CRUACH CLENAMACRIE WIND FARM

CHAPTER 17:

CLIMATE CHANGE AND CARBON BALANCE

November 2024

RESPONSIBILITIES

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CONTENTS

ABBREVIATIONS

ABBREVIATION	DESCRIPTION
°C	Degrees Celsius
BESS	Battery Energy Storage Systems
CCC	Climate Change Committee
CEMP	Construction Environmental Management Plan
CGS	Clean Growth Strategy
CO_2	Carbon Dioxide
COP	Conference of Parties
DOC	Dissolved Organic Carbon
EIA	Environmental Impact Assessment
GHG	Greenhouse Gas Emissions
GW	Gigawatt
ha	Hectares
IEMA	Institute of Environmental Management and Assessment
kWh	Kilowatt hours
$MtCO_2e$	Million Tonnes of Carbon Dioxide Equivalent
MW	Megawatt
MWh	Megawatt Hour
NPF4	National Planning Framework 4
POC	Particulate Organic Carbon
SEPA	Scottish Environment Protection Agency
SNH	Scottish Natural Heritage (Now NatureScot)
tCO_2	Tonnes of Carbon Dioxide
tCO_2/yr	Tonnes of Carbon Dioxide per year
TWh	Terawatt Hours
UNFCCC	United Nations Framework Convention on Climate Change
WTG	Wind Turbine Generator

17 CLIMATE CHANGE AND CARBON BALANCE

17.1 Introduction

Renewable electricity from Wind Turbines Generators (WTGs) is considered to be the cheapest and most efficient form of new electricity generation. Onshore wind development can therefore help achieve the ambitious targets set by both the Scottish and UK Governments. The manufacture, construction, and installation of wind turbines on-site does have an associated carbon cost. Additional carbon costs can also occur from the disturbance of peatland and from felling of woodland, which are both carbon stores.

This Chapter addresses the potential effects the Proposed Development will have on climate change through the reduction of Greenhouse Gas (GHG) Emissions. This Chapter includes a GHG Impact Assessment, which provides an estimate of the GHG emissions associated with the manufacture, construction and decommissioning of the Proposed Development. The Chapter also calculates the contribution towards GHG emission savings. These two elements showcase a whole life cycle ‘carbon balance’ of the Proposed Development. Once the manufacture, construction and decommissioning emissions are offset by the wind farm, all wind-generated electricity would displace conventionally generated electricity. The carbon balance over the lifetime of the wind farm will be calculated using the latest version of the Scottish Government’s Carbon Calculator Tool.

Scottish Environment Protection Agency (SEPA) have confirmed the calculator tool is offline and has been since September 2024 due to technical issues. As a result, this chapter has used an Excel format of the Carbon Calculator in the interim, as confirmed with Energy Consents Unit (ECU). Once the technical fault has been fixed, all data will be input to the SEPA online Scottish Government Carbon Calculator and submitted to the ECU as clarification. This chapter should be read alongside **Appendix 17.1: Carbon Calculator Inputs and Results.**

WTGs are designed for optimal performance and reliability in an unpredictable environment, constructed to withstand extreme temperatures and a higher wind class than is necessary. Failure during high winds is unlikely as the turbines are designed to cut-out and automatically stop as a safety precaution in wind speeds over 25 m/s. Based on climate change trends the function of the Proposed Development is not anticipated to be adversely affected therefore no further assessment has been undertaken.

17.2 Legislation, Policy and Guidance

17.2.1 United Nations Framework Convention on Climate Change

The United Nations Framework Convention on Climate Change (UNFCCC) is an international environmental treaty that came into force on 21 March 1994. Its primary objective is to stabilise GHG concentrations in the atmosphere at a level that prevents dangerous human interference with the climate system. The treaty facilitates intergovernmental climate change negotiations and provides technical expertise. The Conference of the Parties (COP) is the supreme decision-making body that meets annually to discuss and assess progress in addressing climate change.

The first significant agreement under the UNFCCC was the Kyoto Protocol, signed in 1997 and put into force in 2005. This protocol committed industrialised countries to limit and reduce GHG emissions according to individual targets, aiming to reduce global warming rates. The Kyoto Protocol acknowledges the role of economic development in a country's ability to combat and adapt to climate change, and it requires developed countries to reduce their current emissions due to their historical responsibility for atmospheric GHG concentrations.

Subsequent COP meetings have led to various important and binding agreements, including the Copenhagen Accord (2009)[1], the Doha Amendment (2012)[2], and the Paris Agreement (2015)[3]. The Copenhagen Accord raised climate change policy to the highest political level and introduced the potential commitment to limit the global average temperature increase to below 2°C above pre-industrial levels. The Doha Amendment set targets for reducing GHG emissions from 2013 to 2020, and the Paris Agreement aims to limit global temperature increases to well below 2°C, with efforts to limit it to 1.5°C above pre-industrial levels.

COP26, held in Glasgow in 2021, focused on securing global net zero emissions, adapting to protect communities and natural habitats, mobilising climate finance, and finalising the Paris Rulebook to accelerate action in tackling climate change. The Glasgow Climate Pact was signed, providing a framework for tackling climate change, and the Paris Rulebook outlined guidelines for implementing the Paris Agreement.

Overall, these international climate agreements represent significant efforts to address climate change and work towards a sustainable and low-carbon future.

17.2.2 Climate Change Act 2008

The Climate Change Act 2008[4] commits the United Kingdom to significant reductions in GHG emissions. Specific net zero targets have been introduced by amendments made by The Climate Change Act 2008 (2050 Target Amendment) Order 2019[5]. It sets legally binding targets to reduce emissions to ensure that the 'net UK carbon account' is reduced by at least 100% by 2050, relative to 1990 levels. The Act establishes a system of 'Carbon Budgets' to guide emission reductions over five-year periods. This legislation aims to tackle climate change and transition the UK towards a low-carbon future through ambitious and sustained decarbonisation efforts.

The six carbon budgets which have been placed into UK law through secondary legislation under the 2008 Act are identified in **Table 17.1** below.

TABLE 17.1: UK CARBON BUDGETS

BUDGET	CARBON BUDGET LEVEL ($MtCO_2e$)	REDUCTION BELOW 1990 LEVELS (UK TARGERTS)	TARGETS MET?
1st Carbon Budget (2008 to 2012)	3,018	26%	Yes
2nd Carbon Budget (2013 to 2017)	2,782	32%	Yes
3rd Carbon Budget (2018 to 2022)	2,544	38%	Yes
4th Carbon Budget (2023 to 2027)	1,950	52%	To be assessed in the CCC 2029 Progress Report

[1] Copenhagen Accord (2009) (Accessed 03/10/2024)
[2] Doha Amendment (2012) (Accessed 03/09/2024)
[3] The Paris Agreement (2015) (Accessed 03/10/2024)
[4] Climate Change Act 2008 (Accessed 03/10/2024)
[5] The Climate Change Act 2008 (2050 Target Amendment) Order 2019 (Accessed 13/11/2024)

BUDGET	CARBON BUDGET LEVEL ($MtCO_2e$)	REDUCTION BELOW 1990 LEVELS (UK TARGERTS)	TARGETS MET?
5th Carbon Budget (2028 to 2032)	1,725	58%	To be assessed in the CCC 2034 Progress Report
6th Carbon Budget (2033 to 2037)	965	78%	To be assessed in the CCC 2039 Progress Report

17.2.3 The Climate Change (Scotland) Act 2009

The Climate Change (Scotland) Act 2009[6] is key legislation which creates the statutory framework for GHG emissions reductions to achieve 'net zero' in Scotland. In 2019 the Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 Bill was passed which states; Scottish Ministers must ensure that the net Scottish emissions account for the net-zero emissions target year is at least 100% lower than the baseline which is secured through. The 2020 target was amended to 48.5% in 2023.

The Progress in Reducing Emissions in Scotland Report (2022) by the Climate Change Committee, states that in 2019 the Scottish Parliament legislated an interim target of a 75% reduction on 1990 levels by 2030. This report finds this is an extremely challenging target and proposes a 65-67% reduction in Scotland's emissions by 2030 to be more feasible. The Report also finds that Scotland must do more to reach this ambitious target, particularly through making homes more energy efficient and through the restoration of peatland. Following a Climate Change Committee report submitted in March 2024, it was found that Scotland has no comprehensive strategy to decarbonise towards net zero, and will miss its statutory 2030 goal to reduce emissions by 75%. The Scottish Government has now created the Climate Change (Emissions Reduction Targets) (Scotland) Bill,[7] which changes the system of targets for the reduction of GHG emissions. The Bill will replace those targets with a system of targets based on carbon budgets. The Bill was introduced on 5th September 2024, it has now been passed and is awaiting royal ascent.

17.2.4 The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017

Schedule 4, Section 5 of the Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017 (the EIA Regs)[8] sets out the information for inclusion in Environmental Statements or EIA Reports. Paragraph 5(f) requires that the impact of the development on climate (for example the nature and magnitude of GHG emissions) and the vulnerability of the development to climate change is considered in the EIA Report.

17.2.5 UK Clean Growth Strategy

In October 2017, the UK Government released the Clean Growth Strategy[9] (CGS) titled 'Leading the Way to a Low Carbon Future.' The central objective of the CGS is to achieve clean growth, which is defined as 'promoting economic growth while simultaneously reducing GHG emissions. The CGS presents a comprehensive set of policies and proposals aimed at accelerating the pace of clean growth, fostering economic development, and curbing emissions. It states that "in order to meet these objectives, the UK will

[6] The Climate Change (Scotland) Act 2009 (Accessed 03/10/2024)
[7] Climate Change (Emissions Reduction Targets) (Scotland) Bill (Accessed 13/11/2024)
[8] Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017(Accessed 14/11/2024)
[9] UK Clean Growth Strategy (Accessed 03/10/2024)

need to nurture low carbon technologies, processes and systems that are as cheap as possible". The CGS is considered to be "at the heart of the UK's Industrial Strategy".

The CGS builds upon the UK's commitments under the Climate Change Act 2008.

The UK has demonstrated significant progress in achieving its emission reduction targets set by the first, second, and third Carbon Budgets, surpassing the expected reductions compared to 1990 levels.

- First Carbon Budget: The UK achieved a 30% reduction in emissions from 1990 levels by 2011, exceeding the target set for this period.
- Second Carbon Budget: By 2015, the UK achieved a 38% reduction in emissions compared to 1990 levels, again surpassing the set target for this period.
- Third Carbon Budget: As of 2021, the UK has outperformed the targets set for the third Carbon Budget, achieving a provisional 47% reduction from 1990 levels. This represents a substantial decrease of 10% from the 2019 emission levels.

However, it's important to note that while there has been significant progress in reducing emissions, the Covid-19 pandemic had an impact on emission levels. In 2021, emissions were 4% higher than those in 2020, attributed to a rebound effect following the disruptions caused by the pandemic.

The Climate Change Committee (CCC) Progress Report to Parliament in 2024 highlighted the UK's commendable achievements in reducing emissions and meeting its carbon budgets. Continued efforts and robust policies are essential to maintain this positive trend and stay on track to meet future carbon budgets and long-term climate goals, including those set by the Paris Agreement.

Overall, the CGS serves as a central element of the UK's Industrial Strategy, focusing on the dual goals of economic growth and reduced emissions. It aligns with the UK's long-term climate goals and international commitments, emphasising the importance of adopting and investing in clean technologies and policies to create a low-carbon and sustainable future.

17.2.6 Onshore Wind Policy Statement

The Onshore Wind Policy Statement[10] was published in December 2022 and sets out the Scottish target to deploy a minimum of 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[11] which sets out commitments from the Scottish Government to deliver 20GW of onshore wind while delivering maximum benefits to Scotland.

17.2.7 Draft Energy Strategy and Just Transition Plan

The Scottish Government published a new Draft 'Energy Strategy and Just Transition Plan: Delivering a fair and secure zero carbon energy system for Scotland'[12] on 10 January 2023. This draft Strategy and Plan presents the vision for Scotland's future decarbonised energy system and the actions the government and communities need to take to deliver net zero. The new Strategy will replace the one previously published in 2017. The Foreword sets out the main objectives for Scotland's future including:

- More than 20 GW of additional renewable electricity on- and offshore by 2030;
- An ambition for hydrogen to provide 5 GW or the equivalent of 15% of Scotland's current energy needs by 2030 and 25 GW of hydrogen production capacity by 2045;

[10] Onshore Wind Policy Statement (2022) (Accessed 03/10/2024)
[11] Onshore Wind Sector Deal for Scotland (Accessed 15/11/2024)
[12] Draft Energy Strategy and Just Transition Plan (2023) (Accessed 03/10/2024)

- Increased contributions from solar, hydro and marine energy to our energy mix;
- Accelerated decarbonisation of domestic industry, transport and heat;
- Establishment of a national public energy agency – Heat and Energy Efficiency Scotland;
- By 2030, the need for new petrol and diesel cars and vans phased out and car kilometres reduced by 20%;
- Generation of surplus electricity, enabling export of electricity and renewable hydrogen to support decarbonisation across Europe;
- Energy security through development of our own resources and additional energy storage;
- A just transition by maintaining or increasing employment in Scotland's energy production sector against a decline in North Sea production; and
- Maximising the use of Scottish manufactured components in the energy transition, ensuring high-value technology and innovation.

This document aligns with the policy included within the Onshore Wind Policy Statement and National Planning Framework 4 (NPF4). NPF4 Policy 2[13] states development proposals will be designed to minimise lifecycle GHG emissions as far as possible and adapt to current future risks of climate change.

17.2.8 Argyll and Bute Council Decarbonisation Plan 2022-2025

The Argyll and Bute Decarbonisation plan[14] sets out the Councils approach to help tackle climate change. The Plan acts as a route map for the Council's journey towards net zero. There are four main aims within this report:

1. Argyll and Bute Council to achieve 75% carbon reduction by 2030 and net zero before 2045;
2. Support a low carbon economy;
3. Lead by example and develop practices and partnerships that inspire low carbon behaviours; and
4. Make 'Climate Friendly Argyll and Bute' a recognised brand and underpin behaviours of their staff and customers.

17.2.9 Institute of Environmental Management Association (IEMA) Guidance

In the absence of widely recognised guidelines for evaluating the significance of the impact of GHG emissions, the IEMA 'Assessing GHG Emissions and Evaluating their Significance (2022)' has been adhered to. This guidance offers a structured approach to incorporating GHG emissions considerations within the EIA process, aligning with the amending EIA Directive 2014/52/EU. The guidance details how to:

- Establish the GHG emissions baseline by considering both current and projected GHG emissions;
- Identify key sources contributing to GHG emissions and determine the assessment's scope and methodology;
- Evaluate the potential impact of GHG emissions and assess their level of significance; and
- Integrate mitigation strategies, following the hierarchy for managing project-associated GHG emissions, which involves avoiding, reducing, substituting, and compensating for emissions.

By following this guidance, the evaluation of GHG emissions within the EIA process is carried out systematically and in line with contemporary directives and frameworks, ensuring a comprehensive understanding of the potential environmental impact of GHG emissions.

[13] National Planning Framework 4 – Policy 2 (Accessed 15/11/2024)
[14] Argyll and Bute Council Decarbonisation Plan 2022-2025 (Accessed 03/10/2024)

17.3 Consultation

TABLE 17.2 : CONSULTATION RESPONSES

CONSULTEE	RESPONSE	ACTION
NatureScot	NPF4 states where development on peatland, carbon-rich soils or priority peatland habitat is proposed, a detailed site specific assessment will be required to identify: i. The baseline depth, habitat condition, quality and stability of carbon rich soils; ii. The likely effects of the development on peatland, including on soil disturbance; and iii. The likely net effects of the development on climate emissions and loss of carbon.	WTGs and associated infrastructure have been sited to avoid the deepest areas of peat as far as possible within the Site. **EIA Report Chapter 10: Ecology** includes a habitat survey. **Appendix 9.2: Outline Peat Management Plan** is included along with the EIA Report. **EIA Report Chapter 9: Geology, Hydrogeology, Hydrology and Soils** explains the condition of peat, the impacts due to the Proposed Development and where the extracted peat will be re-used. SEPA has confirmed the calculator tool has been offline since September 2024 due to technical issues. As a result, this chapter has used the Excel format of the Carbon Calculator in the interim. Once the technical fault has been fixed, all data can be input to the SEPA's online Scottish Government Carbon Calculator and submitted to the Energy Consents Unit for clarification.

17.4 Methodology

17.4.1 Context

- Embedded Carbon and GHGs: This refers to the emissions resulting from the entire life cycle of the wind turbine components and their associated physical infrastructure. From the extraction and refinement of raw materials to the manufacturing processes, there are GHG emissions associated with the production of WTGs and other components. This includes emissions from mining, transportation, manufacturing and construction processes.
- Operational Emissions: Once the wind farm is operational, there are ongoing emissions related to the combustion of fuels and energy used in various activities. These emissions arise from activities such as operating and maintaining the WTGs, as well as from general site operations and maintenance. Over the lifetime of the wind farm, there will be continuous energy consumption and fuel use, contributing to operational emissions.
- Decommissioning Emissions: When the wind farm reaches the end of its useful life and is decommissioned, there are additional emissions associated with dismantling and removing the infrastructure. The process of decommissioning may also involve transportation and disposal of materials, leading to emissions.

The manufacture of WTGs has the most significant environmental impact across various impact categories and indicators, including global warming potential, acidification potential, eutrophication potential, and non-renewable primary energy demand. This category encompasses the production of several WTG components such as the foundation, tower, nacelle, hub, and rotor blades. The transportation and manufacturing processes of these components also contribute to the large environmental impact.

The main reason for this substantial impact is the production of significant quantities of materials, particularly concrete and metals like steel, cast iron, stainless steel, aluminium, and copper. These materials' extraction, processing, and manufacturing result in high GHG emissions and energy consumption, leading to a considerable environmental footprint during the WTG manufacturing phase.

Other stages of wind farm development, such as the manufacturing of substations, maintenance (including spare parts provision), transportation, logistics, installation, and dismantling, have relatively smaller contributions to the overall environmental impact. The construction of WTGs also has the potential to create GHG emissions through other pathways such as the disturbance of peatlands (carbon stores) and the removal of woodland and forestry.

In efforts to reduce the environmental impact, the use of recycled materials during the manufacturing phase, particularly metals, has a positive effect. By giving end-of-life credits for recycled materials, the overall environmental impact of WTGs can be partially mitigated. This underscores the importance of sustainable practices and recycling in the wind energy industry, to promote a more environmentally friendly approach to wind farm development and operation.

17.4.2 Greenhouse Gas Assessment

The annual carbon dioxide (CO_2) emissions saving of a wind turbine are estimated as:

CO_2 Emissions Saving =

Total electricity generation expected [MWh]

x

Emission Factor of Displaced Generation [tCO_2/MWh]

The NatureScot Technical Guidance Note[15] 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 17.3.**

TABLE 17.3 : COUNTERFACTUAL EMISSION FACTORS

ENERGY	EMISSION FACTOR (tCO_2 per kWh)
Grid Mix	0.207
Fossil Fuel Mix	0.424
Coal Fired	0.945

The GHG Assessment of the Proposed Development would typically be completed using the latest version of the Scottish Government's Carbon Calculator Tool. This is the standard method for calculating carbon costs and savings for onshore wind farms sited on Scottish peatlands. The tool assesses the carbon costs of a wind farm against the carbon savings attributed to the wind farm development. The calculator takes into account peat disturbance and felling of forestry, which enables a life-cycle analysis of the Proposed Development. A description of the carbon calculator and the calculator inputs and results can be seen in **Appendix 17.1**. Due to the calculator being offline at the time of writing, the excel version of the online carbon calculator has been implemented in the interim. Once the technical fault has been fixed, all data

[15] Calculating carbon savings from wind farms on Scottish peat lands: a new approach (Accessed 15/11/2024)

will be input to the SEPA online Scottish Government Carbon Calculator and submitted to the ECU as clarification.

Once GHG emission savings and costs have been compared, the Carbon Calculator will calculate the overall net GHG emission savings of the Proposed Development. The Calculator also produces a carbon payback time, which 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.

17.4.3 Significance

The results from the Carbon Calculator are used to determine the significance conclusion in accordance with the IEMA's Environmental Impact Assessment guide to: Assessing Greenhouse Gas Emissions and Evaluating their Significance (2022)[16]. The guidance states that, a project which causes GHG emissions to be avoided or removed from the atmosphere has a **beneficial effect** that is **significant**. This means the project's net GHG emissions are below zero and causes a reduction in GHG concentration. Beneficial and significant indicates the project causes GHG emissions to be avoided or removed from the atmosphere creating a positive climate impact.

17.5 Baseline

Baseline conditions at the Site relate to a reference point to which the impact of the new project can be compared.

The Land Capability for Forestry within the Site is predominantly graded F5 and F6. The land capability series is a map-based classification of Scotland and described F5 as land "with limited flexibility for growth and management of tree crops". F6 is described as land with "very limited flexibility for growth and management of tree crops"[17]. The access tracks lie predominantly within the F5 classification with turbines, and associated infrastructure within F6.

As outlined in **EIA Report Chapter 9: Geology, Hydrogeology, Hydrology and Soils**, the Site is underlain with Class 2 and Class 5 Peat.

As stated in **EIA Report Chapter 3: EIA Methodology,** the land use of the Site, in the absence of the Proposed Development, will remain as it is currently under the existing landowners, as an area of upland grazing. There are not currently any habitat improvement or biodiversity enhancement plans proposed in the absence of the Proposed Development. Changes in the physical environment due to climate change can subsequently impact the environment via alterations such as an increase in summer temperatures and a decrease in rainfall. This could lead to impacts on habitats and species. A comprehensive assessment of such impacts and effects is challenging due to the uncertainty surrounding how the physical environment reacts to climate change, and for the purposes of this assessment it has been assumed that without the implementation of the Proposed Development it is not anticipated that there will be any change to the baseline scenario.

17.6 Likely Significant Effects

17.6.1 Operation

The operation stage of the Proposed Development is where most carbon savings will occur. Carbon costs of construction activities would no longer exists, and the operation of the turbines alongside the Battery Energy Storage System (BESS) would generate zero-carbon electricity. The carbon savings results are

[16] Assessing Greenhouse Gas Emissions and Evaluating their Significance (IEMA, 2022) (Accessed 03/10/2024)
[17] National Scale Land Capability for Forestry (Accessed 03/10/2024)

presented in **Table 17.4** and are rounded to two significant figures. Results for both the grid-mix and fossil-fuel mix counterfactual are presented below, however the grid-mix shows a more conservative and realistic estimate as this is the same as the national grid, where there are many main sources of energy.

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 onshore wind farms in Scotland for 2022 was 28.4%[18]. The Site is estimated to have slightly higher than average wind speeds for the UK and the turbines have a large rotor diameter, and as such, a capacity factor of 40.2% has been estimated based on a preliminary energy yield assessment. Annual Energy Output has been rounded to two significant figures.

TABLE 17.4: CALCULATED CARBON EMISSION SAVINGS

POWER GENERATION CHARACTERISTICS		
Number of turbines	6	
Turbine capacity	7.2MW	
Capacity factor	40.2%	
Operational lifetime	50 years	
Annual energy output	150,000* MWh/yr	
As stated in **Section 17.4.2** the project CO_2 savings are estimated by the total electricity generated expected (150,000MWh) multiplied by the emission factor of displaced generation (0.207 for grid mix, 0.424 for fossil fuel mix). To calculate over the project lifetime this value is then multiplied by 50 years. These results are displayed in the following tables and are rounded to two significant figures:		
COUNTERFACTUAL EMISSIONS FACTORS		
Grid mix generation	0.207 tCO2 MWh^{-1}	
Fossil fuel sourced mix	0.424 tCO2 MWh^{-1}	
PROJECTED ESTIMATE CO2 SAVINGS	tco2/yr	tco2/50yr (t)
Grid mix generation	31,000*	1,600,000**
Fossil fuel mix generation	64,000	3,200,000
Assuming 1 tonne tCO_2 is equivalent to 0.27 tonnes of Carbon[19]:		
TOTAL PROJECT ESTIMATED CARBON SAVINGS	tc/yr	tc/50yr
Grid mix generation	8,400*	420,000**
Fossil fuel mix generation	17,000	860,000

Based upon an average UK electricity consumption of 3,078kWh per household[20], the turbines are expected to provide enough electricity to power an additional ~48,733 homes per year. This is calculated by taking the annual energy output (MWh) multiplied by 1000 to convert to kWh, then dividing by 3,078 (150,000x1000/3,078).

[18] Regional Renewable Electricity in 2022 (Accessed 03/10/2024)
[19] Converting carbon to CO_2 emissions (Accessed 13/11/2024)
[20] Domestic Energy Map, Available at: https://assets.publishing.service.gov.uk/media/65b12dfff2718c000dfb1c9b/subnational-electricity-and-gas-consumption-summary-report-2022.pdf (Accessed 08/11/2024)

17.6.2 Construction and Decommissioning

17.6.2.1 Backup Power Generation

Wind-generated electricity is inherently variable, therefore as the Scottish Natural Heritage (SNH) Technical Guidance Note[21] 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 Scottish Government Carbon Calculator.

17.6.2.2 Disruption of Peatlands

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 potential for decomposition. This element of the calculation accounts for the loss of carbon fixing potential of the peat that is removed during the 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.

In order to establish peat depth at the Site, a peat probing survey was undertaken, with a total of 562 locations probed across the Site, to ascertain the depth of peat, concentrating on potential access track routes and turbine locations. Where maximum and minimum inputs for average peat depths were required for the carbon calculator, values varying +/- 10% from the average have been applied. The results of the peat probes and site conditions are discussed in **EIA Report Chapter 9: Geology, Hydrogeology, Hydrology and Soils.**

All new access tracks have been designed to avoid sensitive environmental receptors where possible. It is proposed that the access tracks from E196438 N730140 to E196628 N730166 through Fearnoch Forest, are floated to minimise the potential excavation and disruption to the surrounding peatland.

17.6.2.3 Forestry

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

EIA Report Chapter 13: Forestry proposes that 18.1ha of forestry will be felled to facilitate construction of infrastructure for the Proposed Development. The SNH Technical Guidance Note includes estimated figures for carbon sequestration of different species of tree, and in this case the majority of the area that is proposed to be felled comes under the Sitka category. According to the carbon sequestration rate for Sitka of 13.2 tonnes of CO_2 per ha per year[22], a loss of CO_2 due to forestry clearance of ~12,000 tonnes was calculated.

17.6.2.4 Summary of Carbon Losses and Gains

The carbon losses due to turbine life occur from multiple phases. The carbon losses from the WTGs themselves 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.

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[21] Calculating carbon savings from wind farms on Scottish peat lands: a new approach (Accessed 08/11/2024)
[22] Calculating potential carbon losses and savings from wind farms on Scottish peatlands (Accessed 13/11/2024)

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.

Net carbon dioxide emissions for the Proposed Development are summarised from the Excel Carbon Calculator and rounded to two significant figures in **Table 17.5** below.

TABLE 17.5: DEVELOPMENT CARBON LOSSES AND GAINS (PREDICTED)

ACTIVITY	TCO2 EQ (WIND FARM LIFETIME)
Losses due to turbine life (e.g., manufacture, construction, decommissioning)	43,000
Losses due to backup	40,100
Losses due to reduced carbon fixing potential	1100
Losses from soil organic matter	1500
Losses due to DOC & POC leaching	1
Losses due to felling forestry	44,000
Total losses	130,000
Change in emissions due to improvement of degraded bogs	-180
Net GHG emissions	129,000

17.6.3 Net GHG Emissions and Payback Period

Table 17.6 summarises the carbon balance of the development over its 50-year operational lifetime. It is based upon the grid-mix counterfactual, which represents a conservative estimate.

TABLE 17.6: PREDICTED OVERALL CARBON SAVINGS

ELEMENT:	PREDICTED LIFETIME EMISSIONS (TCO2)
Carbon emissions savings:	
Projected CO_2 savings compared to grid mix	1,600,000
Carbon emission losses:	
Total CO_2 Losses	129,000
Net emission savings over project lifetime	**1,471,000**

Table 17.6 shows that over its proposed 50-year lifetime the Proposed Development is expected to result in a CO_2 saving of ~1,471,000 tonnes compared to a grid-mix emissions counterfactual. 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. The carbon payback time of all the emissions associated with the lifetime operation of the Proposed Development, based on a fossil-fuel mix of electricity generation, is two years and against a grid-mix of electricity generation is expected to be 4.1 years.

17.7 Mitigation

An iterative design approach (see **EIA Report Chapter 4: Assessment of Alternatives**) was taken for the layout of the Proposed Development. Turbines and associated infrastructure were sited to avoid the deeper areas of peat and watercourses, as well as utilising existing infrastructure where possible. **EIA Report Chapter 9: Geology, Hydrogeology, Hydrology and Soils** 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) will be prepared and implemented ahead of the commencement of construction. This plan 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 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.

Wind turbines are meticulously engineered to harness the power of wind for energy generation. As a result, they are constructed with the ability to endure harsh climatic conditions. The WTGs are strategically placed in areas exposed to strong and consistent winds. However, it is important to recognise that wind energy projects may still be influenced by substantial shifts in climatic factors. Other mitigation measures will include the management of WTGs during their operation to maintain efficiency during their lifetime.

The Proposed Development is expected to have a beneficial effect on climate change in terms of offsetting GHG emissions and **no adverse effects** are predicted. Therefore, no additional mitigating actions are proposed.

17.8 Cumulative Assessment

The Scottish and UK Governments have set ambitious and strict targets for reducing GHG emissions by 2045 and 2050 respectively. The Proposed Development will positively impact carbon emissions and help contribute to meeting these targets as evidenced by the calculated carbon savings in **Section 17.6.3**. When the Proposed Development is considered with other Scottish and UK Renewable Projects it will have a positive impact on GHG emissions. Based on the assumption that all wind farm projects in the UK will have a similar net positive effect on emissions, the cumulative effect is assumed to be positive. Therefore, no quantitative assessment has been undertaken.

DUKES[23] found renewable energy generation in 2023 exceeded the current 2022 record marginally (by 0.3 per cent) to 135.8TWh. The effect of less favourable weather conditions for wind and solar PV was more than offset by an increase in capacity for both technologies. The capacity for onshore wind continues to grow, evidenced by output increasing by 21% in 2022. With more favourable weather conditions it is anticipated that onshore wind will continue to positively impact carbon emissions in line with targets and legislation.

17.9 Summary

The Proposed Development is expected to produce GHG emissions due to manufacture, construction and decommissioning activities but these emissions will be offset, and all wind-generated electricity would displace conventionally generated electricity. This assessment demonstrates that the Proposed Development would make a positive contribution to Argyll and Bute's Decarbonisation Plan, meanwhile, contributing to the wider national target of achieving net zero by 2050. The Proposed Development may

[23] DUKES Chapter 6: Renewable sources of energy (03/10/2024)

also help meet the Scottish Government's target of securing an overall ambition of 20GW of installed onshore wind capacity in Scotland by 2030, as set out in the Onshore Wind Policy Statement (2022).