EIA Report Chapter 5: Carbon Balance

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5 Carbon Balance

5.1 Introduction

This chapter considers the potential impact of the Proposed Development on climate change through a carbon balance assessment. This chapter should be read combined with **Appendix 5.1 – Carbon Calculator Input and Results.**

The UK and Scottish Governments have developed ambitious targets for tackling climate change:

- The UK Government, in the 2008 Climate Change Act made a commitment to reduce the UK's emissions of CO2 by 34% (on 1990 levels) by 2020 and 80% by 2050.
- The Climate Change (Scotland) Act 2009 set in statute the Government's Economic Strategy target to reduce Scotland's emissions of greenhouse gases by 80% by 2050 (on 1990 levels), with an interim reduction target of at least 42%.
- Scotland has set a target of becoming net zero by 2045. With a new legally binding target for 2030 of a 75% reduction in emissions compared to 1990[1].
- The UK Government amended the Climate Change Act of 80% reduction to 100% reduction by 2050. These targets will be achieved through an investment in energy efficiency and clean technologies such as renewable energy generation.

The Onshore Wind Policy Statement[2] was published in December 2022 and sets out the Scottish target to deploy 20GW of onshore wind by 2030. The Scottish Government wants to accelerate the transition to renewable energy and a net zero society to combat climate change. Scotland currently has 9GW of operational onshore wind which highlights this is a cheap and reliable source of zero-carbon electricity. This policy is supported by the Onshore Wind Sector Deal 2023[3] which sets out commitments from the Scottish Government to deliver 20GW of onshore wind while delivering maximum benefits to Scotland.

Comhairle nan Eilean Siar (CnES) have produced a Climate Change Strategy for 2022-2027 which sets out their ambitions for carbon management and a roadmap for progress. The report highlights CnES are eager to demonstrate leadership and achieve zero direct emissions by 2038 at the latest and reduce their indirect emissions as much as possible.

Renewable electricity generated by wind turbines is already considered to be the cheapest form of new electricity generation and as such, has a vital role to play in achieving the ambitious targets set by both the Scottish and UK Governments.

The manufacturing, construction, and installation of the wind turbines on-site has an associated carbon cost, and carbon losses are also generated by the requirement for extra capacity to back up wind power generation. The carbon balance over the lifetime of the wind farm will be illustrated in detail in this chapter.

5.2 Guidance

This section will consist of GHG assessment to quantify the effect of the Proposed Development on climate change. This methodology provides a carbon balance of the savings and loss over the lifetime of the Proposed

[1] https://www.legislation.gov.uk/asp/2019/15/section/1/enacted (Accessed December 2023)
[2] https://www.gov.scot/publications/onshore-wind-policy-statement-2022/ (Accessed December 2023)
[3] https://www.gov.scot/publications/onshore-wind-sector-deal-scotland/ (Accessed December 2023)

Development. Subsequently, a payback time is estimated which is the time needed to generate carbon saving equivalent to the amount of carbon lost.

The GHG impact assessment within this chapter has been based on the guidance provided from the Scottish Government's Carbon Calculator Tool V1.8.1[4] . The tool is designed to calculate the carbon impact of wind farms. The calculator will be used to inform the discussion in this chapter. Details of the carbon calculator input data, their sources, and results for the expected, maximum and minimum (best and worst case) scenarios can be viewed online at https://informatics.sepa.org.uk/CarbonCalculator/ .

5.3 Consultation

A Scoping Report was submitted to Comhairle Nan Eilean Siar in September 2023. A scoping opinion was received from the council in December 2023. **Table 5.1** states the scoping opinion received from each consultee which mentions carbon balance and explains how this chapter will address the comments.

Table 5.1 - Scoping Opinion

Consultee	Comment	Response
SEPA	*"Whilst we agree with the proposed methodology in terms of peat probing we will wish to see demonstration the impact on peat volumes has been minimise as much as possible with alternative locations for the proposed turbines considered if found on deep peat and also an indication of expected volumes of peat to be excavated and a clear demonstration of where this extracted peat will be re-used in compliance with NPF4 Policy 5. The EIA should include an assessment of the receiving peatland in terms of condition and appropriateness for peat re-use."*	Turbines and associated infrastructure will be sited to avoid the deepest areas of peat as far as possible. A peat excavation figure will be calculated based on peat probing values and this figure will then be incorporated into the carbon calculator equation. An Outline Peat Management Plan will be included along with **Chapter 7: Hydrology** which will explain where the extracted peat will be re-used.
Comhairle nan Eilean Siar	*Scope Generally Agreed. However, the EIA report will be required to demonstrate that the impact on peat volumes has been minimised as much as possible with alternative locations for the proposed turbines considered if found on deep peat and also an indication of expected volumes of peat to be excavated and a clear demonstration of where this extracted peat will be re-used in compliance with NPF4 Policy 5. The EIA should include an assessment of the receiving peatland in terms of condition and appropriateness for peat re-use*	Turbines and associated infrastructure will be sited to avoid the deepest areas of peat as far as possible. A peat excavation figure will be calculated based on peat probing values and this figure will then be incorporated into the carbon calculator equation. An Outline Peat Management Plan will be included along with **Chapter 7: Hydrology** which will explain where the extracted peat will be re-used.

5.4 Methodology

The annual carbon dioxide emissions saving of a wind turbine are estimated as:

[4] https://informatics.sepa.org.uk/CarbonCalculator/ (Accessed December 2023)

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CO_2 Emissions Saving =

Total electricity generation expected [MWh]

x

Emission Factor of Displaced Generation [tCO_2/MWh]

The NatureScot Technical Guidance Note[5] states that "in most circumstances, it is not possible to define the electricity source for which a renewable electricity project will substitute", although it does state that as nuclear power generation is not affected by renewable energy generation "this suggests that carbon emission savings from wind farms should be calculated using the fossil fuel sourced grid mix as the counterfactual". NatureScot's Technical Note presents the result for each of the three sets of figures, as shown in **Table 5.2 - Counterfactual emission factors.**

Table 5.2 - Counterfactual emission factors

Energy	Emission Factor (tCO2e per kWh)[6]
Grid Mix	0.21
Coal Fired	1.00
Fossil Fuel Mix	0.43

The predicted carbon savings against both the Grid Mix and the Fossil Fuel Mix are presented within this assessment. The Grid Mix figures present a more conservative estimate of CO_2 emission savings.

5.5 Capacity Factor

A wind project capacity factor has to be determined in order for the total electricity generation of the wind project to be calculated. This is the ratio of the actual energy generated to the theoretical amount that the machine would generate if running at full-rated power during a given period of time. The average capacity factor (load factor) observed for the onshore wind farms in Scotland for 2022 was 30.5%[7]. The Site is estimated to have slightly higher than average wind speeds for the UK based on nearby wind projects, and as such, a capacity factor of 44.1% has been estimated based on a DW54-X turbine.

5.6 Assessment of Predicted Impacts and Effects

The calculations were carried out in accordance with the figures provided in the Scottish Government's most recent version of the Carbon Calculator. Counterfactual emissions factors have been taken from fixed data provided by the Scottish Carbon Calculator Tool. Where maximum and minimum inputs were required for the carbon calculator, values varying +/- 5% have been applied. The Carbon Calculator inputs and results can be found in **Appendix 5.1 – Carbon Calculator Input and Results**. The results are summarised in **Table 5.3.**

[5] https://www.gov.scot/publications/calculating-carbon-savings-wind-farms-scottish-peat-lands-new-approach/pages/13/ (Accessed December 2023)
[6] Taken from the Scottish Government Online Carbon Calculator (V1.8.1, Last accessed 01/03/2024)
[7] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/838179/ET_6.1.xls (Accessed December 2023)

Table 5.3 - Calculated CO2 emission savings

Power Generation Characteristics	
Number of Turbines	3
Total Turbine Capacity	1.5MW
Capacity Factor	44.1%
Lifetime	35 years
Annual Energy Output	~5795MWh/yr

Counterfactual Emissions Factors	
Overall 'grid' mix generation	0.21 tCO_2 /MWh
Fossil fuel sourced mix	0.42 tCO /MWh

Project estimated CO_2 emission savings over:	**tCO_2 /yr**	**tCO_2 /35yr**
Grid mix generation*	1,200	42,000
Fossil fuel mix generation*	2,500	86,000

Total Project Estimated Carbon saving over:	**tC /yr**	**tC /35yr**
Grid mix generation*	330	12,000
Fossil fuel mix generation*	660	23,000

**Rounded to two significant figures*

Based upon an average Scottish electricity consumption of 3,078kWh per household for Scotland in 2022[8], the turbines are expected to provide enough electricity to power an additional ~1884 homes per year.

5.7 Carbon Cost due to Wind Farm

5.7.1 Backup Power Generation

Wind generated electricity is inherently variable therefore as the NatureScot Technical Guidance Review states extra capacity is required for backup power generation to meet consumer demand. Backup power generation is assumed to be by fossil-fuel mix of electricity generation. The additional CO_2 output is calculated using the NatureScot Carbon Calculator.

At the Proposed Development, the CO_2 emissions associated with the requirement for extra backup generation over the years of operation is calculated as a loss of 975 tonnes of CO_2.

5.7.2 Reduced Carbon Fixing Potential

Peatlands contain large reservoirs of carbon, containing about one-third of the global amount of carbon in all soils. Undisturbed, peatlands sequester carbon from the atmosphere through photosynthesising vegetation. This carbon is then stored in the soil. This accumulates primarily in waterlogged conditions, where there is a low

[8]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1126284/subnational_electricity_and_gas_consumption_summary_report_2021.pdf (Accessed December 2023)

potential for decomposition. This element of the calculation accounts for the loss of carbon fixing potential of the peat that is removed during construction of access tracks, hardstandings, turbine foundations and other site infrastructure. It also factors in the impact of areas of peat that might be drained as a result of the wind turbines.

To establish peat depth at the Site, a peat probing survey was undertaken, with a total of 946 locations probed across the Site to ascertain the depth of peat, concentrating on potential access track routes and turbine locations. Turbines and associated infrastructure have been sited to avoid areas of deep peat as far as possible, based on results from peat probing. For further information refer to **Section 2.2.2: Design Evolution** in **Chapter 2 – Proposed Development and Design Evolution** and **Figure 7.2 Peat Depth Map.**

The survey was undertaken by pushing a rod into the ground by hand and recording the depth to refusal. In addition, at each point the slope of the ground surface, the strength of the deposits, an indication of the ground instability and the surface water/drainage conditions were also recorded. The results of the peat probes and site conditions are discussed in **Chapter 7 – Hydrology** and **Appendix 7.1: Outline Peat Management Plan.**

The results of the peat survey allowed for a peat excavation figure to be calculated which has been incorporated into the carbon calculator. For breakdowns of the peat excavations from different infrastructures see **Appendix 7.1: Outline Peat Management Plan**.

5.7.3 Forestry

Forests and trees are stores for carbon, therefore, when they are felled this carbon dioxide is released back into the atmosphere. This element of the calculation accounts for the loss of carbon storage potential of the forests that is removed during the construction of access tracks, hardstandings, turbine foundations and other site infrastructure.

No felling is required to accommodate the Proposed Development. As such, no losses for the removal of forestry have been calculated at this stage.

5.7.4 Carbon Losses Summary

The carbon losses due to turbine life occur from multiple phases. The carbon losses from the wind turbine itself come from the raw materials used to construct the turbine during the manufacturing phase. Carbon losses from construction and decommissioning arise from the transportation and machinery used.

Dissolved and particulate organic carbon (DOC and POC) are important components in the carbon cycle and serve as a primary food source for aquatic food webs. Carbon losses can arise if leaching of DOC and POC into groundwater occurs.

Carbon losses for the Proposed Development are summarised from the online calculator in **Table 5.4** below.

Table 5.4 - Development Carbon Losses (Predicted)

Activity	tCO_2 eq. (Windfarm lifetime)
Losses due to turbine life (e.g., manufacture, construction, decommissioning)	1,345
Losses due to backup	975
Losses due to reduced carbon fixing potential	81
Losses from soil organic matter	-60
Losses due to DOC & POC leaching	0
Losses due to felling forestry	0
Total losses	**2,341**

5.8 Other Polluting Gas Emission Savings

Other gas emissions resulting from fossil fuel sourced electricity generation are sulphur dioxide (SO_2) and nitrogen dioxide (NO_2), both responsible for acid rains. Emissions savings relating to the project can be calculated using the Renewable UK guidance, shown in **Table 5.5** Other polluting gas emissions savings, below. This suggests that the SO_2 and NO_2 emissions savings are, respectively, 10 and 3 kg per MWh. This translates to emissions factors of 0.01 and 0.003 [tonnes/MWh] respectively.

Table 5.5 - Other pollution gas emission savings

Project total emission savings of:	
Sulphur dioxide SO_2*	~2,000 tonnes /35yr
Nitrogen dioxide NO_2*	~609 tonnes /35yr

5.9 Summary of Carbon Balance

The following table summarises the carbon balance of the Proposed Development over its 35-year lifetime. It is based upon the grid mix counterfactual, which represents a conservative estimate.

Table 5.6 - Predicted overall carbon savings/losses

Element:	**Predicted lifetime emissions (tCO_2)**
Carbon Dioxide savings:	
Projected CO_2 savings compared to grid mix*	202.825
Carbon Dioxide Losses:	
Total CO_2 Losses	2,341
Net Emission Savings over project lifetime*	200,500

**Rounded to two significant figures*

Table 5.6 above shows that over its 35-year lifetime the project is expected to result in a CO_2 saving of ~**200,500 tonnes**. The carbon payback time is an estimate of how long it will take a renewable energy project to offset the carbon emissions emitted as a result of its construction, operation and decommissioning[9]. The carbon payback time of all the emissions associated with the lifetime operation of the Proposed Development based on a grid-mix of electricity generation is expected to be **two years**.

5.10 Mitigation

An iterative design approach was taken for the layout of the Proposed Development therefore turbines and associated infrastructure were placed to avoid the deeper areas of peat and avoid watercourses, as well as utilising existing infrastructure where possible. **Chapter 7: Hydrology** outlines the measures to be taken to mitigate water pollution and flood risk during construction activities.

To mitigate potential effects during the construction phase, a comprehensive Construction Environmental Management Plan (CEMP) framework will be prepared and implemented ahead of the commencement of construction. This framework will outline a range of optimal practices, encompassing environmental best practices such as the efficient processing and reuse of all reclaimed materials on-site whenever feasible. By incorporating

[9] https://www.iema.net/articles/calculating-carbon-payback-for-wind-farms#:~:text=The%20carbon%20payback%20period%20is,%E2%80%9Cthe%20carbon%20saving%E2%80%9D). (Accessed December 2023)

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training and contractual obligations, the project aims to uphold the highest standards of environmental protection and water management throughout the construction phase. This approach underscores the Proposed Development's commitment to minimising its environmental impact and ensuring responsible construction practices.

As the Proposed Development is expected to have a beneficial effect on climate change in terms of offsetting greenhouse gas emissions, no further mitigating actions are deemed necessary at present.

5.11 Conclusion

The assessment demonstrates that the Proposed Development would make a significant contribution to Comhairle nan Eilean Siar net zero targets and support the decarbonisation targets set by the local authority, while contributing to the wider national target of achieving net zero by 2045.

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