of felled plantation land				
Area of felled plantation to be improved (ha)	14.42	12.978	15.862	EIA Chapter 16
Water table depth in felled area before improvement (m)	0	0	0	EIA Chapter 3
Water table depth in felled area after improvement (m)	0	0	0	EIA Chapter 3
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)	10	5	15	standard value
Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years)	30	30	30	EIA Chapter 3
Restoration of peat removed from borrow pits				
Area of borrow pits to be restored (ha)	0.48	0.432	0.528	EIA Chapter 3
Depth of water table in borrow pit before restoration with respect to the restored surface (m)	0.1	0.05	0.3	observed in site survey
Depth of water table in borrow pit after restoration with respect to the restored surface (m)	0.09	0.04	0.29	EIA Chapter 8
Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years)	10	5	15	Standard value
Period of time when effectiveness of the restoration of peat removed from borrow pits can be guaranteed (years)	30	30	30	EIA Chapter 3
Early removal of drainage from foundations and hardstanding				

Input data	Expected value	Minimum value	Maximum value	Source of data
Water table depth around foundations and hardstanding before restoration (m)	0	0	0	EIA Chapter 3
Water table depth around foundations and hardstanding after restoration (m)	0	0	0	EIA Chapter 3
Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)	0.1	0.1	0.1	EIA Chapter 3
Restoration of site after decomissioning				
Will the hydrology of the site be restored on decommissioning?	Yes	Yes	Yes	
Will you attempt to block any gullies that have formed due to the windfarm?	Yes	Yes	Yes	CEMP
Will you attempt to block all artificial ditches and facilitate rewetting?	Yes	Yes	Yes	CEMP
Will the habitat of the site be restored on decommissioning?	Yes	Yes	Yes	
Will you control grazing on degraded areas?	Yes	Yes	Yes	EIA Chapter 8
Will you manage areas to favour reintroduction of species	Yes	Yes	Yes	EIA Chapter 8
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
Site				
Number of turbines in this area	4	4	4	EIA Chapter 3
Turbine foundations				
Depth of hole dug when constructing foundations (m)	0.38	0.342	0.418	EIA Chapter 11
Aproximate geometric shape of whole dug when constructing foundations	Circular	Circular	Circular	EIA Chapter 3
Diameter at bottom	15	15	15	
Diameter at surface	15	15	15	
Hardstanding				
Depth of hole dug when constructing hardstanding (m)	0.38	0.342	0.418	EIA Chapter 11
Aproximate geometric shape of whole dug when constructing hardstanding	Rectangular	Rectangular	Rectangular	EIA Chapter 3
Length at surface	165	165	165	
Width at surface	10	10	10	
Length at bottom	165	165	165	
Width at bottom	10	10	10	
Piling				
Is piling used?	No	No	No	EIA Chapter 3
Volume of Concrete				
Volume of concrete used (m^3) in the entire area	632.75	569.475	696.025	EIA Chapter 3

Carbon Calculator Output

Payback Time

Payback Time
Payback Time - ChartsInput Data
1. Windfarm CO2 emission saving 2. CO2 loss due to turbine life 3. CO2 loss due to backup 4. Loss of CO2 fixing potential 5. Loss of soil CO2 (a,b) 5. Loss of soil CO2 (c,d,e) 6. CO2 loss by DOC & POC loss 7. Forestry CO2 loss 8. CO2 gain - site improvement

1. Windfarm CO2 emission saving over...	Exp.	Min.	Max.
...coal-fired electricity generation (t CO2 / yr)	36,042	32,441	39,644
...grid-mix of electricity generation (t CO2 / yr)	9,934	8,942	10,927
...fossil fuel-mix of electricity generation (t CO2 / yr)	17,629	15,868	19,391
Energy output from windfarm over lifetime (MWh)	1,175,284	1,057,844	1,292,724

Total CO2 losses due to wind farm (tCO2 eq.)	Exp.	Min.	Max.
2. Losses due to turbine life (eg. manufacture, construction, decomissioning)	14,027	14,007	14,047
3. Losses due to backup	9,934	9,934	9,934
4. Lossess due to reduced carbon fixing potential	322	107	520
5. Losses from soil organic matter	2,534	378	3,948
6. Losses due to DOC & POC leaching	173	0	536
7. Losses due to felling forestry	5,710	4,625	6,910
Total losses of carbon dioxide	32,700	29,051	35,895

8. Total CO2 gains due to improvement of site (t CO2 eq.)	Exp.	Min.	Max.
8a. Change in emissions due to improvement of degraded bogs	7	0	-89
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	7	0	-87
8d. Change in emissions due to removal of drainage from foundations & hardstanding	0	0	0
Total change in emissions due to improvements	14	0	-177

RESULTS	Exp.	Min.	Max.
Net emissions of carbon dioxide (t CO2 eq.)	32,714	28,874	35,895
Carbon Payback Time			
...coal-fired electricity generation (years)	0.9	0.7	1.1
...grid-mix of electricity generation (years)	3.3	2.6	4.0
...fossil fuel-mix of electricity generation (years)	1.9	1.5	2.3
Ratio of soil carbon loss to gain by restoration (not used in Scottish applications)	No gains!	2.14	No gains!
Ratio of CO2 eq. emissions to power generation (g/kWh) (for info. only)	27.83	22.34	33.93

Summary

This section presents a summary of the carbon balance assessment which has been undertaken in respect of the Proposed Development. An assessment has been undertaken to calculate the carbon emissions which would be generated during the construction, operation and decommissioning of the Proposed Development as well as the carbon payback period resulting from the operation of the Proposed Development.

The calculations of total CO_2 emission savings and payback time for the Proposed Development indicates that overall payback period of a wind farm of four turbines with an indicative installed capacity of 4.2 MW per turbine would be approximately 1.9 years, when compared to the fossil fuel-mix of electricity generation.

The potential savings in CO2 emissions due to the Proposed Development replacing other electricity sources over the lifetime of the Proposed Development are approximately:

- 36,042 tonnes of CO_2 per year over coal-fired electricity (1.081 million tonnes assuming a 30 year lifetime for the purposes of the carbon calculator).
- 9,934 tonnes of CO_2 per year over grid-mix of electricity (298,020 tonnes assuming a 30 year lifetime for the purposes of the carbon calculator).
- 17,629 tonnes of CO_2 per year over fossil fuel-mix of electricity (528,870 tonnes assuming a 30 year lifetime for the purposes of the carbon calculator).

The Proposed Development is expected to take 1.9 years (23 months) to repay the carbon exchange to the atmosphere (the CO_2 debt) through construction of the Proposed Development. There are no current guidelines about what payback time constitutes a significant impact, however, this is a relatively small percentage (6.33 %) of the 30 year lifespan of the Proposed Development (based on the conservative lifespan used in the carbon calculator). Compared to fossil fuel electricity generation projects, which also produce embodied emissions during the construction phase and significant emissions during operation due to combustion of fossil fuels, the Proposed Development has a very low carbon footprint and after 1.9 years, the electricity generated is estimated to be carbon neutral and will displace grid electricity generated from fossil fuel sources. The site would, in effect, be in a net gain situation following this time period and will then be contributing to national objectives of reducing GHG emissions and meeting the 'net zero' carbon targets by 2050. Therefore, the Proposed Development is evaluated to have an overall beneficial effect on climate change.