Bute Energy

Aberedw Energy Park

Appendix 2.8:

Carbon Balance Assessment

Aberedw Energy Park Limited

Aberedw Energy Park Environmental Statement

Appendix 2.8: Carbon Balance Assessment

Prepared by LUC
June 2025

Aberedw Energy Park Limited

Aberedw Energy Park Environmental Statement

Appendix 2.8: Carbon Balance Assessment

Bristol
Cardiff
Edinburgh
Glasgow
London
Manchester
Sheffield

landuse.co.uk

Land Use Consultants Ltd
Registered in England
Registered number 2549296
Registered office:
250 Waterloo Road
London SE1 8RD

Contents

1. Introduction

1.1 Introduction

1.1.1 Global atmospheric concentrations of greenhouse gas (GHG) emissions, such as carbon dioxide (CO_2) are increasing and resulting in global warming and catastrophic changes to the climate. Burning fossil fuels, such as coal, oil and gas for energy or electricity generation is a major contributor to the increase in GHG emissions, with gas accounting for 38% of the UK's electricity mix as of January 2025[1]. Therefore, the UK and Welsh Governments have plans to achieve net zero emissions by 2050[2][3], with the aim of replacing traditional fossil fuel power generation with renewable energy sources, such as onshore wind. As such, renewable generation accounted for 50.8% of the UK's total energy generation in 2024[4].

1.1.2 However, no form of electricity generation is completely carbon free. For onshore wind farms, there will be emissions resulting from the manufacturing of turbines, as well as emissions from both construction and decommissioning activities and transport. Additional emissions can result from the displacement of carbon stores, such as peat bogs or the removal of sequestering activities, such as forestry. The carbon losses and gains during the construction and operation of a wind farm, and the long-term impacts on the locations on which they are sited, need to be evaluated to understand the consequences of permitting such developments.

1.1.3 In the case of the Proposed Development, peat probing was carried out across the Site in accordance with the Scottish Government's Guidance on Developments on Peatland in the absence of equivalent guidance in Wales. This survey demonstrated that there are no areas of peat or forestry on the Site. Therefore, the Site will have limited impact on carbon stores.

1.1.4 This Carbon Balance Assessment (CBA) has been carried out by Land Use Consultants (LUC) on behalf of the Applicant for the proposed Aberedw Energy Park, hereafter referred to as the "Proposed Development". The aim of the CBA is to provide clear information about the whole life carbon balance of the Proposed Development and provide an estimate of the expected net carbon savings over the lifetime of the Proposed Development, once carbon losses from materials and ecological disturbance have been considered.

1.1.5 As there is currently no specific methodology for undertaking a CBA for wind farms in Wales, this Appendix has been informed by the use of the Scottish Government Windfarm Carbon Assessment Tool (V2.14.1) to estimate the carbon emissions savings associated with the Proposed Development. Use of this excel spreadsheet enables calculation of the overall benefit of renewable electricity generation in a consistent and comprehensive manner.

1.1.6 At the time of carrying out this assessment, the Scottish Government's online Carbon Calculator Tool is currently unavailable from the Scottish Government website. Therefore, the original carbon calculator tool that was developed in excel was used instead as there is currently no alternative. However, it should be noted that the excel tool does not replicate the functionality of the online tool due to differences in the precision of certain data and is therefore likely to be less accurate. As such, the assessment will be updated accordingly, if and when the online tool becomes available.

1.2 Input Data

1.2.1 The carbon balance tool requires a range of indicators to be input including number of turbines, length of access roads, depth of peat, area of woodland to be felled and restoration activities. Input data has been obtained from the work of other consultants where possible or a best estimate using professional judgement where site specific data was not available (**Table 1.1**).

1.2.2 The fraction of backup generation has been assumed to be 5% in line with the guidance from the Scottish Government under the assumption that more than 20% of national electricity is generated by wind energy.

[1] https://www.edenseven.co.uk/britain-electricity-analysis-january-2025
[2] https://commonslibrary.parliament.uk/research-briefings/cbp-9888/
[3] Net Zero Wales: Second Carbon Budget 2021-2025, available at: https://www.gov.wales/net-zero-wales-carbon-budget-2
[4] https://assets.publishing.service.gov.uk/media/67e4f62cf356a2dc0e39b522/Energy_Trends_March_2025.pdf

1.2.3 The input data is provided in the form of a central estimated value and a maximum and minimum value. Where the maximum and minimum values are known, these are included, where these are not known, reasonable worst- and best-case figures are used.

Table 1.1 Input parameters used in the Carbon Calculator

Input Data	Expected	Minimum	Maximum	Source of Data
Windfarm Characteristics				
Dimensions				
Number of turbines	18	18	18	ES Volume 1, Chapter 1: Introduction.
Duration of Consent	40	40	40	ES Volume 1, Chapter 1: Introduction.
Performance				
Power rating of turbine (MW)	6.7	6.7	6.7	Fixed.
Capacity Factor	34.6	34.6	34.6	Fixed.
Backup				
Extra capacity required for backup (%)	5	5	5	Standard value set under the assumption that more than 20% of national electricity is generated by wind energy. The National Grid reported that in 2023 wind power contributed 29.4% of the UK's total electricity generation.
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}) (e.g. manufacture, construction, decommissioning)	Calculate with reference to installed capacity	Calculate with reference to installed capacity	Calculate with reference to installed capacity	N/A
Characteristics of peatland before Windfarm Development				
Type of peatland	Acid bog	Acid bog	Acid bog	Site Survey carried out in March 2025.
Average annual air temperature at site (°C)	9.435	5.94	12.93	Met Office UK climate average data from Llandrindod Wells climate station.
Average depth of peat at site (m)	0	0	0	ES Volume 1, Chapter 9. No peat present on Site.
C Content of dry peat (% by weight)	0	0	0	ES Volume 1, Chapter 9. No peat present on Site.
Average extent of drainage around drainage features at site (m)	0.01	0.01	0.01	ES Volume 1, Chapter 9. No drainage features within the Site.
Average water table depth at site (m)	3	0.5	5	Assumption based on professional judgement. No site specific data on water table depth.

Input Data	Expected	Minimum	Maximum	Source of Data
dry soil bulk density (g cm-3)	1.8	1.7	2.2	Assumption based on literature[5]. Soil across the Site is mostly organic rich loam
Characteristics of Bog Plants				
Time required for regeneration of bog plants after restoration (years)	15	10	20	Standard figure
Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha-1 yr-1)	0.25	0.12	0.31	Standard figure
Forestry Plantation Characteristics				
Area of forestry plantation to be felled (ha)	0	0	0	No plantation forestry to be felled
Average rate of carbon sequestration in timber (tC ha-1 yr-1)	3.6	3.5	3.7	Standard value
Counterfactual Emission Factors				
Coal-fired plant emission factor (tCO2 MWh-1)	1.002	1.002	1.002	Fixed.
Grid-mix emission factor (tCO2 MWh-1)	0.19338	0.19338	0.19338	Fixed.
Fossil fuel-mix emission factor (tCO2 MWh-1)	0.432	0.432	0.432	Fixed.
Borrow Pits				
Number of borrow pits	2	2	2	ES Volume 1, Chapter 4: Project Description
Average length of pits (m)	264.5	235	294	ES Volume 2, Chapter 4 figures
Average width of pits (m)	137.5	105	170	ES Volume 2, Chapter 4 figures
Average depth of peat removed from pit (m)	0	0	0	ES chapter 9. No peat present on Site.
Foundations and Hardstanding Area Associated with Each Turbine				
Average length of turbine foundations (m)	25	25	25	Fixed. ES Volume 2, Figure 4.3
Average width of turbine foundations (m)	25	25	25	Fixed. ES Volume 2, Figure 4.4
Average depth of peat removed from turbine foundations(m)	0	0	0	No turbines are placed on peat.
Average length of hard-standing (m)	204	204	204	Fixed – including crane hardstanding area.
Average width of hard-standing (m)	71	71	71	Fixed – including crane hardstanding

[5] Carter M & Bentley, SP 2016. Soil properties and their correlations 2nd edition. Wiley

Input Data	Expected	Minimum	Maximum	Source of Data
Average depth of peat removed from hard-standing (m)	0	0	0	No turbines are placed on peat.
Access Tracks				
Total length of access track (m)	13347	13347	13347	Fixed.
Existing track length (m)	1691	1691	1691	Fixed.
Length of access track that is floating road (m)	0	0	0	No floating road.
Floating road width (m)	0	0	0	No floating road.
Floating road depth (m)	0	0	0	No floating road.
Length of floating road that is drained (m)	0	0	0	No floating road.
Average depth of drains associated with floating roads (m)	0	0	0	No floating road.
Length of access track that is excavated road (m)	0	0	0	No excavated road on peat
Excavated road width (m)	0	0	0	No excavated road on peat
Average depth of peat excavated for road (m)	0	0	0	No excavated road on peat
Length of access track that is rock filled road (m)	15,038	15,038	15,038	Fixed.
Rock filled road width (m)	6	6	6	Informed by Principal Designer.
Rock filled road depth (m)	0.5	0.5	0.5	Informed by Principal Designer.
Length of rock filled road that is drained (m)	15,038	15038	15,038	Informed by Principal Designer.
Average depth of drains associated with rock filled roads (m)	0.2	0.2	0.2	Informed by Principal Designer.
Cable Trenches				
Length of any cable trench on peat that does not follow access tracks and is lined with a permeable medium (e.g. sand) (m)	0	0	0	ES Chapter 9. No peat present on Site.
Average depth of peat cut for cable trenches (m)	0	0	0	ES Chapter 9. No peat present on Site.
Additional Peat Excavated				
Volume of additional peat excavated (m3)	0	0	0	ES Chapter 9. No peat present on Site.
Area of additional peat excavated (m2)	0	0	0	ES Chapter 9. No peat present on Site.
Peat Landslide Hazard				

Input Data	Expected	Minimum	Maximum	Source of Data
Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments	None	None	None	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	0	0	No improvement to degraded bog proposed.
Water table depth in degraded bog before improvement (m)	0	0	0	No improvement to degraded bog proposed.
Water table depth in degraded bog after improvement (m)	0	0	0	No improvement to degraded bog proposed.
Time required for hydrology and habitat of bog to return to its previous state on improvement (years)	0	0	0	No improvement to degraded bog proposed.
Period when effectiveness of the improvement in degraded bog can be guaranteed (years)	0	0	0	No improvement to degraded bog proposed.
Improvement of Felled Plantation Land				
Area of felled plantation to be improved (ha)	0	0	0	No improvement of felled plantation proposed.
Water table depth in felled area before improvement (m)	0	0	0	No improvement of felled plantation proposed.
Water table depth in felled area after improvement (m)	0	0	0	No improvement of felled plantation proposed.
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)	0	0	0	No improvement of felled plantation proposed.
Period when effectiveness of the improvement in felled plantation can be guaranteed (years)	0	0	0	No improvement of felled plantation proposed.
Restoration of Peat Removed from Borrow Pits				
Area of borrow pits to be restored (ha)	0	0	0	No peat to be removed from borrow pits
Depth of water table in borrow pit before restoration with respect to the restored surface (m)	0	0	0	No peat to be removed from borrow pits
Depth of water table in borrow pit after restoration with respect to the restored surface (m)	0	0	0	No peat to be removed from borrow pits
Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years)	0	0	0	No peat to be removed from borrow pits

Input Data	Expected	Minimum	Maximum	Source of Data
Period of time when effectiveness of the restoration of peat removed from borrow pits can be guaranteed (years)	0	0	0	No peat to be removed from borrow pits
Early Removal of Drainage from Foundations and Hardstanding				
Water table depth around foundations and hardstanding before restoration (m)	3	0.5	5	Assumption based on professional judgement. No site specific data on water table depth.
Water table depth around foundations and hardstanding after restoration (m)	3	0.5	5	No change expected to water table depth. .
Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)	5	3	5	Represents the construction period plus “establishment period” to allow the vegetation to regenerate following end of construction.
Restoration of Site after Decommissioning				
Will you attempt to block any gullies that have formed due to the windfarm?	N/A	N/A	N/A	ES chapter 9. No peat present on Site.
Will you attempt to block all artificial ditches and facilitate rewetting?	No	No	No	ES Chapter 9. Ditches associated with the tracks are unlikely to be blocked, as the Decommissioning Plan assumes tracks will stay in place. There will be no other artificial ditches installed as part of the Proposed Development.
Will you control grazing on degraded areas?	No	No	No	ES Chapter 7. The majority of the Site is on Common land where grazing management is not permitted.
Will you manage areas to favour reintroduction of species?	No	No	No	ES Chapter 7.
Methodology				
Choice of methodology for calculating emission factors	Site specific			As required for planning applications.

1.3 Results of Carbon Balance Assessment

1.3.1 The results from the Carbon Balance Assessment are set out in **Tables 1.2**, **1.3, 1.4,** and **1.5**. Carbon emissions savings and losses from the various aspects of the model allow a calculation of a payback period based on the three counterfactual emission factors: coal-fired plant, normal grid-mix and fossil fuel-mix.

1.3.2 **Table 1.2** details the expected windfarm CO_2 emissions savings over alternative energy generation sources.

1.3.3 **Table 1.3** details the total CO_2 losses due to the Proposed Development. **Table 1.4** details the total gains in CO_2 sequestration due to improvement of the site and the net emissions of CO_2. **Table 1.5** details the payback time for the Proposed Development. The calculation takes into account the predicted direct and indirect emissions of carbon resulting from the construction and operation of the Proposed Development over its 40-year operation lifetime for which it has been designed.

Table 1.2 Estimated CO_2 savings

Windfarm CO_2 emission savings over…	Expected	Minimum	Maximum
Coal-fired electricity generation (tCO_2/yr)	813,922	813,922	813,922
Grid-mix of electricity generation (tCO_2/yr)	157,082	157,082	157,082
Fossil fuel-mix of electricity generation (tCO_2/yr)	350,912	350,912	350,912
Energy output from windfarm over lifetime (MWh)	20,307,432	20,307,432	20,307,432

Table 1.3 Estimated CO_2 losses

Total CO_2 losses due to windfarm (tCO_2 eq.)	Expected	Minimum	Maximum
Losses due to turbine life (e.g. manufacture, construction, decommissioning)	232,159	232,159	232,159
Losses due to backup	126,775	126,775	126,775
Losses due to reduced carbon fixing potential	2,724	1,076	3,940
Losses from soil organic matter	-71,387	-68,416	-55,533
Losses due to DOC and POC leaching	0	0	0
Losses due to felling forestry	0	0	0
Total losses of carbon dioxide	290,271	291,593	307,340

Table 1.4 Estimated CO^2 gains

Total CO_2 gains due to improvement of Site (tCO_2 eq.)	Expected	Minimum	Maximum
Change in emissions due to improvement of degraded bogs	0	0	0
Change in emissions due to improvement of felled forestry	0	0	0
Change in emissions due to restoration of peat from borrow pits	0	0	0
Change in emissions due to removal of drainage from foundations and hardstanding	0	0	4
Total change in emissions due to improvements	0	0	4

Table 1.5 CO_2 emissions and payback time

Results	Expected	Minimum	Maximum
Net emissions of CO_2 (tCO_2 eq.)	290,271	291,597	307,340
Carbon Payback Time			
Coal-fired electricity generation (years)	0.4	0.4	0.4
Grid-mixed of electricity generation (years)	1.8	1.9	2
Fossil fuel-mix of electricity generation (years)	0.8	0.8	0.9

1.4 Summary

1.4.1 The results show that the Proposed Development is likely to produce a certain amount of CO_2 emissions, mainly from the construction phase of the turbines, access tracks and other infrastructure.=. The calculations however indicated that these losses would be paid back within approximately 0.8 years of operation, through the displacement of a fossil fuel-mix of electricity generation in the National Grid.