Appendix 10-8: Garn Fach Wind Farm Carbon balance Assessment

Contents

1 Introduction

Wallingford HydroSolutions Ltd (WHS) has been commissioned by Dulas Ltd, on behalf of EDF Renewables, to complete a Carbon Balance Assessment for the proposed Garn Fach Wind Farm. This document forms an appendix to the Environmental Statement (ES) to accompany a planning application for a proposed 17 turbine windfarm to the south of Newtown, Powys, NGR: SO 03413 81467 covering an area of approximately 700ha.

This assessment has been completed using the latest version of the Scottish Government Carbon Calculator[1] tool in accordance with the associated guidance[2], which is used as standard throughout the UK. The Carbon Calculator determines the carbon emission savings and the carbon payback of wind farms and explores the potential implications under different scenarios of developments and assumptions about the site i.e. expected, best case and worst case scenarios. It discusses the potential carbon savings and carbon costs associated with the proposed development as follows:

- Carbon emission savings (based on emissions from different power sources);
- Loss of carbon due to production, transportation, erection, operation and decommissioning of the wind farm;
- Loss of carbon from backup power generation;
- Loss of carbon-fixing potential of peatland;
- Loss and/or saving of carbon stored in peatland (by peat removal or changes in drainage;
- Carbon saving due to improvement of habitat; and
- Loss and/or saving of carbon-fixing potential as a result of forestry clearance.

The methodology provides a balance of total carbon savings, including the impacts described above, and carbon losses over the life of the wind farm. It estimates the carbon payback time for the wind farm based on the source of power being displaced (i.e. the time needed to generate carbon savings equivalent to the amount of carbon lost). The raw data input to the online calculation tool is submitted as an Appendix to this report.

It should be noted that estimates of emissions from peat removal within the tool are uncertain as they depend upon assumptions made on the rate or loss or gain of carbon in Scottish Soils. There are also several values which are fixed within the model and based on historic datasets which may now be outdated. However, the SEPA Carbon Calculator estimation tool is widely used by regulators and is accepted as the best practice form for calculating carbon savings from wind farm development on peatlands.

2 Input Data

The data inputs for the online calculator tool have been extracted from the source listed below:

- Garn Fach Windfarm ES, Chapter 5, Project Description.
- Garn Fach Windfarm ES Phase 2 Peat Survey completed by WHS in November 2020 and March 2021.
- Construction information provided by Pell Fischmann and Dulas via email (May 2021, November 2021 and February 2023)
- Garn Fach Infrastructure Layout Shapefiles Named P7

Where site specific parameters were unavailable, default values suggested within the online guidance document were used along with professional judgement. A range of values for the required parameters were assessed to present a best and worst-case scenario. The expected values were used for all other input data. The input data can be seen in Appendix 1 (Ref: P9S8-U01G-3R34 v10).

3 Results

The model calculates carbon emission savings and losses from the various aspects of the model and also calculates a payback period based on the three counterfactual emission factors; coal fired plant, normal grid mix and fossil fuel mix as shown in Table 3-3. The counterfactual emission factors are fixed within the calculator tool, the values for coal-fired and fossil fuel-mix emission factors are based upon DUKES[3] data for the UK which is annually updated. The grid-mix emission factor is the list of emission factors used to report on 2016 greenhouse gas emissions as published by DECC[4].

This shows that even if the wind farm is replacing the normal fossil fuel sourced grid-mix of electricity generation, the proposed Garn Fach Wind Farm would produce a CO_2 saving of 112,584 tonnes per year.

Table 3-1: Estimate CO_2 emission savings

Windfarm CO2 emission saving over…	Expected values	Minimum Values	Maximum Values
Coal-fired electricity generation (t CO_2/yr)	261,131	246,209	276,053
Grid-mix of electricity generation (t CO_2/yr)	50,397	47,517	53,277
Fossil fuel-mix of electricity generation (t CO_2/yr)	112,584	106,150	119,017
Energy output from windfarm over lifetime (MWh)	7,818,300	7,371,540	8,265,060

Table 3-2 and Table 3-3 present the estimated losses and gains from the various aspects of the windfarm construction and operation. This shows that the improvement of degraded bogs will have a positive impact on carbon capture.

[1] Scottish Government Wind Farm developments on Peat Land: Carbon Calculator Tool v1.7.0 https://informatics.sepa.org.uk/CarbonCalculator/
[2] Calculating Carbon Savings from Wind Farms on Scottish Peatlands – A new Approach (Nayak et al., 2008; Nayak et al., 2010 and Smith et al., 2011).

[3] Department for Business, Energy & Industrial Strategy. Digest of UK Energy Statistics (DUKES), available via: https://www.gov.uk/government/collections/digest-of-uk-energy-statistics-dukes
[4] Department for Business, Energy & Industrial Strategy. Greenhouse gas reporting- Conversion factors 2016. Available via https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2016

Table 3-2: Estimated CO_2 losses

Total CO_2 losses due to wind farm (t CO_2 eq.)	Expected values	Minimum values	Maximum values
Losses due to turbine lies (e.g. manufacture, construction, decommissioning)	75,500	75,500	75,500
Losses due to backup	48,250	48,250	48,250
Losses due to reduced carbon fixing potential	999	293	6464
Losses from soil organic matter	16,870	2007	167333
Losses due to DOC & POC leaching	8	0	46
Losses due to felling forestry	721	673	773
Total losses of carbon dioxide	**142,348**	**126,723**	**298,366**

Table 3-3: Estimated CO_2 Gains

Total CO2 gains due to improvement of site (t CO_2 eq)	Expected values	Minimum values	Maximum values
Change in emissions due to improvement of degraded bogs	10,931	0	21,862
Change in emissions due to improvement of felled forestry	0	0	0
Change in emissions due to restoration of peat from borrow pits	-415	0	-585
Change in emissions due to removal of drainage from foundations and hardstanding	-4,266	0	-36,077
Total change in emissions due to improvements	**6250**	**0**	**-14,800**

Table 3-4 demonstrates that the net emissions of carbon dioxide are estimated at 136,098 tonnes of CO_2, with an estimate payback period of 1.2 to 2.8 years. Thus, the proposed Garn Fach Wind Farm will produce a reduction in emissions from grid electricity of around 112,584 tonnes of CO_2 per year (this assumes that the wind farm replaces grid electricity generated from a fossil fuel mix).

Over the 30-year lifetime of the proposed wind farm, 3,377520 tonnes of CO_2 will be by displacing a fossil fuel-mix electricity generation. Given the total net emissions of CO_2 due to the construction of the windfarm there will be a total net saving of 3,241422 tonnes of CO_2 over the lifetime of the wind farm.

Table 3-4: CO2 Emissions and Payback Time

Results	Expected Values	Minimum Values	Maximum Values
Net emissions of carbon dioxide (t CO_2 eq)	136,098	126,723	313,166
Carbon Payback Time			
…coal-fired electricity generation (years)	0.5	0.5	1.2
…grid-mix of electricity generation (years)	2.7	2.5	6.2
…fossil fuel-mix of electricity generation (years)	1.2	1.1	2.8

4 Conclusions

The results show that the proposed Garn Fach Wind Farm is likely to produce a certain amount of CO_2 emissions, primarily from the construction phase, where carbon rich soils are excavated to construct foundations, access tracks and other infrastructure, or where changes to the hydrology of the site cause some loss of carbon from soils. However, the calculations indicate that these losses would be paid back within approximately 1.2 years of operation, through the displacement of fossil fuel generated electricity in the National Grid. Over the lifetime of the development 3,377,520 tonnes of CO_2 are expected to be saved from the production of wind energy relative to fossil fuel-mix electricity generation.

Appendix 1 Carbon Calculator Input Data (P9S8-U01G-3R34 v10)

Carbon Calculator v1.7.0
Garn Fach Location: 52.422367 -3.42138
EDF

Core input data

Input data	Expected value	Minimum value	Maximum value	Source of data
Windfarm characteristics				
Dimensions				
No. of turbines	17	17	17	ES
Duration of consent (years)	30	30	30	ES
Performance				
Power rating of 1 turbine (MW)	5	5	5	ES
Capacity factor	35	33	37	ES
Backup				
Fraction of output to backup (%)	5	5	5	Dale et al 2004
Additional emissions due to reduced thermal efficiency of the reserve generation (%)	10	10	10	Fixed
Total CO_2 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	WHS Peat Survey Site visit
Average annual air temperature at site (°C)	9.2	5.2	13.2	https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/gcm95nm2h
Average depth of peat at site (m)	0.3	0.2	0.5	WHS Peat Survey Site Visit
C Content of dry peat (% by weight)	55.5	49	62	Birnie et al. 1991
Average extent of drainage around drainage features at site (m)	10	5	50	generic precautionary values
Average water table depth at site (m)	0.1	0.05	0.3	typical intact peat values
Dry soil bulk density (g cm^{-3})	0.2	0.15	0.25	Default value taken from Lilly et al., 2010

Input data	Expected value	Minimum value	Maximum value	Source of data
Characteristics of bog plants				
Time required for regeneration of bog plants after restoration (years)	10	10	15	Conservative estimate
Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha^{-1} yr^{-1})	0.25	0.12	0.31	default
Forestry Plantation Characteristics				
Area of forestry plantation to be felled (ha)	1.82	1.8	1.85	ES
Average rate of carbon sequestration in timber (tC ha^{-1} yr^{-1})	3.6	3.4	3.8	Default (Cannell, 1999)
Counterfactual emission factors				
Coal-fired plant emission factor (t CO_2 MWh^{-1})	1.002	1.002	1.002	
Grid-mix emission factor (t CO_2 MWh^{-1})	0.19338	0.19338	0.19338	
Fossil fuel-mix emission factor (t CO_2 MWh^{-1})	0.432	0.432	0.432	
Borrow pits				
Number of borrow pits	2	2	4	Dulas email 18/05/2021
Average length of pits (m)	34	28	40	Calculated from layout shapefiles
Average width of pits (m)	91	65	138	Calculated from layout shapefiles
Average depth of peat removed from pit (m)	0.095	0.045	0.29	Phase 1 and 2 peat visits- interpolated peat depths
Foundations and hard-standing area associated with each turbine				
Average length of turbine foundations (m)	7.5	7	8	P7 development area shapefiles provided by Dulas
Average width of turbine foundations (m)	15	14.5	15.5	P7 development area shapefiles provided by Dulas
Average depth of peat removed from	0.47	0.46	0.48	P7 development area shapefiles provided by Dulas

Input data	Expected value	Minimum value	Maximum value	Source of data
turbine foundations(m)				
Average length of hard-standing (m)	62	61.5	62.5	P7 development area shapefiles provided by Dulas
Average width of hard-standing (m)	25	24.5	25.5	P7 development area shapefiles provided by Dulas
Average depth of peat removed from hard-standing (m)	0.47	0.46	0.48	P7 development area shapefiles provided by Dulas
Volume of concrete used in construction of the ENTIRE windfarm				
Volume of concrete (m^3)	12750	12750	12750	Email from Pell Frischmann dated 20/05/2021
Access tracks				
Total length of access track (m)	12366	12363	12369	Email from Dulas on 16/11/2021
Existing track length (m)	3163	3162	3164	Email from Pell Frischmann on 23/02/2023
Length of access track that is floating road (m)	3120	3119	3121	Email from Pell Frischmann on 23/02/2023
Floating road width (m)	5	5	5	Email from Pell Frischmann on 23/02/2023
Floating road depth (m)	0.5	0.499	0.501	Email from Pell Frischmann on 23/02/2023
Length of floating road that is drained (m)	0	0	0	NA
Average depth of drains associated with floating roads (m)	0	0	0	NA
Length of access track that is excavated road (m)	6083	6082	6084	Email from Dulas on 16/11/2021
Excavated road width (m)	7	5	15	Average estimated from drawing of earthworks footprint
Average depth of peat excavated for road (m)	0.4	0.1	1	Phase 2 peat survey by WHS
Length of access track that is rock filled road (m)	0	0	0	all tracks assumed to be excavated or floating
Rock filled road width (m)	5	5	5	all tracks assumed to be excavated or floating
Rock filled road depth (m)	0	0	0	all tracks assumed to be excavated or floating
Length of rock filled road that is drained (m)	0	0	0	all tracks assumed to be excavated or floating

Input data	Expected value	Minimum value	Maximum value	Source of data
Average depth of drains associated with rock filled roads (m)	0	0	0	all tracks assumed to be excavated or floating
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)	2747	2746	2748	Calculated from Phase 2 Peat survey and infrastructure footprint shapefiles
Area of additional peat excavated (m^2)	5464	5463	5465	Calculated from Phase 2 Peat survey and infrastructure footprint shapefiles
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)	31.5934	0	31.5934	According to indicative bunded areas
Water table depth in degraded bog before improvement (m)	0.3	0.1	0.5	typical degraded peat values
Water table depth in degraded bog after improvement (m)	0.1	0.05	0.3	typical intact peat values
Time required for hydrology and habitat of bog to return to its previous state on	10	5	15	estimated by hydrologist

Input data	Expected value	Minimum value	Maximum value	Source of data
improvement (years)				
Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years)	20	15	25	wind farm lifetime minus time for improvement
Improvement of felled plantation land				
Area of felled plantation to be improved (ha)	0	0	0	Currently unspecified
Water table depth in felled area before improvement (m)	0.3	0.1	0.5	typical degraded peat values
Water table depth in felled area after improvement (m)	0.1	0.05	0.3	typical intact peat values
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)	10	5	15	estimated by hydrologist
Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years)	20	15	25	wind farm lifetime minus time for improvement
Restoration of peat removed from borrow pits				
Area of borrow pits to be restored (ha)	0.6	0.55	0.65	Email from Dulas indicating 2x borrow pits to be restored
Depth of water table in borrow pit before restoration with respect to the restored surface (m)	0.3	0.1	0.5	typical degraded peat values
Depth of water table in borrow pit after restoration with respect to the restored surface (m)	0.1	0.05	0.3	typical intact peat values
Time required for hydrology and	5	2	10	estimated by hydrologist

Input data	Expected value	Minimum value	Maximum value	Source of data
habitat of borrow pit to return to its previous state on restoration (years)				
Period of time when effectiveness of the restoration of peat removed from borrow pits can be guaranteed (years)	25	20	28	Wind farm lifetime minus time for improvement
Early removal of drainage from foundations and hardstanding				
Water table depth around foundations and hardstanding before restoration (m)	0.3	0.1	0.5	typical degraded peat values
Water table depth around foundations and hardstanding after restoration (m)	0.1	0.05	0.3	typical intact peat values
Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)	2	1	5	estimated by hydrologist
Restoration of site after decomissioning				
Will the hydrology of the site be restored on decommissioning?	No	No	No	
Will you attempt to block any gullies that have formed due to the windfarm?	No	No	No	Currently unspecified
Will you attempt to block all artificial ditches and facilitate rewetting?	Yes	Yes	Yes	Assumed
Will the habitat of the site be restored on decommissioning?	No	No	No	
Will you control grazing on	No	No	No	Currently unspecified

Input data	Expected value	Minimum value	Maximum value	Source of data
degraded areas?				
Will you manage areas to favour reintroduction of species	Yes	Yes	Yes	Assumed
Methodology				
Choice of methodology for calculating emission factors	IPCC default			

Forestry input data

N/A

Construction input data

N/A

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