CALEDONIA
Offshore Wind Farm

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Volume 6 Intertidal and Combined Assessments

Chapter 4 Greenhouse Gases

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OCEAN WINDS

Volume 6 Chapter 4 Greenhouse Gases

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Table of Contents

Executive Summary ix

4 Greenhouse Gas Emissions 1

4.1 Introduction 1

4.2 Legislation, Policy and Guidance 1

4.3 Stakeholder Engagement 5
4.3.1 Overview 5

4.4 Baseline Characterisation 9
4.4.1 Study Area 9
4.4.2 Data Sources 9
4.4.3 Baseline Description 9
4.4.4 Data Gaps and Limitations 11

4.5 EIA Approach and Methodology 12
4.5.1 Overview 12
4.5.2 Impacts Scoped in to the Assessment 12
4.5.3 Impacts Scoped out of the Assessment 13
4.5.4 Assessment Methodology 13
4.5.5 Approach to Cumulative Effects 17
4.5.6 Embedded Mitigation 18

4.6 Key Parameters for Assessment 20

4.7 Potential Effects 27
4.7.1 Caledonia North and a Single Phase of the Proposed Development (Onshore) 27
4.7.2 Caledonia South and a Single Phase of the Proposed Development (Onshore) 34

4.8 Cumulative Effects 41
4.8.2 Construction 42
4.8.3 Operation 44
4.8.4 Decommissioning 45
4.8.5 Evaluation of Significance 46

4.9 In-combination Effects 49

4.10 Transboundary Effects 49

4.11 Mitigation Measures and Monitoring 50
4.11.2 Construction 50
4.11.3 Operation 51
4.11.4 Decommissioning 51

4.12 Residual Effects 52
4.12.1 Construction Effects 52
4.12.2 Operation Effects 52
4.12.3 Decommissioning Effects 52

4.13 Summary of Effects 52
4.14 References 58

List of Figures

Figure 4-1: GHG Emissions Study Area 10

List of Tables

Table 4-1: Legislation Policy and Guidance 2
Table 4-2: Scoping Opinion Response (Offshore) 6
Table 4-3: Summary of key publicly available datasets for GHG emissions 9
Table 4-4: Annual baseline GHG emissions for the Proposed Development 11
Table 4-5: GHG Emissions Scope of Assessment 13
Table 4-6: Summary of GHG components within the assessment 15
Table 4-7: Embedded Mitigation 19
Table 4-8: Realistic worst Case Assessment Scenario Considered for Each Impact as Part of the Assessment of Likely Significant Effects 21
Table 4-9: GHG Emissions associated with the construction of Caledonia North and a single phase of the Proposed Development (Onshore) 28
Table 4-10: Annual GHG Emissions associated with the operation of Caledonia North (Offshore) and a single phase of Proposed Development (Onshore) to 2050 29
Table 4-11: Annual GHG Emissions associated with the decommissioning of Caledonia North and a single phase of the Proposed Development (Onshore) 31
Table 4-12: Comparison of Caledonia North and a single phase of the Proposed Development (Onshore) Construction Emissions to UK Carbon Budgets 32
Table 4-13: GHG Emissions associated with the Construction of Caledonia South and a single phase of the Proposed Development (Onshore) 35
Table 4-14: Annual GHG Emissions associated with the operation of Caledonia South and a single phase of the Proposed Development (Onshore) to 2050 36
Table 4-15: Annual GHG Emissions associated with the Decommissioning of Caledonia South and a single phase of the Proposed Development (Onshore) 38
Table 4-16: Comparison of Caledonia South and a single phase of the Proposed Development (Onshore) to UK Carbon Budgets 39
Table 4-17: GHG Emissions associated with the construction of the Proposed Development 43
Table 4-18: Annual GHG Emissions associated with the operation of the Proposed Development to 2050 44
Table 4-19: Annual GHG Emissions associated with the decommissioning of the Proposed Development 45
Table 4-20: Comparison of the Proposed Development to UK Carbon Budgets 47
Table 4-21: Additional Mitigation Hierarchy 51

Table 4-22: Summary of Effects for GHG Emissions 53

Acronyms and Abbreviations

BNG	Biodiversity Net Gain
BRE	Building Research Establishment
CIA	Cumulative Impact Assessment
CMS	Construction Method Statement
CEMP	Construction Environmental Management Plan
DE	Design Envelope
DESNZ	Department for Energy Security and Net Zero
DEFRA	Department for Environment, Food and Rural Affairs
DM Scenario	Do-Minimum Scenario
DS Scenario	Do-Something Scenario
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
EMP	Environmental Management Plan
EU	European Union
GHG	Greenhouse Gas
GW	Gigawatt
GW	Gigawatt hour
ICE	Inventory of Carbon and Energy
IEMA	Institute of Environmental Management & Assessment
kW	Kilowatt
kWh	Kilowatt hour
LCA	Life Cycle Assessment

LETI	Low Energy Transformation Initiative
MHWS	Mean High Water Springs
MW	Megawatt
MWh	Megawatt hours
MD-LOT	Marine Scotland Licensing Operations Team
NDC	Nationally Determined Contribution
NETS	National Electricity Transmission System
NPF	National Planning Framework
OfTI	Offshore Transmission Infrastructure
OnTI	Onshore Transmission Infrastructure
OSP	Offshore Substation Platform
OWF	Offshore Wind Farm
PAS	Publicly Available Specification
PPP	Planning Permission in Principle
RICS	Royal Institution of Chartered Surveyors
RLB	Red Line Boundary
tCO_2e	Tonnes of carbon dioxide equivalent
UK	United Kingdom
UNFCCC	United Nations Framework Convention on Climate Change
WLCA	Whole Life Carbon Assessment
WTG	Wind Turbine Generator
ZoI	Zone of Influence

Executive Summary

This chapter of Volume 6 of the Environmental Impact Assessment Report (EIAR) assesses the potential effects on Greenhouse Gas (GHG) emissions from the construction, operation and decommissioning of the Caledonia Offshore Wind Farm (OWF). The Caledonia OWF comprises, Caledonia North and Caledonia South, collectively referred to as the Proposed Development (Offshore) and the Onshore Transmission Infrastructure, (OnTI) required to transfer the power from the Proposed Development (Offshore) to a connection to the National Electricity Transmission System (NETS), referred to as the Proposed Development (Onshore). The assessment approach captures both direct and indirect GHG emissions arising as a result of the Proposed Development (Offshore) and Proposed Development (Onshore) combined.

The impact assessment takes into account the embedded mitigation of the Proposed Development including:

- Development of and adherence to a Construction Method Statement (CMS);
- Development of and adherence to an Offshore Environmental Management Plan (EMP); and
- Development of a Construction Environmental Management Plan (CEMP).

Aligning with Institute of Environmental Management and Assessment (IEMA) (IEMA, 2022[25]) guidance the emissions attributable to the Proposed Development have been calculated against the UK National Carbon Budgets. For the Proposed Development (Onshore) and Proposed Development (Offshore) the assessment conclusions are as follows:

- The GHG emissions assessment considered the construction materials (A1-3), construction processes (A4-5), the operational use stage (B), the decommissioning stage (C), and any benefits and loads beyond the boundary of the Proposed Development (D) such as land use and blue (marine) carbon sequestration.
- The GHG emissions assessment results for the Proposed Development (Onshore) and Proposed Development (Offshore) combined were between 4,685,282 – 4,987,854 tCO_2e for construction, 343,100 – 365,573 tCO_2e for operational maintenance and 954,761 – 1,013,953 tCO_2e for decommissioning. There are also GHG emissions impacts associated with land use and blue carbon change as a result of the Proposed Development (Onshore) and Proposed Development (Offshore). A range has been provided for the GHG emissions results to account for the design decisions still to be made for the number and size of the Wind Turbine Generators (WTGs). The WTG configurations will be confirmed at detailed design.
- The significance conclusion for the construction and decommissioning phases of the Proposed Development is minor adverse (not significant) due to the increase in emissions associated with construction/decommissioning materials and processes. The conclusion for the operation of the Proposed Development is significant beneficial due to the generation of low carbon electricity, aligning with IEMA guidance (IEMA, 2022[25]). Overall, for the Proposed Development (Onshore) and the Proposed Development (Offshore) combined the assessment conclusions are significant beneficial, when considering the needs case for helping the UK and Scotland achieve national carbon targets of net zero by 2050 and 2045 respectively.

- In line with best practice, the whole life GHG emissions associated with construction, maintenance and decommissioning of the Proposed Development, would seek to be reduced as far as practicable.
- No potential in-combination effects for GHG emissions were identified.

Considering additional mitigation measures, minimising GHG emissions through design is a core principle of the UK Government's Infrastructure Carbon Review (H.M. Treasury, 2013[1]) and the Publicly Available Specification (PAS) 2080:2023 specification of infrastructure and buildings carbon management (BSI, 2023[27]). The PAS 2080 carbon management hierarchy should also be used by the Caledonia Offshore Wind Farm (the Applicant) design team when developing the design of the Proposed Development including considering opportunities to "*Build nothing, Build less, Build clever, Build efficiently*".

Given the nature and scale of the Proposed Development it is expected that there will be residual construction and decommissioning-related emissions associated with the Proposed Development. However, the Proposed Development is, by design, reducing national emissions and Scotland's and the United Kingdom (UK)'s reliance on fossil fuels within the national electricity generation and transmission system.

4 Greenhouse Gas Emissions

4.1 Introduction

4.1.1.1 This chapter of the Environmental Impact Assessment Report (EIAR) identifies the potential effects on Greenhouse Gas (GHG) emissions associated with the construction, operation and decommissioning of the Proposed Development covering both the offshore (marine) and onshore (terrestrial) environments. This chapter also discusses appropriate mitigation and monitoring as required to address any significant effects.

4.1.1.2 The Caledonia Offshore Wind Farm (OWF) comprises, Caledonia North and Caledonia South, collectively referred to as the Proposed Development (Offshore) and the Onshore Transmission Infrastructure (OnTI) required to transfer the power from the Proposed Development (Offshore) to a connection to the National Electricity Transmission System (NETS), referred to as the Proposed Development (Onshore).

4.1.1.3 Collectively, the Proposed Development (Offshore) and Proposed Development (Onshore) are referred to as the "Proposed Development".

4.1.1.4 This chapter is supported by the following technical appendices:

- Volume 7F, Appendix 4-1: Greenhouse Gases, which provides full details of the assessment methodology, assumptions and conclusions; and
- Volume 7F, Appendix 3-3: Climate Change Policy, which provides further detail on the legislation, policy and guidance relating to the GHG emissions assessment.

4.1.1.5 Throughout this chapter, the term 'carbon' is used as a shorthand to refer to all GHG[i], consequently there may be instances where the terms are used interchangeably.

4.2 Legislation, Policy and Guidance

4.2.1.1 Volume 1, Chapter 2: Legislation and Policy, of this EIAR sets out the policy and legislation associated with the Proposed Development.

4.2.1.2 Legislation, Policy and Guidance that relate to the GHG emissions assessment are identified and described in Table 4-1

[i] The 'basket' of GHGs defined under the Kyoto Protocol (which will form the basis of this assessment) comprises carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3).

Table 4-1: Legislation Policy and Guidance

Relevant Legislation, Policy, and Guidance	Description
The Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017 (Scottish Parliament, 2017[2]) Marine Works (Environmental Impact Assessment) Regulations 2007 (as amended) (HM Government, 2007[3]) (for Scottish offshore waters) and the Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017 (as amended) (Scottish Government, 2017[4]) (for Scottish inshore waters) Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017 (as amended) (Scottish Government, 2017a[5]).	The EIA regulations require assessments to include climate change (including both mitigation of GHG emissions and adaptation/vulnerability of projects) within the assessment and decision-making process.
Kyoto Protocol (United Nations Framework Convention on Climate Change (UNFCCC), 1997[6])	An international treaty that extends the UNFCCC and commits member parties to reducing GHG emissions.
The Paris Agreement (UNFCCC, 2015[7])	A legally binding treaty whereby signatories pledge to limit the increase in global temperatures to well below 2°C, and to aim for 1.5°C, above pre-industrial levels.
Climate Change Act 2008 (United Kingdom (UK) Parliament, 2008[8])	UK legislation to address climate change, committing the UK to the reduction and reporting of GHG emissions. It also stipulates the requirements for a national adaptation programme and the periodic publication of a climate change risk assessment every five years.
Climate Change Act 2008 (2050 Target Amendment) Order 2019 (UK Parliament, 2019[9])	An amendment to the Climate Change Act 2008[8], outlining the UK's net zero target by 2050.
Carbon Budget Order 2009 (UK Government, 2009[10]) Carbon Budget Order 2011 (UK Government, 2011[11]) Carbon Budget Order 2016 (UK Government, 2016[12]) Carbon Budget Order 2021 (UK Government, 2021[13])	Sets out the UK's carbon budgets for the budgetary periods 2008-2012, 2013-2017, and 2018-2022. Sets out the UK's fourth carbon budget for the 2023-2027 budgetary period. Sets out the UK's fifth carbon budget for the 2028-2032 budgetary period. Sets out the UK's sixth carbon budget for the 2033-2037 budgetary period.

Relevant Legislation, Policy, and Guidance	Description
UK Nationally Determined Contribution (NDC) (UK Government, 2022[14])	Sets out the UK's commitment to reducing economy wide GHG emissions by at least 68% by 2030, compared to 1990 levels.
Construction 2025: UK Government Construction Industry Strategy (Department for Business, Innovation and Skills, 2013[15])	A UK Government strategy paper that sets out how efficiency improvements will be created in construction, covering sustainability and carbon, and including a target to reduce emissions by 50%.
UK Clean Growth Strategy (Department for Business, Energy and Industrial Strategy, 2017[16])	This aims to achieve economic growth while reducing greenhouse gas emissions. This strategy introduced carbon budgets and the Climate Change Act.
Net Zero Strategy: Build Back Greener (Department for Energy Security and Net Zero (DESNZ), 2022[17])	This sets out policies and proposals for decarbonising all sectors of the economy to meet the net zero target by 2050.
Powering Up Britain: Net Zero Growth Plan (DESNZ, 2023[18])	This provides additional detail on the Just Transition of the main sectors of the UK economy and delivering the UK Government's commitments to net zero by 2050, as set out in the Carbon Budget Delivery Plan[19]
Carbon Budget Delivery Plan (DESNZ, 2023[19])	The delivery plan outlines a comprehensive set of proposals and policies aimed at ensuring that the UK carbon budgets are achieved.
Climate Change (Scotland) Act 2009 (Scottish Government, 2009[20]) The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 (Scottish Government, 2019[21])	The act commits Scotland to GHG emissions reduction and reporting, creation of and update to a climate adaptation programme, and regular updates to both GHG and adaptation reporting.
National Planning Framework 4 (NPF4) (Scottish Government, 2023[22])	Scotland's plan on how to tackle and adapt to climate change, and how to make progress towards the target of net zero emissions, including the importance of offshore renewables in transitioning to net zero.
Update to the Climate Change Plan 2018 – 2032 (Scottish Government, 2020[23])	The update to the Scottish Government's legislative commitment to reduce emissions by 75% by 2030 and to reach net-zero by 2045. Includes a focus update policy to continue the growth of renewable energy generation.

Relevant Legislation, Policy, and Guidance	Description
Scottish Energy Strategy (Scottish Government, 2017[24])	The Scottish Government's ambition to capitalise on the potential that offshore wind development can bring to Scotland and the role this technology could play in meeting our commitment to reach net zero by 2045.
Institute of Environmental Management & Assessment (IEMA) Guide to: Assessing Greenhouse Gas Emissions and Evaluating their Significance (IEMA, 2022[25])	This guidance provides a framework for assessing greenhouse gas emissions in EIA.
IEMA GHG Management Hierarchy (IEMA, 2020[26])	A framework for carbon and GHG emissions management and supports net zero approaches in EIA mitigation and planning documents.
Publicly Available Specification (PAS) 2080:2023 Carbon Management in buildings and infrastructure (British Standards Institute, 2023[27])	This framework ensures consistent and transparent quantification of carbon at key points in infrastructure delivery, promoting data sharing along the value chain. This is the main carbon management and reduction guidance document available for infrastructure projects.
Royal Institution of Chartered Surveyors (RICS) Whole Life Carbon Assessment for the built environment (2nd edition) Version 2 (RICS, 2023[28])	This standard, effective from 1 July 2024, is used to consistently and accurately measure carbon emissions in the built environment. This includes guidance for the production of consistent whole life carbon assessments.
Low Energy Transformation Initiative (LETI) Embodied Carbon Primer (LETI, 2020[29])	Guidance for embodied carbon calculations and reduction strategies used in buildings. This document provides benchmarks that are helpful within the carbon accounting process.
BS EN 17472:2022 Sustainability of construction works – sustainability assessment of civil engineering works – calculation method (British Standards Institute, 2022[30])	The lifecycle assessment methodology of infrastructure projects through pre-construction, construction, use and end of life stages.

4.3 Stakeholder Engagement

4.3.1 Overview

4.3.1.1 The Offshore Scoping Report was submitted to Marine Directorate Licensing Operations Team (MD-LOT)[ii] in September 2022, who then circulated the report to relevant consultees. A Scoping Opinion was received from MD-LOT on 13 January 2023. Similarly, the Onshore Scoping Report was submitted to Aberdeenshire Council in December 2022, who then circulated the report to relevant consultees. A Scoping Opinion was received from Aberdeenshire Council on 1 February 2023 and no specific responses relevant to GHG Emissions were received. Relevant comments from the Proposed Development (Offshore) Scoping Opinion specific to the GHG emissions assessment are provided in Table 4-2.

[ii] In 2023, Marine Scotland was renamed Marine Directorate, and thus the marine licensing and consents team is now referred to as Marine Directorate Licensing Operations Team (MD-LOT).

Table 4-2: Scoping Opinion Response (Offshore)

Consultee	Comment	Response
MD-LOT	The Scoping Report proposes that the impact of climate change effects will be considered as a standalone climate receptor topic which is a welcomed approach. The Scottish Ministers are mindful that Greenhouse Gas ("GHG") emissions from all projects contribute to climate change. In this regard, the Scottish Ministers highlight the IEMA Environmental Impact Assessment Guide "Assessing Greenhouse Gas Emissions And Evaluating Their Significance" ("IEMA GHG Guidance"), which states that "GHG emissions have a combined environmental effect that is approaching a scientifically defined environmental limit, as a such any GHG emissions or reductions from a project might be considered significant." The Scottish Ministers have considered this together with the Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 and the requirement of the EIA Regulations to assess significant effects from the Proposed Development on climate. For the avoidance of doubt, the Scottish Ministers therefore advise that the EIA Report must include a GHG Assessment which should be based on a Life Cycle Assessment ("LCA") approach and note that the IEMA GHG Guidance provides further insight on this matter. The Scottish Ministers highlight however that this should include the pre-construction, construction, operation and decommissioning phases, including consideration of the	This approach has been adopted in preparation of this chapter of the EIAR and confirmed through the formal scoping process. IEMA Guidance (IEMA, 2022[25]) has been followed (see Section 4.5) and cognisance given to the Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 (Scottish Parliament, 2019[21]) through the assessment of significance. The 2022 IEMA guidance provides further nuance to the assessment of significance for GHG emission assessments, stating "the crux of significance therefore is not whether a project emits GHG emissions, nor even the magnitude of GHG emissions alone, but whether it contributes to reducing GHG emissions relative to a comparable baseline consistent with a trajectory towards net zero". This chapter of the EIAR includes a GHG assessment based on a Life Cycle Assessment (LCA) approach.

Consultee	Comment	Response
	supply chain as well as benefits beyond the life cycle of the Proposed Development.	
MD-LOT	The Developer sets out the baseline data sources used regarding climate in Table 18.1 of the Scoping Report. The Scottish Ministers agree with the NatureScot representation that a blue carbon assessment should be undertaken in addition to the assessments listed in paragraph 18.1.1.2 of the Scoping Report as outlined above in section 5.3 of this Scoping Opinion. The Scottish Ministers are otherwise content with the baseline data sources and the approach to the baseline environment.	A blue carbon assessment has been prepared as part of this chapter of the EIAR. The blue carbon assessment is presented throughout this chapter, with further details provided in Volume 7F, Appendix 4-1: Greenhouse Gases.
MD-LOT	In Table 18.5 of the Scoping Report the Developer summarises the potential impacts to climate during the different phases of the Proposed Development. The Scottish Ministers agree with the impacts scoped into the EIA Report but advise that consideration of the carbon cost of the wind farm (including supply chain) and to what extent this is offset through the production of green energy should also be scoped into the EIA Report in line with the NatureScot representation. The Developer must fully address the representation from NatureScot in the EIA Report.	An assessment of the embodied carbon of the Proposed Development compared with the renewable energy generation has been addressed through undertaking an assessment in line with the latest IEMA GHG assessment guidance (i.e. assessing significance against a trajectory towards net zero). The results of the assessment of embodied carbon of the Proposed Development against the renewable energy generated are presented in Section 4.7: Potential Effects.
NatureScot	The impact of climate change effects should be considered, both in future proofing the project design and how certain climate stressors may work in combination with potential	Volume 6, Chapter 3: Climate Change Resilience considers the impact of climate change effects both on the Proposed Development and on other environmental receptors. This

Consultee	Comment	Response
	effects from the proposed wind farm. The EIA Report should also consider the carbon cost of the wind farm (including supply chain) and to what extent this is offset through the production of green energy	chapter provides an assessment of the embodied carbon of the Proposed Development compared with the renewable energy generation has been addressed through undertaking an assessment in line with the latest IEMA GHG assessment guidance (i.e. assessing significance against a trajectory towards net zero). The results of the assessment of embodied carbon of the Proposed Development against the renewable energy generated are presented in Section 4.7: Potential Effects.
NatureScot	In additional to the climate change assessments mentioned in the scoping report, we advise that a blue carbon assessment is undertaken. This should expand on the information and assessment conducted for benthic ecology to focus on the potential impacts of the proposed development on marine sediments.	A blue carbon assessment has been prepared as part of this chapter of the EIAR. The blue carbon assessment is presented throughout this chapter, with further details provided in Volume 7F, Appendix 4-1: Greenhouse Gases. The assessment aligns with the approach taken within Volume 2, Chapter 4: Benthic Subtidal and Intertidal Ecology and Volume 2, Chapter 3: Marine Water and Sediment Quality.

4.4 Baseline Characterisation

4.4.1 Study Area

4.4.1.1 Aligning with 2022 IEMA guidance[25], the baseline (Do-Minimum (DM) scenario) is the reference against which the impact of the Proposed Development will be compared and assessed. Assumptions are made on the projected aggregated GHG emissions over the temporal scope under this DM scenario. The DM scenario comprises the aggregated GHG emissions within the study area without implementation of the Proposed Development over the study period.

4.4.2 Data Sources

Desk Study

4.4.2.1 The data sources that have been used to inform this GHG emissions assessment chapter of the EIAR are presented within Table 4-3.

Table 4-3: Summary of key publicly available datasets for GHG emissions

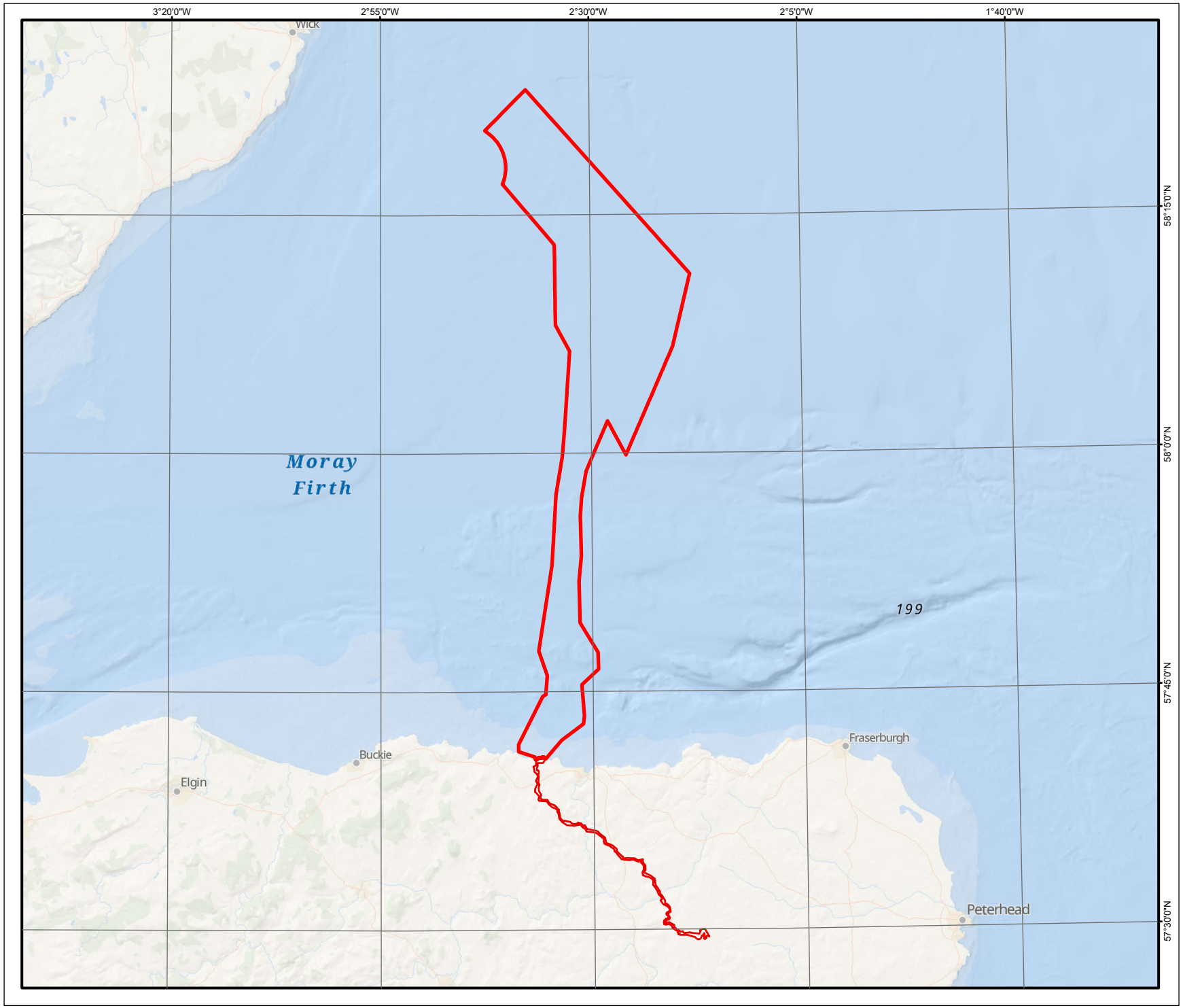
Title	Year	Author
Whole life carbon assessment (WLCA) for the built environment	2023	RICS[28]
UK Government GHG Conversion Factors for Company Reporting V1.1	2023	DESNZ and DEFRA[31]
Inventory of carbon and energy (ICE) Database V3	2019	Circular ecology[32]
Carbon Storage and Sequestration by Habitat 2021 (NERR094)	2022	Natural England[33]
Sediment type and surficial sedimentary carbon stocks across the United Kingdom's Exclusive Economic Zone and the territorial waters of the Isle of Man and the Channel Islands	2021	Marine Scotland and University of St Andrews[34]

Site Specific Surveys

4.4.2.2 No site-specific surveys are required for the GHG emissions assessment.

4.4.3 Baseline Description

4.4.3.1 The study area for the GHG emissions assessment is the construction footprint of the Proposed Development, including both temporary and completed works within the within the consent boundaries, refer to Figure 4-1.



Proposed Development (Offshore) Application Area

Onshore Transmission Infrastructure Red Line Boundary

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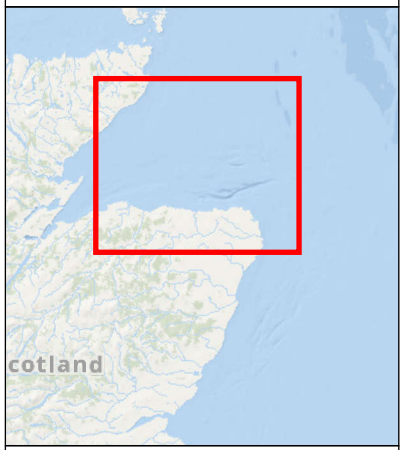

0 5 10 15 20 km

REV	DATE	DOC STATUS	ORIGIN	REVIEW	APP
03	30/08/2024	Approved	CW	KL	EC
02	19/08/2024	For Review	CW	KL	EC
01	17/05/2024	For Review	CW	JN	EC

CALEDONIA Offshore Wind Farm

ARUP

CONTRACTOR DRAWING NO: UKCAL1_ARP_WNF_ENV_MAP_00543

CONTRACTOR REV: 03

GEODETIC PARAMETERS: WGS 84 / UTM Zone 30N (EPSG:32630)

DRAWING TITLE

Figure 4-1: GHG Emissions Study Area

STATUS: Approved

SCALE: 1:600,000

DRAWING NUMBER: N/A

SHEET NO: 01 of 01

REV: N/A

4.4.3.2 The GHG baseline is the continuation of the current situation in which the Proposed Development is not delivered. The GHG emissions assessment baseline is informed by the habitats as described in the Biodiversity Net Gain (BNG) calculations within Volume 7E, Appendix 3-1: Biodiversity Enhancement Report. The GHG Emissions baseline of the onshore terrestrial environment, and the offshore natural marine environment are not expected to change.

4.4.3.3 Baseline GHG emissions for the Proposed Development are summarised in Table 4-4 below. These emissions represent the sequestered carbon as a result of the annual carbon stored by the habitat type. This activity has been converted into equivalent carbon emissions and are a negative figure to demonstrate the sequestration of emissions from the environment, as opposed to release of emissions.

Table 4-4: Annual baseline GHG emissions for the Proposed Development

Emissions Source	GHG Emissions per year (carbon dioxide representative, tCO_2e)
Stage D – land use and forestry emissions associated with onshore elements of the Proposed Development	-284.65
Stage D – Blue carbon associated with organic carbon sources offshore	-97.15 to -110.19

4.4.3.4 The baseline GHG emissions for the Proposed Development summarised in Table 4-4 represent the sequestration benefits from the totality of all habitat types within the OnTI Red Line Boundary (RLB). The quantification of emissions of the Proposed Development (Onshore) provides an overestimation of the total benefit in the baseline as, in reality, disturbance associated with the construction of the Proposed Development (Onshore) will be limited to the 100m cable corridor area, and this 100 metres (m) cable corridor will only represent a portion of the OnTI RLB area. However, as the assessment of impact will similarly consider the full OnTI RLB area this overestimation within the baseline will have minimal effect on the GHG emissions assessment.

4.4.4 Data Gaps and Limitations

4.4.4.1 The assessment methodology for the EIAR is based upon the information available at the time of assessment. In some cases, it has been necessary to draw on benchmark information and make conservative assumptions to provide a reasonable worst-case scenario for the particular project element or factor to provide a precautionary assessment. This reduces the risk of under estimating the total emissions, despite any gaps in accurate information at time of assessment. Professional judgement has been used where required to

adopt appropriate benchmark data (in line with good practice as set out in PAS 2080[27]).

4.4.4.2 Assumptions/judgements in each case have been made from either:

- Emerging design detail;
- Engineering specialist knowledge;
- Environmental specialist knowledge;
- Climate change/carbon specialist knowledge;
- Manufacturer specifications; or
- Suitable proxy data from previous projects.

4.4.4.3 Good practice for the quantification of GHG emissions requires the definition of a study period, which is typically chosen to reflect the service life of an infrastructure asset. This is particularly important as part of a lifecycle carbon management approach whereby impacts from construction and operation must all be considered in order to make informed decisions on design and delivery of a project. For this assessment, the study period for the Proposed Development (Onshore) and Proposed Development (Offshore) combined is 40 years which includes the full duration of construction, the operational period, and completion of decommissioning in 2067.

4.4.4.4 Further information on assessment assumptions and limitations is provided in Volume 7F, Appendix 4-1: Greenhouse Gases.

4.5 EIA Approach and Methodology

4.5.1 Overview

4.5.1.1 This section outlines the methodology for assessing the likely significant effects on GHG emissions from the construction, operation and decommissioning of the Proposed Development. Full details of the methodology, including relevant assumptions and limitations, can be found in Volume 7F, Appendix 4-1: Greenhouse Gases.

4.5.2 Impacts Scoped in to the Assessment

4.5.2.1 The Offshore Scoping Report was submitted to MD-LOT in September 2022, while the Onshore Scoping Report was submitted to Aberdeenshire Council in December 2022. The Scoping Reports set out the overall approach to assessment and allowed for the refinement of the Proposed Development over the course of the assessment. The proposed scope of the assessment is set out in Table 4-5.

Table 4-5: GHG Emissions Scope of Assessment

Potential Impact	Phase	Nature of Impact
GHG Emissions	Construction	Direct
GHG Emissions	Operation	Direct
GHG Emissions	Decommissioning	Direct

4.5.3 Impacts Scoped out of the Assessment

4.5.3.1 No impacts from GHG emissions were scoped out of the assessment at scoping.

4.5.4 Assessment Methodology

4.5.4.1 The project-wide approach to assessment is set out in Volume 1, Chapter 7: EIA Methodology. The assessment methodology for GHG Emissions for the EIAR is consistent with that provided in both the Onshore and Offshore Scoping Reports.

4.5.4.2 The GHG emissions assessment provides an assessment of significance using three scenarios and, within each, assessing the reasonable worst case, i.e. selecting the Proposed Development parameters that represent the greatest aggregate GHG emissions. These scenarios are:

- Caledonia North and a single phase of the Proposed Development (Onshore);
- Caledonia South and a single phase of the Proposed Development (Onshore); and
- Combined assessment considering the Proposed Development (Offshore) and the Proposed Development (Onshore), as per the Cumulative Effects Assessment in Section 4.5.5.

4.5.4.3 When considering a single phase of the Proposed Development (Onshore) a representative scenario is assumed in which half of the OnTI is constructed, and as such, the GHG emissions for half of the Proposed Development (Onshore) are considered within the assessment of significance for these scenarios.

4.5.4.4 The methodology for the assessment of GHG emissions is set out in full in Volume 7F, Appendix 4-1: Greenhouse Gases. An overview is provided in the following sections.

4.5.4.5 The scope for the GHG emissions accounting process is defined according to the lifecycle of the Proposed Development in the built environment. The lifecycle approach is adopted to capture both direct and indirect GHG emissions arising as a result of the Proposed Development.

4.5.4.6 The GHG emissions assessment is carried out across the following Proposed Development scope and lifecycle phases:

- Product stage (A1-3): Emissions calculated for this phase are from the extraction and supply of raw materials, their transport to any manufacturing plant/location, and any subsequent manufacturing process;
- Construction stage (A4-5): Emissions calculated for this phase are primarily concerned with the transportation of materials, plant and people to and from the construction site, the energy consumed through plant use, and the impacts associated with any waste generated through the construction process, including waste treatment and disposal;
- Use stage (B): Use stage emissions refer to the operation of the built asset and the maintenance, repair and replacement of assets over life cycle of the Proposed Development;
- Decommissioning (C): at the time of writing decommissioning plans for the Proposed Development are not known. As a result, GHG emissions associated with the decommissioning phase of the Proposed Development have been estimated as equivalent to the construction phase emissions to account for deconstruction and transport allowance. Waste processing and disposal emissions have been calculated using a benchmark; and
- Benefits and loads beyond the system boundary (D): the renewable energy generation, and the land use and marine blue carbon that will be disturbed/planted as a result of the Proposed Development.

4.5.4.7 The assessment seeks to understand the scale of changes in GHG emissions and the materiality of these on the ability of the UK Government to meet its climate obligations.

4.5.4.8 Since the Scoping Report was submitted, the lifecycle stages included in the assessment have been updated following a review of available project design data. The elements which have been included and excluded from assessment are summarised in Table 4-6.

Table 4-6: Summary of GHG components within the assessment

Emission source	Summary of assessment methodology	Data sources used in assessment
Stage A – Before Use		
Product Stage (A1-3)		
Material Supply	Emissions associated with the raw materials required for construction of all the Proposed Development onshore and offshore components have been calculated based on material quantities and carbon factors for each material type.	Design Envelope (DE) information as provided within Volume 1, Chapters 3, and 4 ICE V3.0, (Circular Ecology, 2019[32])
Construction Stages (A4-5)		
On-site Construction Activities	Emissions associated with the transport of material to site and the construction/assembly process have been estimated based on a typical scaling ratio between product stage (A1-3) and construction stage (A4-5) emissions for building projects.	London Energy Transformation Initiative Embodied Carbon Primer, (LETI, 2020[29])
Transport of Materials to Works Site	Emissions associated with transportation of materials from the manufacturer to site have been calculated by converting material volumes to material mass using typical densities for each material. Emissions have been calculated using the following formula: *transport distance x material mass x carbon conversion factor (average heavy goods vehicle (HGV) or average container ship)*	ICE V3.0, (Circular Ecology, 2019[32]) UK GHG Conversion Factors, (DESNZ & DEFRA, 2023[31]) Whole life carbon assessment for the built environment (RICS, 2023[28])
Stage B – Use		
Maintenance of Onshore Assets	Emissions associated with the maintenance of the onshore assets during their use have been calculated based on the A1-5 emissions, assuming that 1% of these emissions would equate to the scale of emissions from maintenance activities.	London Plan Guidance for Whole Life-Cycle Carbon Assessments, 2022, referenced within Whole life carbon assessment for the built environment, (RICS, 2023[28])
Repair of Onshore Assets	Emissions associated with the repairs of the onshore assets during their use have been calculated based on the assumed maintenance emissions. Assuming that, 25% of maintenance activity emissions would equate to the	Whole life carbon assessment for the built environment (RICS, 2023[28])

Emission source	Summary of assessment methodology	Data sources used in assessment
	scale of emissions associated with repair activities.	
Maintenance, repair and replacement of Offshore Assets	Emissions associated with the maintenance, repair and replacement of offshore assets during their use have been calculated as an assumed percentage of *Stage A – Before Use stage* emissions.	Whole life carbon assessment for the built environment (RICS, 2023[28])
Stage C – End of Life		
End of Life Stages (C1-4)		
Deconstruction of Assets	Emissions associated with the assumed deconstruction of the assets at end of life have been calculated on the assumption that the reuse of all materials will be prioritised and promoted. Deconstruction emissions are calculated based on the A5 construction activity emissions, assuming that 50% of these emissions would equate to the scale of emissions from deconstruction activities.	Whole life carbon assessment for the built environment, (RICS, 2023[28])
Transport of Waste	The emissions associated with the transport and removal of all products and materials from site to the assumed end of life waste processing or disposal centre has been calculated as the same transport emissions associated with all products and materials during construction, at A4.	Volume 7F, Appendix 4-1: Greenhouse Gases
Waste Processing	Waste processing emissions associated with each material waste stream have been calculated based on default end-of-life scenarios at a material level for the UK, by a benchmark proportion of material mass.	Whole life carbon assessment for the built environment (RICS, 2023[28])
Disposal of Waste	Waste disposal emissions associated with each material waste stream have been calculated based on default end-of-life scenarios at a material level for the UK, by a benchmark proportion of material mass.	Whole life carbon assessment for the built environment (RICS, 2023[28])
Stage D – Benefits beyond the boundary		
Land Use	Emissions associated with habitat types lost, and benefits accrued from	BNG habitat types for the OnTI RLB as per Volume 5, Chapter

Emission source	Summary of assessment methodology	Data sources used in assessment
	new habitat creation, as a result of the Proposed Development.	3: Terrestrial Ecology and Biodiversity. Carbon storage factors are based upon the Natural England, 2021 paper[33].
Peat Soil	Emissions associated with release of carbon stored within peat soil as a result of excavation for the Onshore Export Cable.	Peat information from Volume 7E, Appendix 7-2: Peat Survey Reports. Carbon factors from the Natural England, 2021[33] paper
Blue Carbon	Emissions associated with disturbance of the ocean habitats and sea floor sediments. For this assessment, only sediments are included within the calculations.	Disturbance rates from DE within Volume 1, Chapters 3 (Proposed Development Description (Offshore)) and 4 (Proposed Development Description (Onshore)). Carbon factors from Cunningham & Hunt, 2023[35]
Electricity Generation	Generation of electricity per year (Megawatt hours (MWh)) from the Proposed Development is calculated from the installed capacity in Megawatt (MW), factoring in the long-term average load factor for offshore wind in the UK. This assessment calculates the estimated carbon emissions from the generation of the equivalent amount of electricity via the UK National Grid. These emissions are considered avoided via the generation provided by the Proposed Development.	DESNZ long-term average load factor for offshore wind[36]. Generation Based Long-run Marginal Electricity emissions factors to 2100[37]

4.5.5 Approach to Cumulative Effects

4.5.5.1 The Cumulative Impact Assessment (CIA) assesses the impact associated with the Proposed Development together with other relevant plans, projects and activities. Cumulative effects are therefore the combined effect of the Proposed Development in aggregate with the effects from other identified projects, on the same receptor or resource.

4.5.5.2 GHG emission impacts and resulting effects are global, hence the GHG emissions have been assessed against national carbon targets which represent the international consensus on reducing global GHG concentrations, in line with IEMA guidance (IEMA, 2022[25]).

4.5.5.3 The cumulative effects assessment for the GHG emissions chapter considers Caledonia North, Caledonia South and the Proposed Development (Onshore). The GHG Emissions associated with the Proposed Development is reported using the same assessment methodology. The cumulative assessment does not extend to other projects beyond these in the area.

4.5.6 Embedded Mitigation

4.5.6.1 Where possible, GHG mitigation measures will be embedded into the design of the Proposed Development.

4.5.6.2 Where embedded mitigation measures have been developed into the design of the Proposed Development with specific regard to GHG emissions, these are described in Table 4-7. The impact assessment presented in Sections 4.7 to 4.9 takes into account this embedded mitigation.

4.5.6.3 A Construction Environmental Management Plan (CEMP) will also be produced for the Proposed Development (Onshore) which will include standard construction working practices, such as:

- The appointment of a site manager that will manage waste generated by the development using a bespoke version of the Building Research Establishment (BRE) SMARTWaste Plan. The Applicant will use this plan to identify waste streams, forecast waste volumes and identify suitable methods to eliminate, or where this is not practicable, reduce waste generated by the Proposed Development;
- The burning of materials or waste on site will not be permitted;
- Best practice measures and an environmental toolbox of procedures that will minimise the risk and in the event of an incident, will seek to mitigate the environmental impacts. These will ensure minimal loss of carbon stock within vegetation and soil;
- Where practicable, measures will be implemented to manage material resource use during construction including:
  - using materials with lower embodied GHG emissions and water consumption;
  - using sustainably sourced materials; and
  - using recycled or secondary materials.
- Maximising efficient plant usage;
- Mains connected compound provided via a Green Tariff to provide lower carbon-intensive electricity for site operation and construction; and
- Local procurement, local labour and training – therefore reducing reliance on transportation of workforce and provision of accommodation.

Table 4-7: Embedded Mitigation

Code	Mitigation Measure	Securing Mechanism
M-3	Development of, and adherence to, a Construction Method Statement (CMS). The CMS will confirm construction methods and the roles and responsibilities of parties engaged in construction. It will detail any construction-related mitigation measures.	The CMS will be secured through a condition attached to the Planning Permission in Principle (PPP) and to be secured as a condition of the Generation Asset and Transmission Asset Marine Licences
M-8	Development of, and adherence to, an Offshore Environmental Management Plan (EMP). The Offshore EMP will set out mitigation measures and procedures relevant to environmental management, including but not limited to the following topics: Chemical usage, invasive non-native marine species, dropped objects, pollution prevention and contingency planning, and waste management.	To be secured as a condition of the Generation Asset and Transmission Asset Marine Licences
M-39	An Outline Construction Environmental Management Plan (CEMP) has been produced and included alongside the EIAR to support the PPP (Volume 7, Appendix 10: Outline Construction Environment Management Plan). The Outline CEMP includes measures on pollution prevention, noise control, biosecurity, and waste management. The Outline CEMP will then be developed further through the final design process and this will result in a detailed CEMP being submitted for discharge. The CEMP will be implemented to avoid, minimise or mitigate effects on the environment during the construction and decommissioning phases of the Proposed Development (Onshore).	Detailed CEMP secured through a condition attached to the PPP.

4.6 Key Parameters for Assessment

4.6.1.1 Volume 1, Chapter 3: Proposed Development Description (Offshore) and Volume 1, Chapter 4: Proposed Development Description (Onshore) detail the parameters of the Proposed Development using the Rochdale Envelope approach. This section identifies those parameters during construction, operation and decommissioning relevant to potential impacts on GHG emissions.

4.6.1.2 The reasonable worst-case assumptions with regard to GHG emissions are summarised in Table 4-8. Further details of all assumptions made within the GHG emissions assessment are documented in Volume 7F, Appendix 4-1: Greenhouse Gases.

Table 4-8: Realistic worst Case Assessment Scenario Considered for Each Impact as Part of the Assessment of Likely Significant Effects

Potential Impact	Assessment Parameter	Explanation
Construction		
GHG emissions associated with Proposed Development (Offshore) infrastructure	**Materials** *Proposed Development (Offshore)* Under a realistic worst case scenario this assessment assumes two scenarios; A maximum number of WTG scenario featuring: ▪ 140 WTG across both Caledonia North and Caledonia South. This scenario includes: o Caledonia South: 24 fixed monopile foundation WTGs & 39 semi-submersible floating foundation WTGs; and o Caledonia North: 77 fixed monopile foundation WTGs. A maximum WTG rating scenario across both Caledonia North and Caledonia South. This scenario includes: ▪ Caledonia South: 24 fixed monopile foundation WTGs & 29 semi-submersible floating foundation WTGs; and ▪ Caledonia North: 47 fixed monopile foundation WTGs. Array Area footprint of approximately 423 kilometres squared (km^2). Offshore Export Cable Corridor footprint of approximately 221.3km^2. Offshore Transmission Infrastructure (OfTI): ▪ Four Offshore Substation Platforms (OSPs) with monopile foundations; ▪ 60km interconnector cables;	The GHG Emissions associated with construction activities should be considered for a whole life carbon assessment, as per IEMA guidance (IEMA, 2022[25]). A key parameter for the Proposed Development (Offshore), as in Volume 1, Chapter 3: Proposed Development Description (Offshore), is a maximum of 140 WTG for the Proposed Development (Offshore). This assessment presents two scenarios for the Proposed Development: a maximum 140 WTG scenario of 15MW WTG and a Maximum Rating scenario of fewer, larger WTGs (100 WTGs rated 20-25MW). It also presents an individual worst case scenario of the maximum number of WTGs for Caledonia North (77 fixed monopile foundation WTGs) and Caledonia South (39 fixed monopile foundation WTGs & 39 semi-submersible floating foundation WTGs) individually. The following foundation types were considered for all ratings of WTGs and both array locations: ▪ Jacket with pin piles (bottom-fixed);

Potential Impact	Assessment Parameter	Explanation
	▪ 725km inter-array cable; and ▪ 330km Offshore Export Cable. *Caledonia North Alone* ▪ 77 fixed monopile foundation WTGs; ▪ Caledonia North Site footprint of approximately 218.5km^2; ▪ Offshore Export Cable Corridor footprint of approximately 221.3km^2; ▪ Two OSPs; ▪ One 30km interconnector cable; ▪ 360km inter-array cable; and ▪ 180km Offshore Export Cable. *Caledonia South Alone* ▪ 39 fixed monopile foundation WTGs; ▪ 39 semi-submersible floating foundation WTGs; ▪ Caledonia South Site footprint of approximately 204.5km^2; ▪ Offshore Export Cable Corridor of 221.3km^2; ▪ Two Offshore Substation Platforms (OSPs); ▪ One 30km interconnector cable; ▪ 365km inter-array cable; and ▪ 150km Offshore Export Cable. **Transportation** It is assumed that all Proposed Development (Offshore) components will arrive by sea to the selected port before being transported to be constructed. An assumption of 50km to the Proposed Development (Offshore) has been included for all offshore elements.	▪ Jacket with suction caissons (bottom-fixed); ▪ Monopile (bottom-fixed); ▪ Fully-restrained platform (bottom-fixed); ▪ Semi-submersible (floating); and ▪ Tension leg platform (floating). Through assessment of all foundation types it was determined that monopile foundations for fixed WTGs and semi-submersible foundations for floating WTGs result in greater emissions, therefore this assessment is presented with Monopile and Semi-submersible foundations forming a worst case scenario. For the assessment of Caledonia North and Caledonia South it was determined that the configurations presented are the realistic worst case scenarios from a GHG emissions perspective.

Potential Impact	Assessment Parameter	Explanation
	Construction Processes For all construction processes for the Proposed Development (Offshore), a benchmark percentage of material emissions has been applied to calculate equivalent construction activity emission.	
GHG Emissions associated with the Proposed Development (Onshore) infrastructure	**Materials** *Landfall Site* Up to four Offshore Export Cable Circuits will come to shore and will be connected to the Onshore Export Cable Circuits via four Transition Joint Bays (TJB) buried beneath the ground. Landfall Site (seaward of Landfall Site TJB) cables maximum outer diameter of 330mm. Maximum temporary land take at Landfall Site: 100m x 200m, 20,000 metres squared (m^2) Up to four TJBs (one TJB per export cable), permanent land take of approximately 65m^2. *Onshore Export Cable Corridor* Up to four Onshore Export Cable Circuits will exit the TJBs and be routed south-east inland towards the Onshore Substation Site. Onshore Export Cable Route length approximately 37km Onshore Export Cable Route width 100m Onshore Export Cable Circuits maximum outer diameter of 298mm. Target Burial depth 1m to top of cable. *Grid Connection Cable Corridor* 2 x Onshore Grid Connection Cable Circuits to connect the Onshore Substations to the Grid Connection Point at the existing New Deer Substation	The GHG Emissions associated with construction activities should be considered for a whole life carbon assessment, as per IEMA guidance (IEMA, 2022[25]).

Potential Impact	Assessment Parameter	Explanation
	(for Phase 1), located within an Onshore Grid Connection Cable Route (i.e., the working corridor) of up to 100m wide. **Onshore Substation Site** Two Onshore Substations will be co-located within the same Onshore Substation Site Permanent land take: 120,000m^2 Foundations for structures and equipment will be raft/slab or pad concrete foundations, founded on the in situ cut subgrade or on the recompacted fill. Approximate depth 750mm (Equipment slabs will be sized according to equipment sizes). The following buildings may be required: ▪ 4 x switchgear buildings; ▪ A control building; ▪ Steel framed and acoustically/weatherproof clad enclosures shunt reactors and SGTs; and ▪ A building to house control equipment for the SVC/STATCOM together with internal Thyristor/IGBT equipment. Maximum level of excavated material:75,000 metres cubed (m^3). **Transportation** Transportation of materials to the OnTI RLB has been estimated using assumed distances provided by the RICS guidance (RICS, 2023[28]). **Construction Processes** For all construction processes for the Proposed Development (Onshore), a benchmark percentage of construction material emissions has been used. **Land use and Peat soils**	

Potential Impact	Assessment Parameter	Explanation
	For all habitat types within the OnTI RLB of the Proposed Development (Onshore), a Natural England[33] carbon sequestration rate has been applied. Assumed area of peat soil excavation as per the worst case assumptions from Volume 7E, Appendix 7-2: Peat Survey Reports: ▪ 400m length; and ▪ 4m width.	
Operation		
GHG Emissions associated with the Proposed Development (Offshore) operations	The final Operation and Maintenance (O&M) strategy will be finalised post-consent and will be informed by the location of the O&M base(s) and the final design parameters of the Proposed Development (Offshore). The final O&M strategy will be implemented throughout the anticipated 35 years operational phase of the Proposed Development (Offshore). It is not anticipated that there will be the need for helicopters to be used during the O&M phase of the Proposed Development (Offshore). For all maintenance and replacement activities offshore, a benchmark percentage of construction emissions has been used. In addition, consideration has been made to the renewable energy generation as a result of the Proposed Development.	The GHG Emissions associated with operational activities should be considered for a whole life carbon assessment, as per IEMA guidance (IEMA, 2022[25]).
GHG Emissions associated with the Proposed Development (Onshore) operations	It is anticipated that the Onshore Substations will be unmanned and operate 24 hours a day, 7 days a week. It is anticipated that there would be weekly operational vehicles movements under normal operation, with more frequent movements during planned maintenance or repair works. No major refurbishment works at the Landfall Site and Onshore Export Cable Circuits are currently envisaged during the design life.	The GHG Emissions associated with operational activities should be considered for a whole life carbon assessment, as per IEMA guidance (IEMA, 2022[25]).

Potential Impact	Assessment Parameter	Explanation
	For all maintenance and replacement activities onshore, a benchmark percentage of construction emissions has been used, as per the RICS guidance (RICS, 2023[28]).	
Decommissioning		
GHG Emissions associated with the Proposed Development (Offshore) decommissioning	At the end of the operational lifetime of the Proposed Development (Offshore), it is anticipated that all structures above the seabed level will be completely removed. The decommissioning of Caledonia North and Caledonia South may or may not be carried out at the same time. The decommissioning sequence and method is anticipated to generally be the reverse of the construction sequence and involve similar types and numbers of vessels and equipment. Closer to the time of decommissioning, it may be decided that removal would lead to greater environmental impacts than leaving components in situ, in which case certain components may be cut at or below the seabed (e.g., piles) or left buried (e.g., inter-array, interconnector and offshore export cables). Waste rates provided by RICS guidance (RICS, 2023)[28] have been used for main material types from offshore elements. Recovery and disposal rates used as a benchmark percentage of construction emissions, as per RICS guidance.	The GHG Emissions associated with decommissioning activities should be considered for a whole life carbon assessment, as per IEMA guidance (IEMA, 2022[25]).
GHG Emissions associated with the Proposed Development (Onshore) decommissioning	At the time of decommissioning, it is likely that all underground equipment and the Onshore Substations foundations will remain in-situ. Above ground equipment at the Onshore Substation Site will be cleared and the site reinstated. Waste rates provided by RICS guidance (RICS, 2023[28]) have been used for main material types from the Onshore Substation Site, including aggregate, concrete, steel and plastic. Recovery and disposal rates used as a benchmark percentage of construction emissions, as per RICS guidance.	The GHG Emissions associated with decommissioning activities should be considered for a whole life carbon assessment, as per IEMA guidance (IEMA, 2022[25]).

4.7 Potential Effects

4.7.1 Caledonia North and a Single Phase of the Proposed Development (Onshore)

4.7.1.1 In line with IEMA guidance (2022[25]) the starting point for assessment of effects is to compare the future emissions arising from the comparison of Do-Something and Do-Minimum against the UK Carbon Budgets for those periods where budgets currently exist. The emissions attributable to the Caledonia North have been calculated for each of the five-year budget periods (Carbon Budget 4 from 2023-2027, Carbon Budget 5 from 2028-2032 and Carbon Budget 6 from 2033-2038) and are presented against the total UK Carbon Budgets (and the associated trajectory to net zero this reflects) in order to assess their significance.

4.7.1.2 For the GHG emissions assessment associated with Caledonia North and a single phase of the Proposed Development (Onshore), this assessment assumes a worst case scenario (in GHG emissions terms) of 77 fixed monopile foundation 15MW WTGs and 2 Offshore Platforms plus half of the GHG emissions associated with the Proposed Development (Onshore). Full details of the key parameters associated with Caledonia North and the Proposed Development (Onshore) are provided in Table 4-8.

Construction

4.7.1.3 The construction process generates GHG emissions directly and indirectly through the production or materials and onsite energy consumption. All assumptions used in the calculations are contained within Volume 7F, Appendix 4-1: Greenhouse Gases.

4.7.1.4 Table 4-9 presents the total GHG emissions across the construction period. The emissions relate to the construction of the Caledonia North and is presented across three main emissions sources: construction materials, material transport, and construction plant usage.

4.7.1.5 In addition, a single phase of the Proposed Development (Onshore) has been included within Table 4-9 below.

Table 4-9: GHG Emissions associated with the construction of Caledonia North and a single phase of the Proposed Development (Onshore)

Lifecycle Module	Lifecycle Description	Total GHG Emissions (tCO_2e)[iii]	% Total Construction GHG Emissions[iv]
Caledonia North			
A1-3	Materials	1,316,993	64.25%
A4	Transportation to Works Site	124,273	6.06%
A5	Construction Processes	526,797	25.70%
D	Blue Carbon associated with Proposed Development (Offshore)	11,273	0.55%
A Single Phase of Proposed Development (Onshore)			
A1-3	Proposed Development (Onshore) Construction	32,922	1.61%
A4	Transportation to Works Site	26,887	1.31%
A5	Construction Processes	9,877	0.48%
D	Land Use Emissions associated with Proposed Development (Onshore) during construction	115	0.01%
	Peat soil released carbon emissions associated with Proposed Development (Onshore) during construction	582	0.03%
Total Construction Emissions for Caledonia North and a single phase of the Proposed Development (Onshore)		2,049,718	100%

4.7.1.6 The largest source of emissions during the construction phase is expected to arise from construction materials, including sourcing, processing and manufacturing. Construction materials (A1-3) associated with the Proposed Development (Offshore) and a single phase of the Proposed Development (Onshore) account for 65.86% of total construction emissions.

4.7.1.7 Emissions associated with the loss of carbon stock from habitats lost onshore[v] during construction equate to 0.01% of total construction stage emissions

[iii] Figures rounded to nearest tonne of carbon dioxide equivalent.
[iv] Percentages rounded to two decimal places. Shown percentages may not equal 100% as a result.
[v] The land use calculations are based on the full extent of the OnTI RLB and are therefore conservative. In practice, the habitat areas lost during construction will be confined to the 100m Onshore Export Cable Route which at time of writing is not defined.

although in practice the planting of new habitats leads to sequestration benefit during the operational phase.

4.7.1.8 Emissions associated with the loss of carbon stored within peat soil, lost onshore during excavation equate to 0.03% of construction emissions.

4.7.1.9 Emissions associated with the loss of blue (marine) carbon offshore during the construction equate to 0.55% of total construction stage emissions.

Operation

4.7.1.10 The assessment of operational GHG emissions has considered the emissions associated with maintenance, repair and replacement of key elements Caledonia North; the annual results are presented in Table 4-10. All assumptions used in the calculations are contained within Volume 7F, Appendix 4-1: Greenhouse Gases.

4.7.1.11 In addition, a single phase of Proposed Development (Onshore) has been included within Table 4-10.

Table 4-10: Annual GHG Emissions associated with the operation of Caledonia North (Offshore) and a single phase of Proposed Development (Onshore) to 2050

Lifecycle Module	Lifecycle Description	Total GHG Emissions (tCO_2e)[vi]	% Total Operational GHG Emissions[vii]
Caledonia North			
B2-4	Offshore Maintenance, Repair and Replacement	143,482	95.33%
D	Blue Carbon	2,077	1.38%
A Single Phase of Proposed Development (Onshore)			
B2-4	Proposed Development (Onshore) Maintenance, Repair and Replacement	3,596	2.39%
D	Land Use Emissions associated with Proposed Development (Onshore) works during operation	1,362	0.90%
Total Operational Emissions for Caledonia North and a single phase of the Proposed Development (Onshore)		150,517	100%

4.7.1.12 Table 4-10 presents the annual emissions during operation. For this assessment, lifecycle impacts have been averaged across the duration of the operational phase of Caledonia North (until 2064). Therefore, from the

[vi] Figures rounded to nearest tonne of carbon dioxide equivalent.
[vii] Percentages rounded to two decimal places. Shown percentages may not equal 100% as a result.

assumed opening year (2030) to 2064, emissions associated with the operation of the Caledonia North will be 143,482 tCO_2e.

4.7.1.13 During operation, Caledonia North will generate low carbon electricity that will be conveyed onshore for use. The anticipated renewable energy generation is 3,460 Gigawatt hours (GWh) per year and 121,107 GWh to 2064. The consideration of this within the assessment is set out in the Evaluation of Significance below.

Decommissioning

4.7.1.14 Due to the available information within the DE at time of assessment, the anticipated GHG Emissions associated with decommissioning of Caledonia North have been calculated using the construction information, as in Section 4.7.1 above. Table 4-11 provides the results for the End-of-Life modules within the Whole Life Carbon assessment for waste materials, transportation offsite and waste processing and disposal. Where possible, construction information has been combined with waste and recovery rates from RICS Whole Life Carbon for the Built Environment guidance (RICS, 2023[28]).

4.7.1.15 In addition, a single phase of the Proposed Development (Onshore) has been included within Table 4-11.

Table 4-11: Annual GHG Emissions associated with the decommissioning of Caledonia North and a single phase of the Proposed Development (Onshore)

Lifecycle Module	Lifecycle Description	Total GHG Emissions (tCO_2e)[viii]	% Total Decommissioning GHG Emissions[ix]
Caledonia North			
C1	Offshore Deconstruction and demolition	263,399	62.25%
C2	Offshore Decommissioning Transport	124,273	29.37%
C3	Offshore Decommissioning Waste processing	2,787	0.66%
C4	Offshore Decommissioning material disposal	136	0.03%
D	Blue Carbon	183	0.04%
A Single Phase of Proposed Development (Onshore)			
C1-4	Onshore End of Life	32,213	7.61%
D	Land Use Emissions associated with Proposed Development (Onshore) works during operation	117	0.03%
Total Decommissioning Emissions for Caledonia North and a single phase of the Proposed Development (Onshore)		423,107	100.0%

Evaluation of Significance

4.7.1.16 In line with IEMA guidance (2022[25]), the contextualisation of construction and operational GHG emissions has been carried out based on a comparison of GHG emissions associated with the Caledonia North and a single phase of the Proposed Development (Onshore) against UK's trajectory to net zero. The UK's Carbon Budgets have been used where budgets currently exist (carbon budgets 4, 5 and 6), in addition to the 6th Carbon Budget report trajectory beyond the last available Carbon Budget.

4.7.1.17 Absolute emissions attributable to the Caledonia North and a single phase of the Proposed Development (Onshore), have been calculated and presented against the five-year carbon budget periods in Table 4-12.

[viii] Figures rounded to nearest tonne of carbon dioxide equivalent.
[ix] Percentages rounded to two decimal places. Shown percentages may not equal 100% as a result.

Table 4-12: Comparison of Caledonia North and a single phase of the Proposed Development (Onshore) Construction Emissions to UK Carbon Budgets

Proposed Development Element	Carbon Budget 4 (2023-2027)	Carbon Budget 5 (2028-2032)	Carbon Budget 6 (2033-2037)	Beyond 2038 - 2050
Carbon Budget Total (tCO_2e)	1,950,000,000	1,725,000,000	965,000,000	N/A
Construction Emissions (tCO_2e)	23,229	2,014,519	0	0
Construction Percentage of Carbon Budget (%)	0.001%	0.117%	0.000%	N/A
Operation Emissions (tCO_2e)	0	12,607	21,011	113,460
Operation Percentage of Carbon Budget (%)	0.000%	0.001%	0.002%	N/A
Decommissioning Emissions (tCO_2e)	0	0	0	422,807
Decommissioning Percentage of Carbon Budget (%)	0.000%	0.000%	0.000%	N/A
Net Blue Carbon & Land Use emissions (tCO2e)	233	11,977	500	3,000
Blue Carbon and Land Use Percentage of Carbon Budget (%)	<0.001%	0.001%	<0.001%	N/A
Total Emissions (tCO_2e)	23,461	2,039,103	21,511	539,268
Total Percentage of Carbon Budget (%)	0.001%	0.118%	0.002%	N/A
Renewable energy generation (MWh)	0	11,989,593	19,982,655	107,906,337

4.7.1.18 Due to the nature of the GHG emissions assessment, the sensitivity of the single receptor, the global concentration of GHG emissions within the atmosphere, is always high.

4.7.1.19 During construction, taking the magnitude of emissions against the carbon budgets in Table 4-12, the overall effect of GHG emissions is considered to be minor adverse and not significant in EIA terms. Construction emissions are not of a scale that will impact on the ability of the UK to meet its carbon reduction targets.

4.7.1.20 In the absence of considering the benefits that accrue from generation of low carbon electricity the operational emissions would be minor adverse and not significant in EIA terms. The renewable energy generation from the Proposed Development will provide significant beneficial effects as discussed in the next section (Renewable Energy Generation).

4.7.1.21 During decommissioning, taking the magnitude of emissions against the carbon budgets in Table 4-12, the overall effect of GHG emissions is considered to be minor adverse and not significant in EIA terms.

Renewable Energy Generation

4.7.1.22 The UK is reliant on increasing renewable energy generation as part of the national trajectory to net zero by 2050. Renewable energy generation from the offshore wind sector is an integral part of the UK's net zero strategy.

4.7.1.23 Whilst this assessment has focussed on the emissions associated with Caledonia North and a single phase of the Proposed Development (Onshore), it has not sought to assess or demonstrate the impact that this wind farm will have on the wider decarbonisation of the UK energy grid.

4.7.1.24 The IEMA guidance on the assessment of GHG emissions places emphasis on the importance of contextualisation of Proposed Development emissions as part of the process of determining the significance of impacts. IEMA directs that:

"The crux of significance therefore is not whether a project emits GHG emissions, nor even the magnitude of GHG emissions alone, but whether it contributes to reducing GHG emissions relative to a comparable baseline consistent with a trajectory towards net zero by 2050 [or other date as defined in targets for devolved administrations]"

4.7.1.25 While the assessment of GHG emissions from the Proposed Development confirms that emissions will arise from the construction, operation, and decommissioning of the Proposed Development - it is also necessary to consider the context that the Proposed Development will play in the decarbonisation of the power sector in Scotland and the wider UK. Given that the Proposed Development falls within the need for low carbon energy generation to replace existing fossil-fuelled power generation as part of the UK's transition to net zero, and that a wider benefit will accrue to the

decarbonisation of electrical power in the UK, the Proposed Development is considered to be beneficial when this wider contribution is considered.

4.7.1.26 Given the scale of equivalent generation emissions using conventional energy generation methods, this assessment concludes the impact of the Caledonia North and a single phase of the Proposed Development (Onshore) is not significant (as outlined in section above). The assessment concludes there is a minor adverse impact from construction of Caledonia North and a single phase of the Proposed Development (Onshore), however given the context of the purpose of Caledonia North and a single phase of the Proposed Development (Onshore) then it is reasonable to conclude there is a benefit in GHG Emissions terms for Caledonia North and a single phase of the Proposed Development (Onshore).

4.7.2 Caledonia South and a Single Phase of the Proposed Development (Onshore)

4.7.2.1 In line with IEMA guidance (2022[25]) the starting point for assessment of effects is to compare the future emissions arising from the comparison of Do-Something and Do-Minimum against the UK Carbon Budgets for those periods where budgets currently exist. The emissions attributable to the Proposed Development have been calculated for each of the five-year budget periods (Carbon Budget 4 from 2023-2027, Carbon Budget 5 from 2028-2032 and Carbon Budget 6 from 2033-2038) and are presented against the total UK Carbon Budgets (and the associated trajectory to net zero this reflects) in order to assess their significance. The assessment is based on information available from the DE at the time of assessment.

4.7.2.2 For the GHG emissions assessment associated with Caledonia South and a single Phase of the Proposed Development (Onshore), this assessment assumes a worst case scenario (in GHG emissions terms) of 39 fixed monopile foundation 15MW WTGs, 39 semi-submersible floating foundation 15MW Turbines and 2 Offshore Platforms plus half of the GHG emissions associated with the Proposed Development (Onshore). Full details of the key parameters associated with Caledonia South are provided within Table 4-8.

Construction

4.7.2.3 The construction process generates GHG emissions directly and indirectly through the production or materials and onsite energy consumption. All assumptions used in the calculations are contained within Volume 7F, Appendix 4-1: GHG Emissions Assessment.

4.7.2.4 Table 4-13 presents the total GHG emissions across the construction period. The emissions relate to the construction of the Caledonia South and is presented across three main emissions sources: construction materials, material transport, and construction plant usage.

4.7.2.5 In addition, a single phase of the Proposed Development (Onshore) has been included within Table 4-13.

Table 4-13: GHG Emissions associated with the Construction of Caledonia South and a single phase of the Proposed Development (Onshore)

Lifecycle Module	Lifecycle Description	Total GHG Emissions (tCO_2e)[x]	% Total Construction GHG Emissions[xi]
Caledonia South			
A1-3	Materials	1,920,890	65.35%
A4	Transportation to Works Site	169,085	5.75%
A5	Construction Processes	768,356	26.14%
D	Blue Carbon	10,861	0.37%
A Single Phase of Proposed Development (Onshore)			
A1-3	Materials	32,922	1.12%
A4	Transportation to Works Site	26,887	0.91%
A5	Construction Processes	9,877	0.34%
D	Land Use Emissions associated with the Proposed Development (Onshore) works during construction	115	<0.01%
	Peat soil released carbon emissions associated with Proposed Development (Onshore) during construction	582	0.02%
Total Construction Emissions for Caledonia South and a single phase of the Proposed Development (Onshore)		2,939,574	100.00%

4.7.2.6 The largest source of emissions during the construction phase is expected to arise from construction materials, including sourcing, processing and manufacturing. Construction materials (A1-3) associated with the Proposed Development (Offshore) and a single phase of the Proposed Development (Onshore) account for 66.47% of total construction emissions.

4.7.2.7 Emissions associated with the loss of carbon stock from habitats lost onshore[xii] during construction equate to 0.004% of total construction stage

[x] Figures rounded to nearest tonne of carbon dioxide equivalent.
[xi] Percentages rounded to two decimal places. Shown percentages may not equal 100% as a result.
[xii] The land use calculations are based on the full extent of the OnTI RLB and are therefore conservative. In practice, the habitat areas lost during construction will be confined to the 100-meter cable corridor which at time of writing is not known.

emissions although in practice the planting of new habitats leads to sequestration benefit during the operational phase.

4.7.2.8 Emissions associated with the loss of carbon stored within peat soil, lost onshore during excavation equate to 0.02%.

4.7.2.9 Emissions associated with the loss of blue (marine) carbon offshore during the construction equate to 0.37% of total construction stage emissions.

Operation

4.7.2.10 The assessment of operational GHG emissions has considered the emissions associated with maintenance, repair and replacement of key elements of Caledonia South; the annual results are presented in Table 4-14. All assumptions used in the calculations are contained within Volume 7F, Appendix 4-1: GHG Emissions Assessment.

4.7.2.11 In addition, a single phase of the Proposed Development (Onshore) has been included within Table 4-14.

Table 4-14: Annual GHG Emissions associated with the operation of Caledonia South and a single phase of the Proposed Development (Onshore) to 2050

Lifecycle Module	Lifecycle Description	Total GHG Emissions (tCO_2e)[xiii]	% Total Operational GHG Emissions[xiv]
Caledonia South			
B2-4	Offshore Maintenance, Repair and Replacement	208,388	96.73%
D	Blue Carbon	2,077	0.96%
A Single Phase of Proposed Development (Onshore)			
B2-4	Onshore Maintenance, Repair and Replacement	3,596	1.67%
D	Land Use Emissions associated with Proposed Development (Onshore) works during operation	1,362	0.63%
Total Operational Emissions for Caledonia South and a single phase of the Proposed Development (Onshore)		215,423	100%

4.7.2.12 Table 4-14 presents the annual emissions during operation. For this assessment, lifecycle impacts have been averaged across the duration of the operational phase Caledonia South (until 2064). Therefore, from the assumed

[xiii] Figures rounded to nearest tonne of carbon dioxide equivalent.
[xiv] Percentages rounded to two decimal places. Shown percentages may not equal 100% as a result.

opening year (2030) to 2064, emissions associated with the operation of Caledonia South will be 215,423 tCO_2e.

4.7.2.13 During operation, the Caledonia South will generate low carbon electricity that will be conveyed onshore for use. The anticipated renewable energy generation is 3,460 MWh per year and 121,107 GWh to 2064. The consideration of this within the assessment is set out in the Evaluation of Significance below.

Decommissioning

4.7.2.14 Due to the available information within the DE at time of assessment, the anticipated GHG emissions associated with decommissioning of Caledonia South has been calculated using the construction information, as in Section 0 above. Table 4-15 provides the results for the End-of-Life modules within the Whole Life Carbon assessment for waste materials, transportation offsite and waste processing and disposal. Where possible, construction information has been combined with waste and recovery rates from RICS Whole Life Carbon for the Built Environment guidance (RICS, 2023[28]).

4.7.2.15 In addition, a single phase of the Proposed Development (Onshore) has been included within as Table 4-15.

Table 4-15: Annual GHG Emissions associated with the Decommissioning of Caledonia South and a single phase of the Proposed Development (Onshore)

Lifecycle Module	Lifecycle Description	Total GHG Emissions (tCO_2e)[xv]	% Total Decommissioning GHG Emissions[xvi]
Caledonia South			
C1	Offshore Deconstruction and demolition	384,178	65.09%
C2	Offshore Decommissioning Transport	169,085	28.65%
C3	Offshore Decommissioning Waste processing	4,244	0.72%
C4	Offshore Decommissioning material disposal	227	0.04%
D	Blue Carbon	183	0.03%
A Single Phase of Proposed Development (Onshore)			
C1-4	Onshore End of Life	32,213	5.46%
D	Land Use Emissions associated with Proposed Development (Onshore) works during operation	117	0.02%
Total Operational Emissions for Caledonia South and a single phase of the Proposed Development (Onshore)		590,247	100.00%

Evaluation of Significance

4.7.2.16 In line with IEMA guidance (2022)[25], the contextualisation of construction and operational GHG emissions has been carried out based on a comparison of GHG emissions associated with the Caledonia South against UK's trajectory to net zero. The UK's Carbon Budgets have been used where budgets currently exist (carbon budgets 4, 5 & 6), in addition to the 6th Carbon Budget report trajectory beyond the last available Carbon Budget.

4.7.2.17 Absolute emissions attributable to the Caledonia South, have been calculated and presented against the five-year carbon budget periods in Table 4-16.

[xv] Figures rounded to nearest tonne of carbon dioxide equivalent.
[xvi] Percentages rounded to two decimal places. Shown percentages may not equal 100% as a result.

Table 4-16: Comparison of Caledonia South and a single phase of the Proposed Development (Onshore) to UK Carbon Budgets

Proposed Development Element	Carbon Budget 4 (2023-2027)	Carbon Budget 5 (2028-2032)	Carbon Budget 6 (2033-2037)	Beyond 2038 - 2050
Carbon Budget Total (tCO_2e)	1,950,000,000	1,725,000,000	965,000,000	N/A
Construction Emissions (tCO_2e)	23,229	2,904,787	0	0
Construction Percentage of Carbon Budget (%)	0.001%	0.168%	0.000%	N/A
Operation Emissions (tCO_2e)	0	18,170	30,283	163,530
Operation Percentage of Carbon Budget (%)	0.000%	0.001%	0.003%	N/A
Decommissioning Emissions (tCO_2e)	0	0	0	589,947
Decommissioning Percentage of Carbon Budget (%)	0.000%	0.000%	0.000%	N/A
Net Blue Carbon & Land Use emissions (tCO2e)	233	11,565	500	3,000
Blue Carbon and Land Use Percentage of Carbon Budget (%)	<0.001%	0.001%	<0.001%	N/A
Total Emissions (tCO_2e)	23,461	2,934,522	30,783	756,477
Total Percentage of Carbon Budget (%)	0.001%	0.170%	0.003%	N/A
Renewable energy generation (MWh)	0	12,145,302	20,242,170	109,307,718

4.7.2.18 Due to the nature of the GHG emissions assessment, the sensitivity of the single receptor, the global concentration of GHG emissions within the atmosphere, is always high.

4.7.2.19 During construction, taking the magnitude of emissions against the carbon budgets in Table 4-16, the overall effect of GHG emissions is considered to be minor adverse and not significant in EIA terms. Construction emissions are not of a scale that will impact on the ability of the UK to meet its carbon reduction targets.

4.7.2.20 In the absence of considering the benefits that accrue from generation of renewable electricity the operational emissions would be minor adverse and not significant in EIA terms. The renewable energy generation from the Proposed Development will provide significant beneficial effects as discussed in the next section (Renewable Energy Generation).

4.7.2.21 During decommissioning, taking the magnitude of emissions against the carbon budgets in Table 4-16, the overall effect of GHG emissions is considered to be minor adverse and not significant in EIA terms.

Renewable Energy Generation

4.7.2.22 The UK is reliant on increasing renewable energy generation as part of the national trajectory to net zero by 2050. Renewable energy generation from the offshore wind sector is an integral part of the UK's net zero strategy.

4.7.2.23 Whilst this assessment has focussed on the emissions associated with Caledonia South, it has not sought to assess or demonstrate the impact that this wind farm will have on the wider decarbonisation of the UK energy grid.

4.7.2.24 The IEMA guidance on the assessment of GHG emissions places emphasis on the importance of contextualisation of Proposed Development emissions as part of the process of determining the significance of impacts. IEMA directs that:

"The crux of significance therefore is not whether a project emits GHG emissions, nor even the magnitude of GHG emissions alone, but whether it contributes to reducing GHG emissions relative to a comparable baseline consistent with a trajectory towards net zero by 2050 [or other date as defined in targets for devolved administrations]"

4.7.2.25 While the assessment of GHG emissions from the Proposed Development confirms that emissions will arise from the construction, operation, and decommissioning of the Proposed Development - it is also necessary to consider the context that the Proposed Development will play in the decarbonisation of the power sector in Scotland and the wider UK. Given that the Proposed Development falls within the need for low carbon energy generation to replace existing fossil-fuelled power generation as part of the UK's transition to net zero, and that a wider benefit will accrue to the

decarbonisation of electrical power in the UK, the Proposed Development is considered to be beneficial when this wider contribution is considered.

4.7.2.26 Given the scale of equivalent generation emissions using conventional energy generation methods, this assessment concludes the impact of Caledonia South is not significant (as outlined in section above). The assessment concludes there is a minor adverse impact from construction of Caledonia South and a single phase of the Proposed Development (Onshore), however given the context of the purpose of Caledonia South and a single phase of the Proposed Development (Onshore) then it is reasonable to conclude there is a benefit in GHG emissions terms for Caledonia South and a single phase of the Proposed Development (Onshore).

4.8 Cumulative Effects

4.8.1.1 As part of the contextualisation required under the IEMA guidance (2022[25]), the assessment of each emissions area compares the overall magnitude of emissions for future assessment years and contextualises these against the UK Carbon Budgets (for those periods for which Budgets currently exist).

4.8.1.2 Across the general EIA process the assessment of cumulative effects is typically intended to examine how the impacts arising from the Proposed Development might cumulatively impact upon individual receptors when other consented or planned development takes place.

4.8.1.3 However, the assessment of cumulative impacts as carried out for other environmental topics is not transferable to the assessment of GHG emissions in an analogous way, as the single receptor for GHG emissions is the global climate in the atmosphere. Impacts arising from GHG emissions differ from other environmental impacts in several important ways:

- The environmental impact arising from GHG emissions is the aggregation and increased concentration of GHGs within the atmosphere (the single receptor for the GHG assessment);
- The location of the emissions source is not relevant to the impact arising from it; it is not feasible to identify a Zone of Influence (ZoI) for GHG emissions at any geographic scale greater than the global scale. Any development leading to GHG emissions has the same impact whether it is located near to the Proposed Development or in another region/country; and
- The climate change impacts on a given location arise from the aggregated GHG levels in the atmosphere, not from the magnitude of GHG emissions in the local area.

4.8.1.4 It is precisely for this reason that the strategic approach adopted by the UK, and other governments is to develop a set of increasingly stringent Carbon Budgets at a national scale to manage and monitor progression towards the UK's 2050 net zero carbon target.

4.8.1.5 The inappropriateness of undertaking a cumulative appraisal (other than by contextualising against Carbon Budgets) is reflected in the IEMA guidance[25]. This guidance notes that "*effects from specific cumulative projects…should not be individually assessed, as there is no basis for selecting any particular (or more than one) cumulative project that has GHG emissions for assessment over any other*".

4.8.1.6 Therefore, the only cumulative assessment that can be undertaken for the Proposed Development is the combined assessment of Caledonia North, Caledonia South and the Proposed Development (Onshore) (i.e. the Proposed Development); the results of which are provided in the following sections.

4.8.1.7 For the GHG emissions assessment associated with the Proposed Development (Offshore), this assessment assumes two worst case scenarios:

- 140 WTG across both Caledonia North and Caledonia South. This scenario includes:
  - Caledonia South: 24(no.) 15MW WTGs with fixed monopile foundations & 39(no.) 15MW WTGs with semi-submersible floating foundations
  - Caledonia North: 77(no.) 15MW WTGs with fixed monopile foundations
- a 100 WTG maximum WTG rating scenario across both Caledonia North and Caledonia South. This scenario includes:
  - Caledonia South: 24(no.) 25MW WTGs with fixed monopile foundation & 29(no.) 20MW with semi-submersible floating foundation
  - Caledonia North: 47(no.) 25MW WTGs with fixed monopile foundations

4.8.1.8 To reflect the possibility of two scenarios for the Proposed Development (Offshore) at time of assessment, a range of the scale of GHG emissions impacts has been provided for cumulative effects. Full details of key parameters associated with the Proposed Development (Offshore) and the Proposed Development (Onshore) is provided within Table 4-8.

4.8.2 Construction

4.8.2.1 Table 4-17 presents the total GHG emissions across the construction period for the Proposed Development.

Table 4-17: GHG Emissions associated with the construction of the Proposed Development

Lifecycle Module	Lifecycle Description	Total GHG Emissions (tCO_2e)[xvii]		% Total Construction GHG Emissions[xviii]	
		140 WTGs - Min rated	100 WTGs - Max Rated	140 WTGs - Min rated	100 WTGs - Max Rated
Proposed Development (Offshore)					
A1-3	Materials	3,034,524	3,238,413	64.77%	64.93%
A4	Transportation to Works Site	276,454	297,175	5.90%	5.88%
A5	Construction Processes	1,213,810	1,295,365	25.91%	25.97%
D	Blue Carbon	19,728	20,134	0.42%	0.40%
Proposed Development (Onshore)[xix]					
A1-3	Materials	65,845	65,845	1.41%	1.32%
A4	Transportation to Works Site	53,773	53,773	1.15%	1.08%
A5	Construction Processes	19,753	19,753	0.42%	0.40%
D	Land Use Emissions	230	230	0.00%	0.00%
	Peat Soils	1,165	1,165	0.02%	0.02%
Total Construction Emissions		4,685,282	4,987,854	100%	100%

4.8.2.2 The largest source of emissions during the construction phase of the Proposed Development is expected to arise from construction materials, including sourcing, processing and manufacturing. As per Table 4-17, these emissions account for approximately 66.2% of total construction emissions for the Proposed Development (Onshore) and the Proposed Development (Offshore).

4.8.2.3 Emissions associated with the loss of carbon stock from habitats lost onshore (including peat losses) during construction equate to 0.02% of total construction stage emissions although in practice the planting of new habitats leads to sequestration benefit during the operational phase.

[xvii] Figures rounded to nearest tonne of carbon dioxide equivalent.
[xviii] Percentages rounded to two decimal places. Shown percentages may not equal 100% as a result.
[xix] Emissions associated with the Proposed Development (Onshore) remain the same for both the 140 WTG and 100 WTG scenarios. However, the onshore percentages of the total are affected by the differing emissions totals under each scenario and therefore differ.

4.8.2.4 Emissions associated with the loss of blue (marine) carbon offshore during the construction equate to approximately 0.4% of total construction stage emissions.

4.8.3 Operation

4.8.3.1 The assessment of operational GHG emissions has considered the emissions associated with maintenance, repair and replacement of key elements of the Proposed Development; the annual results are presented in Table 4-18. All assumptions used in the calculations are contained within Volume 7F, Appendix 4-1: Greenhouse Gases.

Table 4-18: Annual GHG Emissions associated with the operation of the Proposed Development to 2050

Lifecycle Module	Lifecycle Description	Total GHG Emissions (tCO_2e)[xx]		% Total Operational GHG Emissions[xxi]	
		140 WTGs - Min rated	100 WTGs - Max Rated	140 WTGs - Min rated	100 WTGs - Max Rated
Proposed Development (Offshore)					
B2-4	Onshore Maintenance, Repair and Replacement	329,881	351,911	96.15%	96.26%
D	Blue Carbon	3,303	3,746	0.96%	1.02%
Proposed Development (Onshore)[xxii]					
B2-4	Offshore Maintenance, Repair and Replacement	7,192	7,192	2.10%	1.97%
D	Land Use Emissions	2,724	2,724	0.79%	0.75%
Total Operational Emissions		343,100	365,573	100%	100%

4.8.3.2 Table 4-18 presents the annual emissions during the operation of the Proposed Development. This assessment assumes these annual emissions will be constant for the duration of the Proposed Development until 2064. Therefore, from the assumed opening year (2030) to 2064, emissions associated with the operation of the Proposed Development will be 331,326 tCO_2e.

4.8.3.3 During operation, the Proposed Development will generate low carbon electricity that will be conveyed onshore for use. The anticipated renewable energy generation is 6,920 GWh per year and 242,214 GWh to 2064. The

[xx] Figures rounded to nearest tonne of carbon dioxide equivalent.
[xxi] Percentages rounded to two decimal places. Shown percentages may not equal 100% as a result.
[xxii] Emissions associated with the Proposed Development (Onshore) remain the same for both the 140 WTG and 100 WTG scenarios. However, the onshore percentages of the total are affected by the differing emissions totals under each scenario and therefore differ.

consideration of this within the assessment is set out in the Evaluation of Significance below.

4.8.4 Decommissioning

4.8.4.1 Due to the available information within the DE at time of assessment, the anticipated GHG emissions associated with decommissioning of the Proposed Development has been calculated using the construction information, as in Section 4.8.2 above. Table 4-19 provides the results for the End-of-Life modules within the Whole Life Carbon assessment for waste materials, transportation offsite and waste processing and disposal.

Table 4-19: Annual GHG Emissions associated with the decommissioning of the Proposed Development

Lifecycle Module	Lifecycle Description	Total GHG Emissions (tCO_2e)[xxiii]		% Total Decommissioning GHG Emissions[xxiv]	
		140 WTGs -Min rated	100 WTGs - Max Rated	140 WTGs - Min rated	100 WTGs - Max Rated
Proposed Development (Offshore)					
C1	Deconstruction and demolition	606,905	647,683	63.57%	63.88%
C2	Decommissioning Transport	276,454	293,175	28.96%	28.91%
C3	Decommissioning Waste processing	6,143	7,698	0.64%	0.76%
C4	Decommissioning material disposal	308	407	0.03%	0.04%
D	Blue Carbon	291	331	0.03%	0.03%
Proposed Development (Onshore)[xxv]					
C1	Deconstruction and demolition	9,877	9,877	1.03%	0.97%
C2	Decommissioning Transport	53,773	53,773	5.63%	5.30%
C3	Decommissioning Waste processing	753	753	0.08%	0.07%
C4	Decommissioning material disposal	24	24	<0.01%	<0.01%
D	Land Use Emissions associated with Proposed	233	233	0.02%	0.02%

[xxiii] Figures rounded to nearest tonne of carbon dioxide equivalent.
[xxiv] Percentages rounded to two decimal places. Shown percentages may not equal 100% as a result.
[xxv] Emissions associated with the Proposed Development (Onshore) remain the same for both the 140 WTG and 100 WTG scenarios. However, the onshore percentages of the total are affected by the differing emissions totals under each scenario and therefore differ.

	Development (Onshore) works during operation				
Total Decommissioning Emissions		954,761	1,013,953	100%	100%

4.8.5 Evaluation of Significance

4.8.5.1 In line with IEMA guidance (2022[25]), the contextualisation of construction and operational GHG emissions has been carried out based on a comparison of GHG emissions associated with the Proposed Development against UK's trajectory to net zero. The UK's Carbon Budgets have been used where budgets currently exist (carbon budgets 4, 5 & 6), in addition to the 6th Carbon Budget report trajectory beyond the last available Carbon Budget.

4.8.5.2 Absolute emissions attributable to the Proposed Development, have been calculated and presented against the five-year carbon budget periods in Table 4-20.

Table 4-20: Comparison of the Proposed Development to UK Carbon Budgets

Proposed Development Element	Carbon Budget 4 (2023-2027)	Carbon Budget 5 (2028-2032)	Carbon Budget 6 (2033-2037)	Beyond 2038 - 2050
Carbon Budget Total (tCO_2e)	1,950,000,000	1,725,000,000	965,000,000	N/A
Construction Emissions (tCO_2e)	46,457-46,457	4,617,702-4,919,868	0	0
Construction Percentage of Carbon Budget (%)	0.002%	0.268-0.285%	0.000%	N/A
Operation Emissions (tCO_2e)	0	28,892-30,780	48,153-51,300	260,028-277,022
Operation Percentage of Carbon Budget (%)	0.000%	0.002-0.002%	0.005%	N/A
Decommissioning Emissions (tCO_2e)	0	0	0	954,236-1,013,389
Decommissioning Percentage of Carbon Budget (%)	0.000%	0.000%	0.000%	N/A
Net Blue Carbon & Land Use emissions (tCO_2e)	465	21,086-21,518	875-940	5,249-5,641
Blue Carbon and Land Use Percentage of Carbon Budget (%)	<0.001%	0.001-0.001%	<0.001%	N/A
Total Emissions (tCO_2e)	46,922	4,667,680-4,972,166	49,028-52,241	1,219,514-1,296,052
Total Percentage of Carbon Budget (%)	0.002%	0.271-0.288%	0.005%	N/A
Renewable energy generation (GWh)	0	21,799-24,446	36,332-40,744	196,193-220,017

4.8.5.3 Due to the nature of the GHG emissions assessment, the sensitivity of the single receptor, the global concentration of GHG emissions within the atmosphere, is always high.

4.8.5.4 During construction, taking the magnitude of emissions against the carbon budgets in Table 4-20, the overall effect of GHG emissions is considered to be minor adverse and not significant in EIA terms. Construction emissions are not of a scale that will impact on the ability of the UK to meet its carbon reduction targets.

4.8.5.5 In the absence of considering the benefits that accrue from generation of renewable electricity the operational emissions would be minor adverse and not significant in EIA terms. The renewable energy generation from the Proposed Development will provide significant beneficial effects as discussed in the next section.

4.8.5.6 During decommissioning, taking the magnitude of emissions against the carbon budgets in Table 4-20, the overall effect of GHG emissions is considered to be minor adverse and not significant in EIA terms.

4.8.5.7 When considering the Proposed Development (Offshore) and the Proposed Development (Onshore) as a whole, the beneficial renewable energy generation that will aid the UK in achieving its net zero target needs to be taken into consideration. Therefore, the overall effect of GHG emissions associated with the Proposed Development (Offshore) and the Proposed Development (Onshore) is considered to be beneficial and significant in EIA terms.

Renewable Energy Generation

4.8.5.8 The UK is reliant on increasing renewable energy generation as part of the national trajectory to net zero by 2050. Renewable energy generation from the offshore wind sector is an integral part of the UK's net zero strategy.

4.8.5.9 Whilst this assessment has focussed on the emissions associated with the Proposed Development, it has not sought to assess or demonstrate the impact that this wind farm will have on the wider decarbonisation of the UK energy grid.

4.8.5.10 The IEMA guidance on the assessment of GHG emissions places emphasis on the importance of contextualisation of Proposed Development emissions as part of the process of determining the significance of impacts. IEMA directs that:

"The crux of significance therefore is not whether a project emits GHG emissions, nor even the magnitude of GHG emissions alone, but whether it contributes to reducing GHG emissions relative to a comparable baseline consistent with a trajectory towards net zero by 2050 [or other date as defined in targets for devolved administrations]"

4.8.5.11 While the assessment of GHG emissions from the Proposed Development confirms that emissions will arise from the construction, operation, and decommissioning of the Proposed Development - it is also necessary to consider the context that the Proposed Development will play in the decarbonisation of the power sector in Scotland and the wider UK. Given that the Proposed Development falls within the need for low carbon energy generation to replace existing fossil-fuelled power generation as part of the UK's transition to net zero, and that a wider benefit will accrue to the decarbonisation of electrical power in the UK, the Proposed Development is considered to be beneficial when this wider contribution is considered.

4.8.5.12 Given the scale of equivalent generation emissions using conventional energy generation methods, this assessment concludes the impact of the Proposed Development is not significant (as outlined in section above). The assessment concludes there is a minor adverse impact from construction of the Proposed Development, however given the context of the purpose of the Proposed Development then it is reasonable to conclude there is a benefit in GHG emissions terms for the Proposed Development.

4.9 In-combination Effects

4.9.1.1 In-combination impacts may occur through the inter-relationship with another EIAR topic that may lead to different or greater environmental effects than in isolation. There is also the potential for in-combination impacts resulting from onshore and offshore works. These are identified within Volume 6, Chapter 5: Intertidal Assessment, and are therefore not repeated here.

4.9.1.2 There are no potential in-combination effects for GHG emissions.

4.10 Transboundary Effects

4.10.1.1 Owing to the transboundary nature of GHG emissions, the effects of the Proposed Development must be considered in the context of global GHG emissions and concentrations of GHGs in the atmosphere. The IEMA guidance (IEMA, 2020[25,26]) states that the GHG emissions from all projects will contribute to climate change, the largest inter-related cumulative environmental effect.

4.11 Mitigation Measures and Monitoring

4.11.1.1 It is understood in the wider EIA methodology that where residual effects are concluded these will be mitigated. Despite the GHG emissions assessment concluding an overall significant beneficial effect as a result of the Proposed Development, aligning with IEMA guidance (IEMA, 2022[25]) "all new GHG emissions contribute to a negative environmental impact" and "where GHG emissions cannot be avoided, the goal of the EIA process should be to reduce the project's residual emissions at all stages". While the Proposed Development is expected to deliver a benefit in GHG emissions terms across its lifetime, all GHG emissions associated with construction and maintenance will be reduced as far as possible (in order to maximise the benefits associated with the Proposed Development). The following recommendations will be considered by the design team at detailed design. Aligning with the principles of PAS 2080, "work on every existing and new asset needs to contribute towards the urgent transition to net zero carbon".

4.11.2 Construction

4.11.2.1 At this stage in the Proposed Development, full construction design and logistics are yet to be confirmed. However, a range of construction and procurement strategies will be investigated to identify mitigation measures to reduce the GHG emissions associated with the Proposed Development, across the full project life cycle.

4.11.2.2 Minimising GHG emissions through design is a core principle of the UK Government's Infrastructure Carbon Review (H.M. Treasury, 2013[38]) and guidelines for the specification of infrastructure carbon management (such as PAS 2080[27]). In this context, carbon management is assumed to be addressed in the planning, design and construction of the Proposed Development, including appropriate consideration of any relevant planning requirements, guidelines and best practice. As an example strategy, a summary of the PAS 2080 carbon management hierarchy is presented in Table 4-21.

Table 4-21: Additional Mitigation Hierarchy

PAS 2080 Carbon Management Hierarchy	Best practice hierarchy	Examples
Build nothing Assess the basic need for development and consider alternative approaches to achieve the desired outcomes.	Avoid/Prevent	1. Maximise potential for re-using and/or refurbishing existing assets to reduce the extent of new construction required, and/or explore lower carbon alternatives to deliver the project objectives (i.e. shorter route alternatives with smaller construction footprints).
Build less Evaluate the potential for re-using and/or refurbishing existing assets to reduce the extent of new construction required	Reduce	2. Maximise potential for re-using and/or refurbishing existing assets to reduce the extent of new construction required, and/or explore lower carbon alternatives to deliver the project objectives (i.e. shorter route alternatives with smaller construction footprints). 3. Careful construction management to avoid over-ordering of materials, to reduce transportation emissions. 4. The sustainable reuse of soil and aggregate materials won from excavation
Build clever Consider the use of low carbon solutions (including technologies materials and products) to minimise resource consumption during the construction and operation		
Build efficiently Consider techniques which can be used to reduce resource consumption during construction and operation	Remediate	5. Identify, assess and integrate measures to further reduce carbon through on or offsite offsetting or sequestration (as a last resort).

4.11.3 Operation

4.11.3.1 The mitigation measures for the construction of the Proposed Development should also be considered for maintenance and repair of materials during operation. During the operational phase of the Proposed Development, continual opportunities to reduce GHG emissions should be considered throughout the life of the asset.

4.11.4 Decommissioning

4.11.4.1 Decarbonisation measures for decommissioning will follow a similar approach to Section 4.11.2.

4.12 Residual Effects

4.12.1 Construction Effects

4.12.1.1 The construction stage measures have the potential to reduce GHG emissions from the Proposed Development through detailed design stage. However, the nature of the Proposed Development requires significant volumes of building materials, and associated construction related emissions.

4.12.1.2 As noted in Section 4.7: Potential Effects, the assessment of construction phase GHG Emissions has concluded minor adverse not significant in EIA terms. However, given the nature and scale of the Proposed Development it is expected that there will be residual construction-related emissions.

4.12.2 Operation Effects

4.12.2.1 The overall aim of the Proposed Development is to generate renewable energy, therefore as noted in Section 4.7: Potential Effects, the assessment has concluded significant beneficial in EIA terms. Despite the residual emissions associated with construction and decommissioning, the Proposed Development is, by design, reducing national emissions and the Scotland's and the UK's reliance on fossil fuels within the national energy grid.

4.12.3 Decommissioning Effects

4.12.3.1 It is likely there will be fuel and material processing required for decommissioning the Proposed Development. It is unknown at this stage the magnitude of decommissioning GHG emissions; therefore construction emissions have been used as a benchmark for deconstruction activity emissions.

4.12.3.2 As noted in Section 4.7: Potential Effects, given the nature and scale of the Proposed Development it is expected that there will be residual decommissioning-related emissions.

4.13 Summary of Effects

4.13.1.1 Table 4-22 presents a summary of the significant effects assessed within this EIAR, any mitigation required, and the residual effects are provided.

Table 4-22: Summary of Effects for GHG Emissions

Potential Impact	Magnitude	Sensitivity of Receptor	Significance	Mitigation Measure	Residual Effect
Caledonia North and a single phase of the Proposed Development (Onshore)					
Construction					
GHG Emissions	Low	High	Not Significant – Minor adverse	Mitigation through the PAS 2080 Carbon Management Hierarchy of *Build Nothing, Build Less, Build Clever, Build Efficiently* principles should be applied through detailed design to reduce construction emissions as far as practicable.	Caledonia North and a single phase of the Proposed Development (Onshore) will have residual emissions relating to the construction phase. Good practice will seek to reduce residual emissions through mitigation measures set out in Section 4.11: Mitigation Measures and Monitoring.
Operation					
GHG Emissions	Low	High	Significant - Beneficial	Mitigation through the PAS 2080 Carbon Management principles should be applied to reduce whole life carbon emissions as far as practicable.	Caledonia North and a single phase of the Proposed Development (Onshore) will have residual emissions relating to the operational phase. Good practice will seek to reduce residual emissions through mitigation measures set out in Section 4.11: Mitigation Measures and Monitoring. The consideration of significance also considers the wider context and the generation of low carbon electricity as discussed in Section 4.7: Potential Effects.

Potential Impact	Magnitude	Sensitivity of Receptor	Significance	Mitigation Measure	Residual Effect
Decommissioning					
GHG Emissions	Low	High	Not Significant – Minor adverse	Mitigation through the PAS 2080 Carbon Management Hierarchy of *Build Nothing, Build Less, Build Clever, Build Efficiently* principles should be applied through detailed design to reduce decommissioning emissions as far as practicable.	Caledonia North and a single phase of the Proposed Development (Onshore) will have residual emissions relating to decommissioning phase. Good practice will seek to reduce residual emissions through mitigation measures set out in Section 4.11: Mitigation Measures and Monitoring.
Caledonia South and a single phase of the Proposed Development (Onshore)					
Construction					
GHG Emissions	Low	High	Not Significant – Minor adverse	Mitigation through the PAS 2080 Carbon Management Hierarchy of *Build Nothing, Build Less, Build Clever, Build Efficiently* principles should be applied through detailed design to reduce construction emissions as far as practicable.	Caledonia South and a single phase of the Proposed Development (Onshore) will have residual emissions relating to the construction phase. Good practice will seek to reduce residual emissions through mitigation measures set out in Section 4.11: Mitigation Measures and Monitoring.
Operation					
GHG Emissions	Low	High	Significant - Beneficial	Mitigation through the PAS 2080 Carbon Management principles should be applied to reduce whole life carbon emissions as far as practicable.	Caledonia South and a single phase of the Proposed Development (Onshore) will have residual emissions relating to the operational phase. Good practice will seek to reduce residual emissions through

Potential Impact	Magnitude	Sensitivity of Receptor	Significance	Mitigation Measure	Residual Effect
					mitigation measures set out in Section 4.11: Mitigation Measures and Monitoring. The consideration of significance also considers the wider context of the Proposed Development and the generation of low carbon electricity as discussed in Section 4.7: Potential Effects.
Decommissioning					
GHG Emissions	Low	High	Not Significant – Minor adverse	Mitigation through the PAS 2080 Carbon Management Hierarchy of *Build Nothing, Build Less, Build Clever, Build Efficiently* principles should be applied through detailed design to reduce decommissioning emissions as far as practicable.	Caledonia South and a single phase of the Proposed Development (Onshore) will have residual emissions relating to decommissioning phase. Good practice will seek to reduce residual emissions through mitigation measures set out in Section 4.11: Mitigation Measures and Monitoring.
Proposed Development					
Construction					
GHG Emissions	Low	High	Not Significant – Minor adverse	Mitigation through the PAS 2080 Carbon Management Hierarchy of *Build Nothing, Build Less, Build Clever, Build Efficiently* principles should be applied through detailed design to reduce construction emissions as far as practicable.	The Proposed Development will have residual emissions relating to the construction phase. Good practice will seek to reduce residual emissions through mitigation measures set out in Section 4.11: Mitigation Measures and Monitoring.

Potential Impact	Magnitude	Sensitivity of Receptor	Significance	Mitigation Measure	Residual Effect
Operation					
GHG Emissions	Low	High	Significant - Beneficial	Mitigation through the PAS 2080 Carbon Management principles should be applied to reduce whole life carbon emissions as far as practicable.	The Proposed Development will have residual emissions relating to the operational phase. Good practice will seek to reduce residual emissions through mitigation measures set out in Section 4.11: Mitigation Measures and Monitoring. The consideration of significance also considers the wider context of the Proposed Development and the generation of low carbon electricity as discussed in Section 4.7: Potential Effects.
Decommissioning					
GHG Emissions	Low	High	Not Significant – Minor adverse	Mitigation through the PAS 2080 Carbon Management Hierarchy of *Build Nothing, Build Less, Build Clever, Build Efficiently* principles should be applied through detailed design to reduce decommissioning emissions as far as practicable.	The Proposed Development will have residual emissions relating to decommissioning phase. Good practice will seek to reduce residual emissions through mitigation measures set out in Section 4.11: Mitigation Measures and Monitoring.
Proposed Development (Offshore) and Proposed Development (Onshore) Combined Assessment					
GHG Emissions for the Whole Life assessment for	Low	High	Significant - Beneficial	Mitigation through the PAS 2080 Carbon Management Hierarchy of *Build Nothing, Build Less, Build Clever, Build Efficiently* principles should be applied through detailed	The consideration of significance for the whole life emissions of the Proposed Development considers the wider context for the Proposed Development and generation of low

Potential Impact	Magnitude	Sensitivity of Receptor	Significance	Mitigation Measure	Residual Effect
the Proposed Development				design to reduce the whole life emissions as far as practicable.	carbon electricity to aid the UK and Scotland net zero targets.

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