Galileo 03 Ltd.

Mynydd Ty-talwyn Energy Park - Environmental Statement Volume III

Appendix 14.1: Carbon Assessment Tool

Project Reference: 663870

NOVEMBER 2025

APPENDIX 14.1: CARBON ASSESSMENT TOOL

14.1.1 This report has been prepared by Nature Positive on behalf of Galileo 03 Ltd (part of Galileo Empower UK Ltd) (hereinafter referred to as 'Galileo' or the 'Applicant').

14.2 Methodology

14.2.1 This assessment utilises the Scottish Government Carbon Assessment Tool (version 2.14.1), which is based upon the work of Nayak et al. (2008, 2010) and Smith et al. (2011)[1]. The latest online version of the Scottish Government Carbon Calculator Tool (version 1.8.1) was unavailable during the course of this assessment while undergoing maintenance and a server upgrade. Version 2.14.1 of the Calculator was provided as an Excel spreadsheet calculator by the Scottish Government's Energy Consents Unit as a suitable alternative. As there is no Welsh tool, while the tool is distributed by the Scottish Government, it is an industry recognised approach to determine the carbon emissions associated with wind farm developments.

14.2.2 The Carbon Assessment Tool adopts a lifecycle methodology approach to estimate the greenhouse gas (GHG) emissions and savings associated with proposed renewable energy developments. It calculates the anticipated effects of the Proposed Development on peat and forestry habitats, and subsequent implications for GHG emissions. The Carbon Assessment Tool also accounts for the emissions associated with the construction and decommissioning of the Proposed Development, as well as the emissions savings from operation.

Embodied Emissions

14.2.3 GHG emissions from proposed infrastructure fabrication are based on a full lifecycle analysis of typical infrastructure components. This includes GHG emissions resulting from material production, transportation, erection, operation, dismantling and removal, and from foundations and transmission grid connection equipment to the existing electricity grid system. As the Scottish Government Carbon Assessment Tool does not account for the embodied emissions of solar photovoltaic (PV) by standard, a supplementary analysis of these components was carried out and integrated into the outputs of the tool.

Losses Due to Back-up

14.2.4 Due to the inherent variability of electricity generated from renewable energy sources, it is recognised that conventional generation facilities are required to stabilise supply. Nayak *et al*. (2008) refers to *"backup power generation"* and identifies that the balancing capacity (as referred to henceforth) required is estimated as 5 % of the

[1] Smith, J.U., Graves, P., Nayak, D.R., Smith, P., Perks, M., Gardiner, B., Miller, D., Nolan, A., Morrice, J., Xenakis, G., Waldron, S., and Drew, S. (2011) Carbon implications of windfarms located on peatlands – Update of the Scottish Government Carbon Assessment tool. Final Report, RERAD Report CR/2010/05.

rated capacity of the wind farm. It is also stated that balancing capacity is only necessary where wind power contributes more than 20 % to the national grid.

14.2.5 It is assumed that the balancing capacity is from fossil fuels and that where such power is required, there will be additional emissions of 10 % due to reduced thermal efficiency of the reserve generation. This value is the recommended default through the Carbon Assessment tool, sourced from Dale et al (2004).

Power Rating and Capacity Factors

14.2.6 The values assigned as the minimum and maximum for estimated capacity factor were based on the measured values specific to the power rating of the turbines as listed. This results in a situation where the capacity factor associated with the maximum turbine power rating is lower than the capacity factor associated with the minimum turbine power rating. This has not been done in error and is based on the output of modelling exercises carried out on-site.

14.3 Input Data

14.3.1 A variety of data sources have been utilised to compile the input data needed for the Scottish Government's Carbon Assessment Tool. Infrastructure design and site-specific data have been used wherever possible; however, where not available, standard (default) data or estimates have been applied. These are detailed below in **Table 14.1.1**. To reflect design and real-world uncertainty, a range of +/- 10 % has been applied to relevant categories.

Table 14.1.1 Input Parameter Data for the Scottish Government's Carbon Assessment Tool

Scottish Government Wind Farm Carbon Assessment Tool – v 2.14.1				
Input Data	**Expected Value**	**Minimum Value**	**Maximum Value**	**Source of Data**
Wind Farm Characteristic				
Dimensions				
No. of turbines	6	6	6	**ES Volume II, Chapter 2: Proposed Development Description**
Duration of consent (years)	50	50	50	**ES Volume II, Chapter 2: Proposed Development Description**
Performance				
Power rating of 1 turbine (MW)	6	6	6	**ES Volume II, Chapter 2:**

Scottish Government Wind Farm Carbon Assessment Tool – v 2.14.1				
Input Data	**Expected Value**	**Minimum Value**	**Maximum Value**	**Source of Data**
				Proposed Development Description (assuming the most conservative scenario of Nordex 163 turbines)
Capacity factor (%)	37.7	33.9	41.5	Applicant, derived through on-site wind monitoring
Backup				
Fraction of output to backup (%)	5	5	5	Default value of the carbon calculator
Additional emissions due to reduced thermal efficiency of the reserve generation (%)	10	10	10	Default value of carbon calculator - (Dale et al 2004)
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	
Characteristics of Peatland Before Wind Farm Development				
Type of peatland	Acid bog	Acid bog	Acid bog	Peat Specialist (**ES Volume III, Appendix 5.3: Depth of Penetration Survey Report** and **ES Volume III, Appendix 5.4: Outline Soil Management Plan**)
Average annual air temperature at Site (°C)	10.87	7.79	13.95	Met office weather station: St Athan
Average depth of peat at Site (m)	0.15	0	0.30	Peat Specialist (**ES Volume III, Appendix 5.3: Depth of Penetration Survey Report** and **ES Volume III, Appendix 5.4:**

Scottish Government Wind Farm Carbon Assessment Tool – v 2.14.1				
Input Data	**Expected Value**	**Minimum Value**	**Maximum Value**	**Source of Data**
				Outline Soil Management Plan)
Content of dry peat (% by weight)	55	49	61	Default value of carbon calculator - (Birnie et al 1991)
Average extent of drainage around drainage features at Site (m)	0.75	0.5	1.0	Benchmarked based on comparable Welsh development
Average water table depth at Site (m)	0.24	0.03	0.45	Default value of carbon calculator - (Allott et al. 2009)
Dry soil bulk density (g cm^{-3})	0.2	0.18	0.22	Default value of carbon calculator - (Lilly et al 2010)
Characteristics of Bog Plants				
Time required for regeneration of bog plants after restoration (years)	0	0	0	Peat Specialist (**ES Volume III, Appendix 5.3: Depth of Penetration Survey Report** and **ES Volume III, Appendix 5.4: Outline Soil Management Plan**)
Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha^{-1} yr^{-1})	0	0	0	Peat Specialist (**ES Volume III, Appendix 5.3: Depth of Penetration Survey Report** and **ES Volume III, Appendix 5.4: Outline Soil Management Plan**)
Forestry Plantation Characteristics				
Area of forestry plantation to be felled (ha)	0	0	0	No forestry present to be felled
Average rate of carbon sequestration in timber (tC ha^{-1} yr^{-1})	0	0	0	Default value
Counterfactual Emission Factors				

Scottish Government Wind Farm Carbon Assessment Tool – v 2.14.1				
Input Data	**Expected Value**	**Minimum Value**	**Maximum Value**	**Source of Data**
Coal-fired plant emission factor (t CO_2 MWh^{-1})	0.945	0.945	0.945	Default value (Scottish Government Carbon Calculator)
Grid-mix emission factor (t CO_2 MWh^{-1})	0.207	0.207	0.207	Default value (Scottish Government Carbon Calculator)
Fossil fuel-mix emission factor (t CO_2 MWh^{-1})	0.424	0.424	0.424	Default value (Scottish Government Carbon Calculator)
Borrow Pits				
Number of borrow pits	0	0	0	No borrow pits proposed
Average length of pits (m)	0	0	0	No borrow pits proposed
Average width of pits (m)	0	0	0	No borrow pits proposed
Average depth of peat removed from pit (m)	0	0	0	No borrow pits proposed
Foundations and Hardstanding Area Associated with Each Turbine				
Shape (circular/octagonal/ hexagonal)	Circular			Infrastructure design and aggregate estimates
Diameter/side at surface (m)	12	10.8	13.2	Infrastructure design and aggregate estimates
Diameter/side at bottom (m)	25	22.5	27.5	Infrastructure design and aggregate estimates
Average depth of peat removed from turbine foundations (m)	0	0	0	Peat Specialist (**ES Volume III, Appendix 5.3: Depth of Penetration Survey Report** and **ES Volume III, Appendix 5.4: Outline Soil Management Plan**)

Scottish Government Wind Farm Carbon Assessment Tool – v 2.14.1				
Input Data	**Expected Value**	**Minimum Value**	**Maximum Value**	**Source of Data**
Average length of hard-standing at surface (m)	230	207	253	Infrastructure design and aggregate estimates
Average length of hard-standing at bottom (m)	61.5	55.35	67.65	Infrastructure design and aggregate estimates
Average width of hard-standing at surface (m)	230	207	253	Infrastructure design and aggregate estimates
Average width of hard-standing at bottom (m)	61.5	55.35	67.65	Infrastructure design and aggregate estimates
Average depth of peat excavated when constructing hard-standing (m)	0	0	0	Peat Specialist (**ES Volume III, Appendix 5.3: Depth of Penetration Survey Report** and **ES Volume III, Appendix 5.4: Outline Soil Management Plan**)
Is piling used? (Yes/No)	No			Infrastructure design and aggregate estimates
Volume of concrete used in construction of the entire wind farm (m^3)	7,440	6,696	8,184	Infrastructure design and aggregate estimates
Access Tracks				
Total length of access track (m)	11,554	10,399	12,709	Infrastructure design and aggregate estimates
Existing track length (m)	3,499	3,149	3,849	Infrastructure design and aggregate estimates
Length of access track that is floating road (m)	0	0	0	Infrastructure design and aggregate estimates
Width of access track that is floating road (m)	0	0	0	Infrastructure design and aggregate estimates

Scottish Government Wind Farm Carbon Assessment Tool – v 2.14.1				
Input Data	**Expected Value**	**Minimum Value**	**Maximum Value**	**Source of Data**
Floating road depth (m)	0	0	0	Infrastructure design and aggregate estimates
Length of floating road that is drained (m)	0	0	0	Infrastructure design and aggregate estimates
Average depth of drains associated with floating roads (m)	0	0	0	Infrastructure design and aggregate estimates
Length of access track that is excavated road (m)	0	0	0	Infrastructure design and aggregate estimates
Excavated road width (m)	0	0	0	Infrastructure design and aggregate estimates
Average depth of peat excavated for road (m)	0	0	0	Peat Specialist (**ES Volume III, Appendix 5.3: Depth of Penetration Survey Report** and **ES Volume III, Appendix 5.4: Outline Soil Management Plan**)
Length of access track that is rock filled road (m)	8,055	7,250	8,861	Infrastructure design and aggregate estimates
Rock filled road width (m)	6	5.4	6.6	Infrastructure design and aggregate estimates
Rock filled road depth (m)	0.5	0.45	0.55	Infrastructure design and aggregate estimates
Length of rock filled road that is drained (m)	8,055	7,250	8,861	Infrastructure design and aggregate estimates
Average depth of drains associated with rock filled roads (m)	0.2	0.18	0.22	Infrastructure design and aggregate estimates
Cable Trenches				

Scottish Government Wind Farm Carbon Assessment Tool – v 2.14.1				
Input Data	**Expected Value**	**Minimum Value**	**Maximum Value**	**Source of Data**
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	Peat Specialist (**ES Volume III, Appendix 5.3: Depth of Penetration Survey Report** and **ES Volume III, Appendix 5.4: Outline Soil Management Plan**)
Average depth of peat cut for cable trenches (m)	0	0	0	Peat Specialist (**ES Volume III, Appendix 5.3: Depth of Penetration Survey Report** and **ES Volume III, Appendix 5.4: Outline Soil Management Plan**)
Additional Peat Excavated (Not already accounted for above)				
Volume of additional peat excavated (m^3)	0	0	0	Peat Specialist (**ES Volume III, Appendix 5.3: Depth of Penetration Survey Report** and **ES Volume III, Appendix 5.4: Outline Soil Management Plan**)
Area of additional peat excavated (m^2)	0	0	0	Peat Specialist (**ES Volume III, Appendix 5.3: Depth of Penetration Survey Report** and **ES Volume III, Appendix 5.4: Outline Soil Management Plan**)
Peat Landslide Hazard				
Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed	Negligible	Negligible	Negligible	Peat Specialist (**ES Volume III, Appendix 5.3:**

Scottish Government Wind Farm Carbon Assessment Tool – v 2.14.1				
Input Data	**Expected Value**	**Minimum Value**	**Maximum Value**	**Source of Data**
Electricity Generation Developments				**Depth of Penetration Survey Report** and **ES Volume III, Appendix 5.4: Outline Soil Management Plan**)
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	N/A
Water table depth in degraded bog before improvement (m)	0	0	0	N/A
Water table depth in degraded bog after improvement (m)	0	0	0	N/A
Time required for hydrology and habitat of bog to return to its previous state on improvement (years)	0	0	0	N/A
Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years)	0	0	0	N/A
Improvement of Felled Plantation Land				
Area of felled plantation to be improved (ha)	0	0	0	No forestry present to be felled
Water table depth in felled area before improvement (m)	0	0	0	No forestry present to be felled
Water table depth in felled area after improvement (m)	0	0	0	No forestry present to be felled
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)	0	0	0	No forestry present to be felled
Period of time when effectiveness of the improvement in felled	0	0	0	No forestry present to be felled

Scottish Government Wind Farm Carbon Assessment Tool – v 2.14.1				
Input Data	**Expected Value**	**Minimum Value**	**Maximum Value**	**Source of Data**
plantation can be guaranteed (years)				
Restoration of Peat Removed from Borrow Pits				
Area of borrow pits to be restored (ha)	0	0	0	No borrow pits
Depth of water table in borrow pit before restoration with respect to the restored surface (m)	0	0	0	No borrow pits
Depth of water table in borrow pit after restoration with respect to the restored surface (m)	0	0	0	No borrow pits
Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years)	0	0	0	No borrow pits
Period of time when effectiveness of the restoration of peat removed from borrow pits can be guaranteed (years)	0	0	0	No borrow pits
Early Removal of Drainage from Foundations and Hardstanding				
Water table depth around foundations and hard standing before restoration (m)	0.5	0.3	0.8	Benchmarked based on comparable Welsh development
Water table depth around foundation and hard standing after restoration (m)	0.3	0.2	0.5	Benchmarked based on comparable Welsh development
Time to completion of backfilling, removal of any surface drains, and full restoration of hydrology (years)	5.0	2.0	5.0	Benchmarked based on comparable Welsh development
Early Removal of Drainage from Foundations and Hardstanding				
Will you attempt to block any gullies that have formed due to the wind farm?	No	No	No	Applicant
Will you attempt to block all artificial ditches and facilitate rewetting?	Not applicable	Not applicable	Not applicable	Applicant

Scottish Government Wind Farm Carbon Assessment Tool – v 2.14.1				
Input Data	**Expected Value**	**Minimum Value**	**Maximum Value**	**Source of Data**
Will you control grazing on degraded areas?	No	No	No	Applicant
Will you manage areas to favour reintroduction of species	Yes	Yes	Yes	Applicant
Methodology				
Choice of methodology for calculating emission factors	Site specific (required for planning applications)			

14.4 Output Data

14.4.1 The Output data from the Scottish Government Carbon Assessment Tool is provided in a tabular format which allows the results to be broken down and interrogated closely. This provides an estimate of the benefit of displacing conventionally generated electricity in the grid compared to the predicted direct and indirect emissions of carbon resulting from the construction, operation, and decommissioning of the Proposed Development over its 50 year lifespan.

14.4.2 Carbon emission 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.

Table 14.1.2 Output Data for the Scottish Government's Carbon Assessment Tool

Output Data	Expected Value	Minimum Value	Maximum Value
1a. Wind Farm CO_2 Emission Saving over...			
...coal-fired electricity generation (t CO_2 / year)	112,352	101,117	123,587
...grid-mix of electricity generation (t CO_2 / year)	24,610	22,149	27,071
...fossil fuel-mix of electricity generation (t CO_2 / year)	50,410	45,369	55,451
Energy output from wind farm over lifetime (MWh)	5,944,536	5,350,082	6,538,990

Output Data	Expected Value	Minimum Value	Maximum Value
1b. Solar CO_2 Emission Saving over...			
...coal-fired electricity generation (t CO_2 / year)	57,654	51,889	63,420
...grid-mix of electricity generation (t CO_2 / year)	12,629	11,366	13,892
...fossil fuel-mix of electricity generation (t CO_2 / year)	25,868	23,281	28,455
Energy output from solar PV over lifetime (MWh)	3,050,500	2,745,450	3,355,550
1c Whole Development CO_2 Emission Saving over...			
...coal-fired electricity generation (t CO_2 / year)	170,006	153,006	187,007
...grid-mix of electricity generation (t CO_2 / year)	37,239	33,516	40,963
...fossil fuel-mix of electricity generation (t CO_2 / year)	76,278	68,650	83,906
Energy output from Whole Development over lifetime (MWh)	8,995,036	8,095,532	9,894,540
Total CO_2 Losses due to the Proposed Development (t CO_2 eq.)			
2. Losses due to turbine life (e.g. manufacture, construction, decommissioning)	33,182	32,947	33,417
3. Losses due to backup	33,428	33,428	33,428

Output Data	Expected Value	Minimum Value	Maximum Value
4. Losses due to reduced carbon fixing potential	0	0	0
5. Losses from soil organic matter	9,747	5,698	15,828
6. Losses due to DOC & POC leaching	0	0	0
7. Losses due to felling forestry	0	0	0
8. Losses due to embodied emissions of solar PV*	90,422	81,380	99,464
Total losses of carbon dioxide*	**166,780**	**153,453**	**182,138**
9. Total CO_2 Gains due to Improvement of Site (t CO_2 eq.)			
9a. Change in emissions due to improvement of degraded bogs	0	0	0
9b. Change in emissions due to improvement of felled forestry	0	0	0
9c. Change in emissions due to restoration of peat from borrow pits	0	0	0
9d. Change in emissions due to removal of drainage from foundations & hardstanding	0	0	0
Total change in emissions due to improvements	0	0	0
Results			

Output Data	Expected Value	Minimum Value	Maximum Value
Net emissions of carbon dioxide (t CO_2 eq)*	**166,780**	**153,453**	**182,138**
Carbon Payback Time			
...coal-fired electricity generation (years)*	1.0	0.8	1.2
...grid-mix of electricity generation (years)*	4.5	3.7	5.4
...fossil fuel-mix of electricity generation (years)*	2.2	1.8	2.7
Ratio of soil carbon loss to gain by restoration	**No Gains**	**No Gains**	**No Gains**
* Blue shaded cells denote those that have been modified from the carbon assessment output due to the inclusion of embodied emissions and emissions savings from solar PV components.			