



Morven North Offshore Wind Array Project

Environmental Impact Assessment Report

**Volume 3, Annex 18.2: Climate Change Shared
Greenhouse Gases Technical Report**

MVCNS-J1201-RPS-10057
May 2026

B01

| Document status | | | | | |
|------------------------|----------------------------|--------------------|----------------|--------------------|-------------|
| Version | Purpose of document | Authored by | Checker | Approved by | Date |
| FINAL | Application | TTRPSEL | TTRPSEL | MvOWL | May 2026 |

The report has been prepared for the exclusive use and benefit of our client and solely for the purpose for which it is provided. Unless otherwise agreed in writing by Tetra Tech RPS Energy Ltd, any of its subsidiaries, or a related entity (collectively 'Tetra Tech RPS Energy') no part of this report should be reproduced, distributed or communicated to any third party. Tetra Tech RPS Energy does not accept any liability if this report is used for an alternative purpose from which it is intended, nor to any third party in respect of this report.

The report does not account for any changes relating to the subject matter of the report, or any legislative or regulatory changes that have occurred since the report was produced and that may affect the report. The report has been prepared using the information provided to Tetra Tech RPS Energy by its client, or others on behalf of its client.

To the fullest extent permitted by law, Tetra Tech RPS Energy shall not be liable for any loss or damage suffered by the client arising from fraud, misrepresentation, withholding of information material relevant to the report or required by Tetra Tech RPS Energy, or other default relating to such information, whether on the client's part or that of the other information sources, unless such fraud, misrepresentation, withholding or such other default is evident to Tetra Tech RPS Energy without further enquiry. It is expressly stated that no independent verification of any documents or information supplied by the client or others on behalf of the client has been made. The report shall be used for general information only.

| | |
|---------------------|-------------------------------------|
| Prepared by: | Prepared for: |
| TTRPSEL | Morven Offshore Wind Limited |

Table of contents

| | | |
|-----------|--|-----------|
| 1 | Introduction | 1 |
| 2 | Study areas..... | 2 |
| 3 | Methodology..... | 4 |
| 3.1 | Overview..... | 4 |
| 3.2 | Scope..... | 4 |
| 3.2.1 | Embodied carbon..... | 4 |
| 3.2.2 | Blue carbon | 5 |
| 3.2.3 | Operational avoided emissions | 5 |
| 3.3 | Assumptions and limitations..... | 6 |
| 4 | Baseline 8 | |
| 4.1 | Current baseline | 8 |
| 4.1.1 | Morven North | 8 |
| 4.1.2 | Morven South..... | 8 |
| 4.2 | Regional future baseline | 8 |
| 5 | Maximum design scenario | 12 |
| 6 | Assessment of construction effects..... | 17 |
| 6.1 | Blue carbon | 17 |
| 6.1.2 | Morven North | 17 |
| 6.1.3 | Morven South..... | 18 |
| 6.2 | Embodied carbon | 19 |
| 6.2.2 | Morven North | 20 |
| 6.2.3 | Morven South..... | 22 |
| 6.3 | Summary..... | 24 |
| 7 | Assessment of operations and maintenance effects | 26 |
| 7.1 | Blue carbon | 26 |
| 7.1.1 | Morven North | 26 |
| 7.1.2 | Morven South..... | 26 |
| 7.2 | Avoided emissions | 26 |
| 7.2.2 | Sensitivity analysis | 29 |
| 7.3 | Fuel, energy and material use during operations and maintenance activities | 30 |
| 7.3.2 | Morven North | 31 |
| 7.3.3 | Morven South..... | 31 |
| 7.4 | Summary..... | 31 |
| 8 | Decommissioning | 33 |
| 8.2 | Morven North..... | 33 |
| 8.3 | Morven South..... | 33 |
| 9 | Whole life emissions..... | 35 |
| 10 | Cumulative assessment..... | 36 |
| 10.2 | Morven Hawthorn Pit Grid Connection Project | 36 |
| 10.3 | Morven Branxton Area Grid Connection Project | 37 |

| | |
|----------------------------|-----------|
| 10.4 Summary..... | 39 |
| 11 References | 40 |

List of tables

Table 4.1: Department for Energy and Net Zero grid average and long-run marginal grid intensities..... 10

Table 5.1: Maximum Design Scenario considered for assessment of impacts – Morven North 13

Table 5.2: Maximum Design Scenario considered for assessment of impacts – Morven South..... 15

Table 6.1: Sediment composition and emissions factors for Morven North..... 17

Table 6.2: Summary of blue carbon emissions for Morven North 18

Table 6.3: Sediment composition and emissions factors for Morven South 18

Table 6.4: Summary of blue carbon emissions for Morven South 19

Table 6.5: Construction phase embodied carbon emissions for Morven North 20

Table 6.6: Construction phase embodied carbon emissions for Morven South 22

Table 6.7: Summary of construction phase carbon emissions for Morven North and Morven South..... 24

Table 7.1: Energy flows from Morven North or Morven South 26

Table 7.2: Operational greenhouse gas impacts of Morven North or Morven South..... 27

Table 7.3: Sensitivity analysis for Morven North or Morven South 30

Table 7.4: Operations and maintenance phase emissions for Morven North and Morven South 32

Table 9.1: Summary of lifetime emissions for Morven North and Morven South 35

Table 10.1: Summary of calculated emissions as a result of the cumulative infrastructure 39

List of figures

Figure 2.1: The boundaries of the Morven North and the Morven South within the Morven Option Lease Agreement Site 3

Figure 4.1: Future Energy Scenario (National Grid ESO, 2024) and Department of Energy Security and Net Zero future grid carbon intensities (DESNZ, 2023a) 9

1 Introduction

- 1.1.1.1 The Morven North Offshore Wind Array Project (hereafter, “Morven North”) and the Morven South Offshore Wind Array Project (hereafter, “Morven South”) are both located within the Morven Option Lease Agreement Site (hereafter, “Morven Site”) in Scottish offshore waters (Figure 2.1). Morven North is located approximately 61.2km from the Aberdeenshire coast (at its closest point) and Morven South is located approximately 86.1km from the Aberdeenshire coast (at its closest point). Each project will comprise wind turbines and foundations, offshore substation platforms (OSPs) and foundations, inter-array and interconnector cables and associated infrastructure located within the Morven North or Morven South boundary. Consent for the offshore export cables of Morven North and Morven South will be sought separately.
- 1.1.1.2 As shown in Figure 2.1, Morven North is situated northwest of Morven South. The external boundaries of the projects correspond with the boundaries of the Morven Site.
- 1.1.1.3 This Greenhouse Gas (GHG) Assessment Shared Technical Report presents the methodology and calculations of the GHG emissions for both Morven North and Morven South.
- 1.1.1.4 Consent for Morven North and Morven South will be sought separately, aided by the development of a separate Environmental Impact Assessment (EIA) and Habitats Regulations Appraisal (HRA) for each project. However, the survey campaign and/or desk-based studies that will support the impact assessments for Morven North and Morven South are based on the Morven Site, which accommodates both Morven North and Morven South. Given the comparability and consistency of information collected to inform the assessments for both projects, emissions assessments for both Morven North and Morven South are reported in the present GHG Assessment Shared Technical Report.
- 1.1.1.5 The information from this GHG Assessment Shared Technical Report provides the methodology and calculations of GHG emissions, which form the basis of the potential magnitude of impact of Morven North and Morven South on climate change. This report accompanies the EIA provided in Volume 2, Chapter 18: Climate Change, of the Morven North EIA Report and Volume 2, Chapter 18: Climate Change, of the Morven South EIA Report to support the respective consent applications.
- 1.1.1.6 GHG emissions have been estimated by applying published emissions factors to activities in the baseline and to those required for Morven North and Morven South. The emissions factors relate to a given level of activity, or amount of fuel, energy or materials used, and therefore to the mass of GHGs released as a consequence.
- 1.1.1.7 The GHGs considered in this assessment are those in the “Kyoto basket” of global warming gases (United Nations Framework Convention on Climate Change, 1997) expressed as their CO₂-equivalent (CO₂e) Global Warming Potential (GWP). This is denoted by CO₂e units in emissions factors and calculation results. GWPs used are typically the 100-year factors in the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (IPCC, 2013) or as otherwise defined for national reporting under the United Nations Framework Convention on Climate Change.
- 1.1.1.8 The GHG Assessment Shared Technical Report considers Morven North and Morven South during the construction, operations and maintenance, and decommissioning phases. Key emissions sources included in the assessment are:
- offshore land use (seabed) change;
 - embodied carbon emissions in materials for the required offshore infrastructure;
 - transport emissions offshore.
- 1.1.1.9 Additionally, the GHG Assessment Shared Technical Report assesses avoided operational emissions (i.e. those emissions that would have occurred as a result of the predicted United Kingdom (UK) Grid carbon intensity without Morven North and Morven South).

2 Study areas

- 2.1.1.1 The Morven North Climate Change Study Area and Morven South Climate Change Study Area align with the Morven North Boundary and Morven South Boundary respectively, as shown in Figure 2.1 (i.e. the area in which the wind turbines and associated infrastructure will be located) in the context of the domestic and international scope as developed on the basis of established Institute of Environmental Management and Assessment (IEMA) guidance (IEMA, 2022) utilised throughout this report. Domestic scope considers the local and national policy and targets concerning GHG and climate resilience.
- 2.1.1.2 GHG emissions have a global (international) effect rather than directly affecting any specific local receptor. The impact of GHG emissions occurring due to Morven North and Morven South on the global atmospheric concentration of the relevant GHGs, expressed in CO₂-equivalents (CO₂e), is therefore considered within this assessment.
- 2.1.1.3 The study areas for GHG assessments for the Morven Site were presented to and agreed during the scoping process for the Morven Site. The underlying principles used to define the study area(s) for Morven North and Morven South have not changed, other than the limits have been applied relative to each project, rather than the Morven Site. The study areas for Morven North and Morven South for GHG assessments were presented to the Marine Directorate Licensing Operations Team (MD-LOT) via a “Targeted Consultation Exercise” undertaken in Quarter 1, 2025.

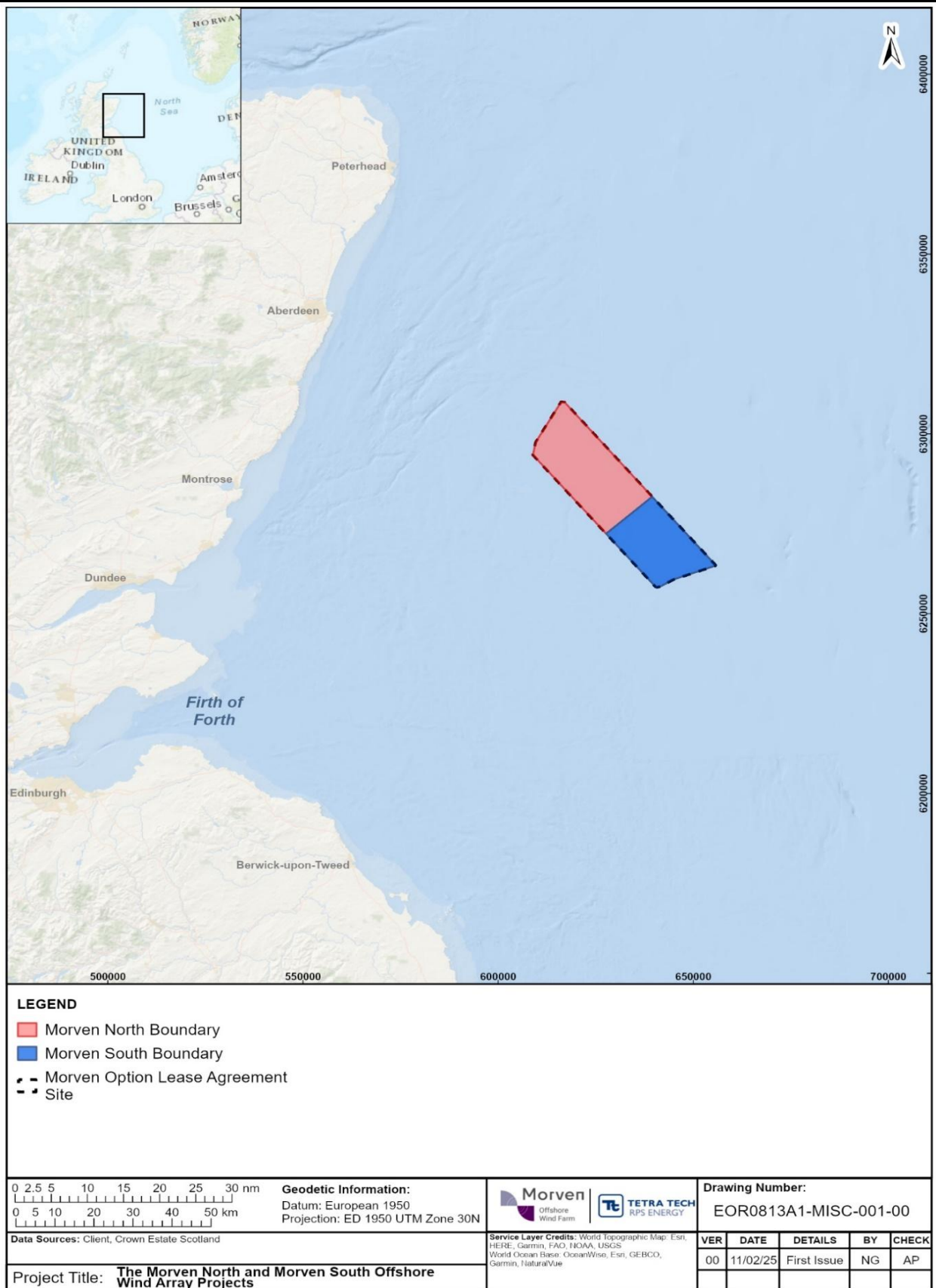


Figure 2.1: The boundaries of the Morven North and the Morven South within the Morven Option Lease Agreement Site

3 Methodology

3.1 Overview

- 3.1.1.1 GHG emissions caused by an activity are often categorised into “scope 1”, “scope 2” or “scope 3” emissions, following the guidance of the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) Greenhouse Gas Protocol suite of guidance documents (WRI and WBCSD, 2004):
- Scope 1 emissions: direct GHG emissions from sources owned or controlled by the company (e.g. from combustion of fuel at an installation);
 - Scope 2 emissions: caused indirectly by consumption of purchased energy (e.g. from generated electricity supplied through the national grid to an installation);
 - Scope 3 emissions: all other indirect emissions occurring as a consequence of the activities of the company (e.g. in the upstream extraction, processing and transport of materials consumed or the use of sold products or services).
- 3.1.1.2 This assessment has sought to include emissions from all three scopes, where this is material and reasonably possible from the information and emissions factors available, to capture the impacts attributable most completely to Morven North and Morven South. These emissions are not separated out by defined scopes (scoped 1, 2 or 3) in the assessment.
- 3.1.1.3 Due to the nature of Morven North and Morven South (i.e. offshore generation infrastructure), the gross GHG emissions total is dominated by avoided operational emissions. The avoided emissions are those that would have occurred as a result of the predicted UK Grid carbon intensity without Morven North and Morven South.
- 3.1.1.4 The assessment has considered (a) the GHG emissions arising from Morven North and Morven South (during construction, operations and maintenance, and decommissioning phases), (b) any GHG emissions that it displaces or are avoided, compared to the current or future baseline, and hence (c) the net impact on climate change due to these changes in GHG emissions overall.
- 3.1.1.5 Consideration of GHG emissions over the lifetime of Morven North and Morven South is required to quantify each project’s net contribution to climate change and as such the magnitude of change owing to Morven North and Morven South.
- 3.1.1.6 Given the methodologies used to calculate emissions associated with Morven North and Morven South are consistent, this technical assessment details the methodology associated with each element once and provides a breakdown regarding the magnitude of emissions calculated each for Morven North and Morven South.

3.2 Scope

3.2.1 Embodied carbon

- 3.2.1.1 A Life Cycle Assessment (LCA) comprises an evaluation of the inputs, outputs and potential environmental impacts that occur throughout the lifecycle of a particular project, in this case electricity generation infrastructure, encompassing either a cradle-to-gate (extraction of raw materials and the manufacture of products) or a cradle-to-grave (accounting also for in use and decommissioning) approach. This can be further broken down into the following LCA phases of development:
- materials and construction (LCA stages A1-A5);
 - operations and maintenance (LCA stages B1-B5);
 - decommissioning (LCA stages C1-C4).

3.2.1.2 As Morven North and Morven South are currently in the relatively early stages of design, data relating to specific metrics for site specific design details including chosen design and manufacturer of wind turbines and OSPs are currently unavailable.

3.2.1.3 Therefore, emissions resulting from the manufacturing and construction of the wind turbines and foundations, OSPs and foundations, inter-array and interconnector cables, and associated infrastructure located within the Morven North or Morven South Boundary have been calculated via the application of material or fuel emission factors to approximate material or fuel quantities, and published LCA literature. Key sources relied upon for the assessment are as follows:

- Environmental Product Declaration Power transformer TrafoStar 500 MVA (ABB, 2003);
- Inventory of Carbon & Energy (ICE) database (Jones and Hammond, 2024);
- UK Government GHG Conversion Factors for Company Reporting (DESNZ and Department for Environment, Food and Rural Affairs (DEFRA), 2025).

3.2.1.4 Methodology specific to each element comprising Morven North and Morven South is detailed within Sections 6.2.2 and 6.2.3.

3.2.2 Blue carbon

3.2.2.1 The calculation of climate change effects for Morven North and Morven South considers the impact of temporary and permanent habitat loss and disturbance, affecting 'blue carbon' stocks within the baseline. The term 'blue carbon' refers to organic carbon that has been captured and stored through biological processes in the coastal and marine environment. Blue carbon can be stored within living biomass, root systems and sediments. Within the coastal and marine environment, there are a variety of habitat types that contribute to the global blue carbon stocks, including sediment habitats, such as those found in the Morven North Climate Change Study Area and Morven South Climate Change Study Area (Cunningham and Hunt, 2023).

3.2.2.2 Where habitats are disturbed or lost through impacts from a development, this affects the habitat's ability to store and sequester blue carbon. For example, when organic sediments are disturbed and enter the water column, stored blue carbon within these organic sediments can be converted to CO₂ through a process called remineralisation (Cunningham and Hunt, 2023).

3.2.2.3 Site specific benthic survey data (see Volume 3, Annex 8.1: Benthic Subtidal Ecology Shared Technical Report) and published emission factors have been used to calculate the extent of blue carbon stocks within the Morven North Climate Change Study Area and Morven South Climate Change Study Area. The resulting impact of Morven North and Morven South upon the blue carbon stocks has been calculated based on the total area of disturbance by the construction, operations and maintenance, and decommissioning of Morven North and Morven South, alongside published literature values for the overall effects of disturbance. Key sources relied upon for the assessment are as follows:

- Scottish Blue Carbon – a literature review of the current evidence for Scotland's blue carbon habitats. NatureScot Research Report 1326 (Cunningham and Hunt, 2023);
- Re-Evaluating Scotland's Sedimentary Carbon Stocks. Marine Scotland Science (Smeaton *et al.*, 2020);
- Volume 3, Annex 8.1: Benthic Subtidal Ecology Shared Technical Report.

3.2.3 Operational avoided emissions

3.2.3.1 The assessment also considers the GHG emissions that would not be generated (i.e. avoided) during the operation of Morven North and Morven South during the future baseline, using a variety of scenarios to characterise the future baseline (see Section 4.2).

3.3 Assumptions and limitations

- 3.3.1.1 Most of the construction phase GHG emissions associated with the manufacturing of components are likely to occur outside the territorial boundary of the UK and hence outside the scope of the UK's national carbon budget, policy and governance. However, in recognition of the climate change effect of GHG emissions (wherever occurring), and the need to avoid 'carbon leakage' overseas when reducing UK emissions, emissions associated with the construction phase have been presented within the assessment and quantification of GHG emissions as part of Morven North and Morven South.
- 3.3.1.2 There is uncertainty about future climate and energy policy and market responses, which affect the likely future carbon intensity of energy supplies, and thereby the future carbon intensity of the electricity generation being displaced by Morven North and Morven South. Government projections consistent with national carbon budget commitments have been used in the assessment ('long-run marginal' projections). It should be noted that latest Government projections include an increase in renewable energy generation, like Morven North and Morven South (DESNZ, 2023a), consistent with the Government's current policy of a clean energy grid by 2030, with no unabated fossil fuel generation (DESNZ, 2024). As such, for Morven North and Morven South's operations and maintenance lifetime, the long-run marginal projections presented assume that Morven North and Morven South will displace low carbon sources of electricity, essentially comparing Morven North and Morven South to projects similar to themselves. Therefore, multiple scenarios have been considered to present a likely range of avoided emissions, including displacement of non-renewable fuels as an upper estimate for the likely avoided emissions, and comparison to the long-run marginal projections as a lower estimate.
- 3.3.1.3 At present construction commencement dates are not known. For the purposes of this assessment, construction is assumed to commence in 2033 for Morven North and Morven South, with each commissioned by 2038 after a five year construction period. The assessment of emissions associated with the operations and maintenance phase has been informed by these timeframes in the absence of further information at this stage. Should Morven North and/or Morven South become operational at a later date, this will affect the operations and maintenance phase avoided emissions estimated, given the decarbonisation of the above-described projections used to calculate emissions associated with the electricity generation being displaced. However, by the time Morven North and Morven South are anticipated to be operational (indicatively from 2038), the UK is expected to have made significant progress towards a low carbon electricity grid. Therefore, decarbonisation of the projections used is anticipated to be marginal and would not affect the conclusions presented.
- 3.3.1.4 The specific wind turbine technology and design of associated infrastructure that would be used by Morven North and Morven South have not yet been specified. Thus, there is a degree of uncertainty regarding GHG emissions at all project phases resulting from the manufacturing and construction of wind turbines and infrastructure. This assessment seeks to limit the impact this might have by using Maximum Design Scenario (MDS) material quantities and material types (i.e. those with the greatest carbon impact), as informed by engineering input, in the calculation of construction phase emissions and emissions resulting from repair and maintenance activities. It is unlikely that these MDS material quantities will be used in the final design of Morven North and Morven South, owing to improvements in wind turbine and associated infrastructure design and refinements to design assumptions. As such, calculated emissions represent a conservative MDS.
- 3.3.1.5 Blue carbon that is released as a result of marine habitat disturbance dissolves into coastal and marine ecosystems, such as the ocean. As such, this impact does not directly contribute to the global atmospheric mass of CO₂ (the receptor). However, it is likely to indirectly impact atmospheric CO₂ concentrations, as an increased concentration of dissolved CO₂ alters ocean and calcium carbonate (CaCO₃) chemistry. Though interactions between different states of carbon in the oceans are complex, it is likely that increased concentrations of ocean CO₂ will overall reduce the capacity of oceans to absorb CO₂ and cause a greater potential for the ocean to release CO₂ to the atmosphere under certain conditions (IPCC, 2021). As such, for the purposes of this assessment,

remineralisation of blue carbon stocks has been assumed to have the same impact as the release of an equivalent mass of CO₂ to the global atmosphere.

- 3.3.1.6 The benthic survey data used in the assessment of impacts to blue carbon stocks was collected based on industry standard sampling methodologies. It should therefore be noted that there is a natural limitation in the accuracy of interpretations from extrapolating habitat information from samples. However, the samples taken have been deemed sufficient to accurately characterise the habitats present within the Morven North Climate Change Study Area and Morven South Climate Change Study Area.
- 3.3.1.7 Literature used to calculate the blue carbon value of habitats within the Morven North Climate Change Study Area and Morven South Climate Change Study Area provide stored blue carbon factors for the top 10cm of sediment only, as there are limited data available on sediment thickness and organic carbon content of deeper sediments (Cunningham and Hunt, 2023). As organic carbon contained within deeper sediments is likely to be more stable than that found in the top sediment layer, and less vulnerable to remineralisation following disturbance (Smeaton *et al.*, 2020), the baseline characterisation of the blue carbon value of the habitats within the Morven North Climate Change Study Area and Morven South Climate Change Study Area is deemed to be sufficient.
- 3.3.1.8 It is important to note that Morven North and Morven South would not operate in isolation, as the Morven Hawthorn Pit Grid Connection Project (hereafter, "MHPGC Project") or the Morven Branxton Area Grid Connection Project (hereafter, "MBAGC Project"), or both, are required to connect Morven North and Morven South to the grid. Without this infrastructure (subject to separate consent applications), avoided emissions presented as part of this assessment would not be realised. As such, it is necessary to consider the embodied emissions associated with the export cable corridors within the cumulative assessment, so as to understand the whole life net effects of Morven North with the MHPGC Project or MBAGC Project, and Morven South with the MHPGC Project or MBAGC Project.
- 3.3.1.9 The design parameters of the export cable corridor(s) for the MHPGC Project and MBAGC Project required to connect Morven North and Morven South to the grid are not yet completely defined. As such, calculations for the assessment of cumulative effects, in order to quantify whole life GHG emissions for Morven North, Morven South, the MHPGC Project and the MBAGC Project have been based on high level, indicative parameters. These parameters will be refined in subsequent applications for the MHPGC Project and MBAGC Project, alongside the associated calculations as more information becomes available.

4 Baseline

4.1 Current baseline

4.1.1 Morven North

- 4.1.1.1 With regard to GHG emissions, the current baseline for Morven North is the offshore sea surface, water column and seabed use, which will be impacted either through permanent seabed take (e.g. laying of interconnector and inter-array cables, installation of wind turbines and OSP foundations), or through temporary seabed take and other disturbance (e.g. additional areas required during construction).
- 4.1.1.2 Benthic surveys classified five different sediment types through the collection of sediment samples across the Morven North Benthic Subtidal Ecology Study Area (see Volume 3, Annex 8.1: Benthic Subtidal Ecology Shared Technical Report, for detailed methodology). The sediment composition is as follows: 73% sand, 13% slightly gravelly sand, 8% muddy sand, 5% slightly gravelly muddy sand, and 1% sandy gravel. It has been assumed that these compositions are directly applicable to the Morven North Climate Change Study Area. The standing blue carbon stock in the subtidal sediments present within the Morven North Climate Change Study Area is presented in Sections 6.1.2 and 7.1.1.
- 4.1.1.3 With regards to the current baseline concerning the UK Electricity Grid at the time of writing, the conversion factor for companies reporting UK Electricity generation carbon intensity resides at 222.9kgCO₂e/MWh (including scope 3 but as generated, i.e. excluding transmission and distribution losses) (DESNZ and DEFRA, 2025).

4.1.2 Morven South

- 4.1.2.1 With regard to GHG emissions, the current baseline for Morven South is consistent with that described for Morven North at paragraph 4.1.1.1.
- 4.1.2.2 Benthic surveys classified four different sediment types through the collection of sediment samples across the Morven South Benthic Subtidal Ecology Study Area (see Volume 3, Annex 8.1: Benthic Subtidal Ecology Shared Technical Report, for detailed methodology). The sediment composition is as follows: 68% sand, 7% slightly gravelly sand, 22% muddy sand, and 3% slightly gravelly muddy sand. It has been assumed that these compositions are directly applicable to the Morven South Climate Change Study Area. The standing blue carbon stock in the subtidal sediments present within the Morven South Climate Change Study Area is presented in Sections 6.1 and 7.1.2.
- 4.1.2.3 The current baseline concerning the UK Electricity Grid is consistent with that described for Morven North at paragraph 4.1.1.3

4.2 Regional future baseline

- 4.2.1.1 The future baseline GHG emissions for existing land use (seabed) without Morven North and Morven South are expected to remain similar to the current baseline identified in Sections 4.1.1 and 4.1.2. There are limited published data available regarding blue carbon sequestration rates for sedimentary marine habitat types. However, it is acknowledged that blue carbon sequestration rates in marine habitats are lower than those of terrestrial habitats, in particular sediment-based habitats. Some sediment areas of the North Sea, for instance, experience almost no sediment accumulation and associated carbon sequestration (Cunningham and Hunt, 2023). As such, no material change to the blue carbon stocks currently present within the Morven North Climate Change Study Area and Morven South Climate Change Study Area is anticipated in the future baseline.
- 4.2.1.2 The future baseline for electricity generation that would be displaced by Morven North and Morven South depends broadly on future energy and climate policy in the UK, and more specifically (with regards to day-to-day emissions) on the demand for the operation of Morven North and Morven

South, compared to other generation sources available; this will be influenced by commercial factors and National Grid’s needs.

- 4.2.1.3 The carbon intensity of baseline electricity generation is projected to reduce over time and so too would the intensity of the marginal generation source, displaced at a given time.
- 4.2.1.4 DESNZ publishes projections of the carbon intensity of long-run marginal electricity generation and supply that would be affected by small (on a national scale) sustained changes in generation or demand (DESNZ, 2023a). DESNZ projections over the operations and maintenance phase of Morven North and Morven South’s lifetime (indicatively from 2038 to 2073) are used to estimate the potential emissions as a result of both Morven North and Morven South.
- 4.2.1.5 DESNZ also publishes projections of the grid average emissions factor, which is the carbon intensity of all sources of electricity generation, at the point of generation (i.e. excluding transmission and distribution losses). The marginal factor is assumed to converge to the grid average emissions factor by 2050 and both projections are assumed to be constant after that point.
- 4.2.1.6 National Grid publishes ‘Future Energy Scenario’ (FES) projections (National Grid Electricity System Operator (NESO), 2024) of grid average carbon intensity under several possible evolutions of the UK energy market.
- 4.2.1.7 As illustrated in Figure 4.1, all FES grid average carbon intensity projections except ‘Counterfactual’ achieve net negative values due to the sequestration of biogenic CO₂, via Bioenergy with Carbon Capture and Storage (BECCS). ‘Counterfactual’ is an energy scenario in which the National Grid does not decarbonise, due to unabated use of gas. It has been assumed that Morven North and Morven South would not displace other forms of electricity generation with net adverse GHG effects illustrated by both the DESNZ and National Grid projected carbon intensity factors for displaced electricity generation.

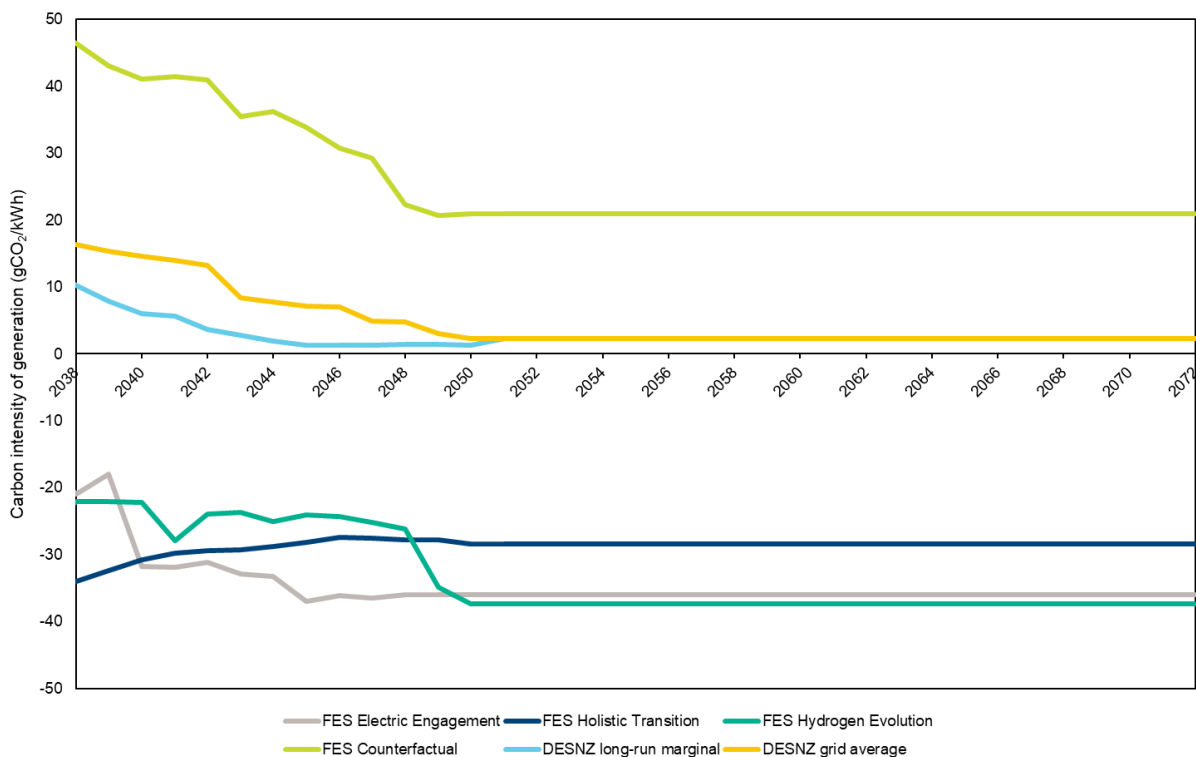


Figure 4.1: Future Energy Scenario (National Grid ESO, 2024) and Department of Energy Security and Net Zero future grid carbon intensities (DESNZ, 2023a)

4.2.1.8 Table 4.1 lists the DESNZ grid average and marginal factors for the indicative 35 years of Morven North and Morven South’s operations and maintenance phases. The factors are consistent for both Morven North and Morven South. As stated in paragraph 3.3.1.3, construction dates for Morven North and Morven South are not currently known. As such, it is not known whether the construction phases for both projects will overlap or whether there will be a gap between both projects’ construction phases. For the purposes of the assessment, it has been assumed that construction for Morven North and Morven South will commence in 2033 and that both projects will be built concurrently.

Table 4.1: Department for Energy and Net Zero grid average and long-run marginal grid intensities

| Year of operation | Year | DESNZ long-run marginal (tCO ₂ e/MWh) | DESNZ grid average (tCO ₂ e/MWh) |
|-------------------|------|--|---|
| 1 | 2038 | 0.01 | 0.016 |
| 2 | 2039 | 0.008 | 0.015 |
| 3 | 2040 | 0.006 | 0.015 |
| 4 | 2041 | 0.006 | 0.014 |
| 5 | 2042 | 0.004 | 0.013 |
| 6 | 2043 | 0.003 | 0.008 |
| 7 | 2044 | 0.002 | 0.008 |
| 8 | 2045 | 0.001 | 0.007 |
| 9 | 2046 | 0.001 | 0.007 |
| 10 | 2047 | 0.001 | 0.005 |
| 11 | 2048 | 0.001 | 0.005 |
| 12 | 2049 | 0.001 | 0.003 |
| 13 | 2050 | 0.001 | 0.002 |
| 14 | 2051 | 0.002 | 0.002 |
| 15 | 2052 | 0.002 | 0.002 |
| 16 | 2053 | 0.002 | 0.002 |
| 17 | 2054 | 0.002 | 0.002 |
| 18 | 2055 | 0.002 | 0.002 |
| 19 | 2056 | 0.002 | 0.002 |
| 20 | 2057 | 0.002 | 0.002 |
| 21 | 2058 | 0.002 | 0.002 |
| 22 | 2059 | 0.002 | 0.002 |

| Year of operation | Year | DESNZ long-run marginal (tCO ₂ e/MWh) | DESNZ grid average (tCO ₂ e/MWh) |
|-------------------|------|--|---|
| 23 | 2060 | 0.002 | 0.002 |
| 24 | 2061 | 0.002 | 0.002 |
| 25 | 2062 | 0.002 | 0.002 |
| 26 | 2063 | 0.002 | 0.002 |
| 27 | 2064 | 0.002 | 0.002 |
| 28 | 2065 | 0.002 | 0.002 |
| 29 | 2066 | 0.002 | 0.002 |
| 30 | 2067 | 0.002 | 0.002 |
| 31 | 2068 | 0.002 | 0.002 |
| 32 | 2069 | 0.002 | 0.002 |
| 33 | 2070 | 0.002 | 0.002 |
| 34 | 2071 | 0.002 | 0.002 |
| 35 | 2072 | 0.002 | 0.002 |

5 Maximum design scenario

- 5.1.1.1 The MDS identified in Table 5.1 and Table 5.2 have been selected as those having the potential to result in the greatest total emissions as a result of their construction, operations and maintenance, and decommissioning, and thus the greatest effect on global climate change. These scenarios have been selected from the Project Design Envelope (PDE) provided in Volume 1, Chapter 3: Project Description, of the Morven North EIA Report and Volume 1, Chapter 3: Project Description, of the Morven South EIA Report. Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the PDE (e.g. different infrastructure layout), be taken forward in the final design.

Table 5.1: Maximum Design Scenario considered for assessment of impacts – Morven North

C = construction; O = O&M; D = decommissioning phases

“√” is used to denote the phase the potential impact can occur, “X” outlines there is no impact within this project phase

| Impact | Phase | | | Maximum design scenario | Justification |
|--|-------|---|---|---|--|
| | C | O | D | | |
| The impact of GHG emissions arising from seabed change | √ | √ | √ | <ul style="list-style-type: none"> The greatest seabed footprint of the wind turbine footprint and scour protection (SBJ 3L)- 804,914m² The greatest seabed footprint from OSP foundations and scour protection – 311,333m² The greatest seabed footprint from inter-array cable - 8,475,000m² The greatest seabed footprint from inter-array cable protection – 423,750m² The greatest seabed footprint from interconnector cable - 9,680,000m² The greatest seabed footprint from interconnector cable protection – 484,000m² | The greatest area of disturbance has the potential to disturb the maximum amount of carbon stored in benthic sediments (if these present significant carbon stores). |
| The impact of GHG emissions arising from the manufacturing and installation of Morven North, including vessel movements. | √ | x | x | <ul style="list-style-type: none"> 58 wind turbines, 320m maximum rotor diameter, 8.2m maximum blade width, 8.2m maximum chord width, 203m maximum hub height (above LAT), 1,600 tonnes nacelle weight (including hub), 8m tower diameter at top, 10.5m tower diameter at bottom. Suction Bucket Jacket (3 legged) wind turbines foundations, one per turbine, 5m jacket leg diameter, 20m suction bucket diameter. Scour protection volume of 1,739,332m³. 5 no. OSPs, 4 no. with 15,000 tonne topside weight, the fifth with two 30,000 tonnes topsides and an 800-tonne link bridge. Suction bucket jacket (6 legged) OSP foundations, 6 no. in total (two foundations for the fifth OSP). Scour protection volume of 142,737m³ and 247,068m³ associated with the 15,000 tonne and 30,000 tonne OSPs respectively. Total inter-array cable length of 281km, maximum external cable diameter of 230mm, 75 no. cables, copper core cable. 10% of the inter-array cables require cable protection, localised protection across 0.5% of the total inter-array cable length. Total length of crossings of 400m. Total interconnector cable length of 484km, maximum external cable diameter of 322mm, 10 no. cables, copper core cable. | <p>The greatest quantity of materials and fuel consumption represents the greatest potential for GHG emissions.</p> <p>58 no. wind turbines and 5 no. OSPs and associated foundations represent the greatest potential for GHG emissions from the construction and installation of Morven North.</p> |

| Impact | Phase | | | Maximum design scenario | Justification |
|--|-------|---|---|---|---|
| | C | O | D | | |
| | | | | <ul style="list-style-type: none"> 10% of the interconnector cables require cable protection, localised protection across 0.01% of the total interconnector cable length. Total length of crossings of 400m. The greatest number of transport vehicles and vessels for the installation of Morven North, measured in return trips (488 main installation and support vessels, 416 tug/anchor handlers, 162 cable lay installation and support vessels, 172 guard vessels, 156 survey vessels, 50 seabed preparation vessels, 1,460 crew transfer vessels, 156 scour protection installation vessels, 1,826 helicopters) over the greatest distance (245km to construction port). | |
| The impact of GHG emissions arising from the consumption of materials and activities required to facilitate the operations and maintenance phase and the impact of estimated abatement of UK Grid emissions during the operations and maintenance phase. | x | ✓ | x | <ul style="list-style-type: none"> Anticipated output capacity of 1,500MW. The greatest number of maintenance vehicles and vessels, measured in annual return trips (219 crew transfer vessels, 13 jack-up vessels, 3 cable repair vessels, 59 other vessels, 1,660 helicopters, 60 unmanned surface vehicles) over the greatest distance (245km to operations and maintenance port). OSP major component replacement up to once every three years per OSP. Inter-array cable repair: 2 no. events every five years on average. Inter-array cable reburial events 1 no. every five years on average covering 4% of cable length. Interconnector cable repair: 1 no. repair per interconnector in 25 years, typically 2km of cable per repair event. Interconnector cable reburial events 1 no. every five years maximum covering 4% of cable length. | The greatest number of vessel movements and maximum amount of maintenance activities will result in the greatest consumption of fuel and materials representing the greatest potential for GHG emissions. Greatest quantity of materials and fuel consumption represents the greatest potential for GHG emissions. |
| The impact of GHG emissions arising from decommissioning works (e.g. plant, fuel and vessel use) and the recovery (or disposal) of materials. | x | x | ✓ | <p>At the end of Morven North’s operational lifetime, it is anticipated that all wind turbines and OSPs (including foundations), inter-array cable and interconnector cables will be removed where possible/practicable. It is assumed that cable protection will be removed.</p> <p>The decommissioning sequence will generally be the reverse of the construction sequence and involve similar types and numbers of vessels and equipment.</p> | The greatest number of vessel movements and the greatest quantity of materials will result in the greatest consumption of fuels and materials representing the greatest potential for GHG emissions from the decommissioning works. |

Table 5.2: Maximum Design Scenario considered for assessment of impacts – Morven South

C = construction; O = O&M; D = decommissioning phases

“✓” is used to denote the phase the potential impact can occur, “X” outlines there is no impact within this project phase

| Impact | Phase | | | Maximum Design Scenario | Justification |
|--|-------|---|---|--|--|
| | C | O | D | | |
| The impact of GHG emissions arising from seabed change | ✓ | ✓ | ✓ | <ul style="list-style-type: none"> The greatest seabed footprint of the wind turbine footprint and scour protection (SBJ 3L) - 796,529m² The greatest seabed footprint from OSP foundations and scour protection – 311,333m² The greatest seabed footprint from inter-array cable - 8,400,000m² The greatest seabed footprint from inter-array cable protection – 420,000m² The greatest seabed footprint from interconnector cable - 5,280,000m² The greatest seabed footprint from interconnector cable protection – 264,000m² | The greatest area of disturbance has the potential to disturb the maximum amount of carbon stored in benthic sediments (if these present significant carbon stores). |
| The impact of GHG emissions arising from the manufacturing and installation of Morven South, including vessel movements. | ✓ | × | × | <ul style="list-style-type: none"> 58 wind turbines, 320m maximum rotor diameter, 8.2m maximum blade width, 8.2m maximum chord width, 203m maximum hub height (above Lowest Astronomical Tide (LAT)), 1,600 tonnes nacelle weight (including hub), 8m tower diameter at top, 10.5m tower diameter at bottom. Suction Bucket Jacket (3 legged) wind turbine foundations, one per turbine, 5m jacket leg diameter, 20m suction bucket diameter. Scour protection volume of 1,739,332m³. 5 no. OSPs, 4 no. with 15,000 tonne topside weight, the fifth with two 30,000 tonnes topsides and an 800-tonne link bridge. Suction bucket jacket (6 legged) OSP foundations, 6 no. in total (two foundations for the fifth OSP). Scour protection volume of 142,737m³ and 247,068m³ associated with the 15,000 tonne and 30,000 tonne OSPs respectively. Total inter-array cable length of 281km, maximum external cable diameter of 230mm, 75 no. cables, copper core cable. 10% of the inter-array cables require cable protection, localised protection across 0.5% of the total inter-array cable length. Total length of crossings of 400m. Total interconnector cable length of 264km, maximum external cable diameter of 322mm, 10 no. cables, copper core cable. 10% of the interconnector cables require cable protection, localised protection across 0.01% of the total interconnector cable length. Total length of crossings of 400m. | <p>The greatest quantity of materials and fuel consumption represents the greatest potential for GHG emissions.</p> <p>58 wind turbines and 5 OSPs and associated foundations represent the greatest potential for GHG emissions from the construction and installation of Morven South.</p> |

| Impact | Phase | | | Maximum Design Scenario | Justification |
|--|-------|---|---|--|--|
| | C | O | D | | |
| | | | | <ul style="list-style-type: none"> The greatest number of transport vehicles and vessels for the installation of Morven South, measured in return trips (488 main installation and support vessels, 416 tug/anchor handlers, 81 cable lay installation and support vessels, 172 guard vessels, 156 survey vessels, 50 seabed preparation vessels, 1,460 crew transfer vessels, 156 scour protection installation vessels, 1,826 helicopters) over the greatest distance (280km to construction port). | |
| The impact of GHG emissions arising from the consumption of materials and activities required to facilitate the operations and maintenance phase and the impact of estimated abatement of UK Grid emissions during the operations and maintenance phase. | x | ✓ | x | <ul style="list-style-type: none"> Anticipated output capacity of 1,500MW. The greatest number of maintenance vehicles and vessels, measured in annual return trips (219 crew transfer vessels, 13 jack-up vessels, 3 cable repair vessels, 59 other vessels, 1,660 helicopters, 60 unmanned surface vehicles) over the greatest distance (280km to operation and maintenance port). OSP major component replacement up to once every three years per OSP. Inter-array cable repair: 2 no. events every five years on average. Inter-array cable reburial events 1 no. every 5 years on average covering 4% of cable length. Interconnector cable repair: 1 no. repair per interconnector in 25 years, typically 2km of cable per repair event. Interconnector cable reburial events 1 no. every 5 years maximum covering 4% of cable length. | <p>The greatest number of vessel movements and maximum amount of maintenance activities will result in the greatest consumption of fuel and materials representing the greatest potential for GHG emissions.</p> <p>Greatest quantity of materials and fuel consumption represents the greatest potential for GHG emissions.</p> |
| The impact of GHG emissions arising from decommissioning works (e.g. plant, fuel and vessel use) and the recovery (or disposal) of materials. | x | x | ✓ | <p>At the end of Morven South’s operational lifetime, it is anticipated that all wind turbines and OSPs (including foundations), inter-array cable and interconnector cables will be removed where possible/practicable. It is assumed that cable protection will be removed.</p> <p>The decommissioning sequence will generally be the reverse of the construction sequence and involve similar types and numbers of vessels and equipment.</p> | <p>The greatest number of vessel movements and the greatest quantity of materials will result in the greatest consumption of fuels and materials representing the greatest potential for GHG emissions from the decommissioning works.</p> |

6 Assessment of construction effects

6.1 Blue carbon

- 6.1.1.1 During construction, it is anticipated that there will be disturbance to blue carbon stocks from the installation of the wind turbine foundations, OSP foundations, interconnector and inter-array cables, and cable protection.
- 6.1.1.2 Emissions associated with such disturbance during the construction phase of both Morven North and Morven South have been calculated based on the total area of seabed disturbance, sediment types present in the Morven North Climate Change Study Area and Morven South Climate Change Study Area, published associated carbon stock values and published literature values of the effect of disturbance on remineralisation. The calculation of associated emissions is detailed below.

6.1.2 Morven North

- 6.1.2.1 The total disturbance of the seabed within the Morven North Climate Change Study Area is calculated to be 2,018ha, informed by values provided in the Volume 1, Chapter 3: Project Description, of the Morven North EIA Report.
- 6.1.2.2 Blue carbon factors assigned to each sediment type, ranging from 7.3tC/ha for slightly gravelly muddy sand to 1.8tC/ha for sandy gravel (Smeaton *et al.*, 2020) were scaled by the relevant areas, resulting in an average blue carbon content across the Morven North Climate Change Study Area of 3.99tC/ha (presented within Table 6.2). It has been assumed that the composition of sediment types within the total area of disturbed seabed is consistent with the sediment composition detailed in Section 4.1.1; this is summarised within Table 4.1 alongside the relevant emissions factor used.

Table 6.1: Sediment composition and emissions factors for Morven North

| Sediment type | Sediment composition within the Morven North Climate Change Study Area | Emissions factor (tC/ha) |
|------------------------------|--|--------------------------|
| Sand | 73% | 3.6 |
| Sandy gravel | 1% | 1.8 |
| Slightly gravelly sand | 13% | 3.3 |
| Slightly gravelly muddy sand | 5% | 7.3 |
| Muddy sand | 8% | 6.8 |
| Average factor | | 3.99 |

- 6.1.2.3 When the average blue carbon content is scaled by the area of disturbed seabed, this corresponds to a total of 8,056 tonnes of carbon across the Morven North Climate Change Study Area that has the potential to be disturbed during construction (presented within Table 6.2).
- 6.1.2.4 While a maximum of 8,056 tonnes of blue carbon stock (equivalent to 29,540tCO₂e when converted from carbon to CO₂e), may be disturbed during the construction phase, not all carbon disturbed will be remineralised to CO₂. Though estimates vary, the majority of blue carbon found in marine sediments further than 5km from the shore is likely to be unreactive, and therefore unlikely to be remineralised following disturbance (Smeaton and Austin, 2022). Instead, following disturbance the

blue carbon may be re-deposited elsewhere, with limited remineralisation of CO₂. Approximately 20% of the blue carbon stocks in marine sediments may be reactive and likely to be converted to CO₂ following disturbance (Smeaton and Austin, 2022).

- 6.1.2.5 Given that alternative studies have suggested a higher percentage of conversion to CO₂, uncertainty remains with the values presented above (Cunningham and Hunt, 2023). Therefore, it is conservatively anticipated that between 20% and 100% of the blue carbon stock disturbed during the construction will be converted to CO₂. This corresponds to an emissions value of between 5,908tCO₂e and 29,540tCO₂e (see Table 6.2).

Table 6.2: Summary of blue carbon emissions for Morven North

| | Morven North |
|---|-----------------|
| Blue carbon per hectare (tC/ha) | 3.99 |
| Total blue carbon (tC) | 8,056 |
| Emissions from blue carbon disturbance (tCO ₂ e) | 5,908 to 29,540 |

6.1.3 Morven South

- 6.1.3.1 The total disturbance of the seabed within the Morven South Climate Change Study Area is calculated to be 1,547ha, informed by values provided in Volume 1, Chapter 3: Project Description, of the Morven South EIA Report.
- 6.1.3.2 Blue carbon factors assigned to each sediment type, ranging from 7.3tC/ha for slightly gravelly muddy sand to 1.8tC/ha for sandy gravel (Smeaton *et al.*, 2020) were scaled by the relevant areas, resulting in an average blue carbon content across the Morven South Climate Change Study Area of 4.46tC/ha (presented within Table 6.4). It has been assumed that the composition of sediment types within the total area of disturbed seabed are consistent with the sediment composition detailed at Section 4.1.2; this is summarised within Table 6.3 alongside the relevant emissions factor used.

Table 6.3: Sediment composition and emissions factors for Morven South

| Sediment type | Sediment composition within the Morven South Climate Change Study Area | Emissions factor (tC/ha) |
|------------------------------|--|--------------------------|
| Sand | 78% | 3.6 |
| Slightly gravelly sand | 7% | 3.3 |
| Slightly gravelly muddy sand | 3% | 7.3 |
| Muddy sand | 22% | 6.8 |
| Average factor | | 4.46 |

- 6.1.3.3 When the average blue carbon content is scaled by the area of disturbed seabed, this corresponds to a total of 6,903 tonnes of carbon across the Morven South Climate Change Study Area, that has the potential to be disturbed during construction (presented within Table 6.4).

- 6.1.3.4 While a maximum of 6,903 tonnes of blue carbon stock (equivalent to 25,311tCO₂e when converted from carbon to CO₂e), may be disturbed during the construction phase, not all carbon disturbed will be remineralised to CO₂. Though estimates vary, the majority of blue carbon found in marine sediments further than 5km from the shore is likely to be unreactive, and therefore unlikely to be remineralised following disturbance (Smeaton and Austin, 2022). Instead, following disturbance the blue carbon may be re-deposited elsewhere, with limited remineralisation of CO₂. Approximately 20% of the blue carbon stocks in marine sediments may be reactive and likely to be converted to CO₂ following disturbance (Smeaton and Austin, 2022).
- 6.1.3.5 Uncertainty remains with the values presented above however, as alternative studies have suggested a higher percentage of conversion to CO₂ (Cunningham and Hunt, 2023). Therefore, it is conservatively anticipated that between 20% and 100% of the blue carbon stock disturbed during the construction phase will be converted to CO₂. This corresponds to an emissions value of between 5,062tCO₂e and 25,311tCO₂e (see Table 6.4).

Table 6.4: Summary of blue carbon emissions for Morven South

| | Morven South |
|---|---------------------|
| Blue carbon per hectare (tC/ha) | 4.46 |
| Total blue carbon (tC) | 6,903 |
| Emissions from blue carbon disturbance (tCO ₂ e) | 5,062 to 25,311 |

6.2 Embodied carbon

- 6.2.1.1 The following sections detail the methodology used to calculate the construction phase emissions associated with Morven North and Morven South. Each section groups relevant elements of Morven North and Morven South by methodology used to calculate resultant emissions.
- 6.2.1.2 The construction phase emissions cover the LCA stages A1-A5, materials and construction (i.e. emissions associated with the extraction, processing and manufacturing of materials). In addition, emissions associated with the transport of materials and technology to site (within the UK) have been analysed.
- 6.2.1.3 The materials involved in the offshore components of Morven North and Morven South are the initial elements to consider within the cradle-to-grave approach towards completing this LCA. Emissions are derived from the raw material production required to manufacture the wind turbines, turbine foundations, OSPs and OSP foundations, interconnector and inter-array cables, and cable protection, and it is often the phase where the majority of embodied carbon is emitted.

Wind turbines, offshore substation platforms and cables

- 6.2.1.4 The construction phase emissions associated with the following elements of Morven North and Morven South have been calculated using approximate material quantities, and relevant material emission factors (sourced from the ICE data base, Jones and Hammond, 2024):
 - wind turbines (blades, towers, nacelles, and foundations);
 - OSP topside structures and foundations;
 - inter-array and interconnector cables;
 - inter-array and interconnector cable protection;
 - scour protection.

Offshore substation platform plant

6.2.1.5 There is limited design information concerning the OSP plant for both Morven North and Morven South, and there are few published LCAs from which to calculate embodied carbon emissions associated with offshore substation equipment. Data from an Environmental Product Declaration (EPD) for a 16kVA to 1,000MVA transformer (ABB, 2003) has therefore been used to provide an approximation of the potential order of magnitude of emissions from the OSP plant, as transformers are among the major substation plant components and have a relatively high materials and carbon intensity. The LCA (ABB, 2003) listed a manufacturing GWP of 2,190kgCO_{2e} per MW. This value includes lifecycle stages A1-A3.

Vessel, helicopter and onshore movements

6.2.1.6 Indicative vessel and helicopter movements were used to calculate emissions associated with their activities during the construction phase for both Morven North and Morven South. Emissions associated with vessel movements were calculated by estimating total main engine capacity requirements, vessel speed and distance from port, based on indicative vessel information and likely base ports provided by the project team.

6.2.1.7 These variables were used to calculate total fuel use for vessel movements during the construction phase of Morven North and Morven South. These values were then scaled by the emission factor for marine gas oil (0.258kgCO_{2e}/kWh, or 3,245kgCO_{2e}/tonne) (DESNZ and DEFRA, 2025).

6.2.1.8 Helicopter movements and their associated emissions were calculated by determining the anticipated fuel consumption, informed by their predicted movements. An indicative number of return trips and assumed distance (see Section 5), alongside average fuel consumption (430kg/hr) and fuel economy data (145 knots per hour (kn/hr)) (obtained from manufacturers specifications) were used to estimate fuel consumption. Emission factors for aviation turbine fuel (2.54l/kgCO_{2e}) (DESNZ and DEFRA, 2025) were then scaled by the fuel consumption to give associated emissions.

6.2.1.9 Emissions associated the transport of materials and products to the likely base port (i.e. from national and international sources) were calculated by scaling the approximate material quantities associated with the construction of Morven North and Morven South, by conservative high level transport scenarios (120km for nationally manufactured products transported by road, 10,000km globally manufactured products transported by sea) (RICS, 2024), and appropriate emissions factors (0.102kgCO_{2e}/tonne/km for national HGV transport, and 0.016kgCO_{2e}/tonne/km for international cargo ship transport) (DESNZ and Defra, 2025).

6.2.2 Morven North

Wind turbines, offshore substation platforms and cables

6.2.2.1 Table 6.5 summarises the relevant material emission intensities sourced from the ICE data base (Jones and Hammond, 2024), and corresponding emissions values for Morven North.

Table 6.5: Construction phase embodied carbon emissions for Morven North

| Item | Material | Emissions factor (kgCO _{2e} /kg) | Emissions (tCO _{2e}) |
|---|-------------|---|--------------------------------|
| Wind turbines (blades, towers and nacelles) | Steel | 2.34 | 287,731 |
| | Glass fibre | 8.10 | 71,410 |
| | Cast iron | 2.03 | 156,531 |

| Item | Material | Emissions factor (kgCO ₂ e/kg) | Emissions (tCO ₂ e) |
|---|-------------------------|---|--------------------------------|
| | Aluminium | 6.67 | 12,826 |
| | Copper | 2.71 | 7,513 |
| | Polyethylene | 2.54 | 4,449 |
| | Wood | 0.49 | 309 |
| | Carbon fibre | 19.85 | 82,894 |
| | Polyurethane rigid foam | 4.26 | 2,224 |
| | Epoxy Resin | 5.70 | 65,988 |
| Wind turbines (foundations, including scour protection) | Steel | 2.34 | 1,316,407 |
| | Concrete | 0.103 | 1,211 |
| | Aluminium | 6.67 | 39,065 |
| | Epoxy resin | 5.70 | 33,391 |
| | Scour protection | 0.00747 | 34,429 |
| OSPs (topside) | Steel | 2.34 | 282,219 |
| OSPs (foundation) | Steel | 2.34 | 404,601 |
| | Concrete | 0.103 | 373 |
| | Aluminium | 6.67 | 12,030 |
| | Coating (epoxy resin) | 5.70 | 10,283 |
| | Scour protection | 0.00747 | 7,716 |
| Inter-array cables | Aluminium | 6.67 | 4,201 |
| | Copper | 2.71 | 20,434 |
| | Steel | 2.34 | 21,256 |
| | Polypropylene | 3.96 | 21,874 |
| Inter-array cable protection | Concrete | 0.103 | 18,838 |
| Localised inter-array cable protection | Concrete | 0.103 | 942 |
| Inter-array cable crossings | Rock | 0.00747 | 1,140 |
| Interconnector cables | Lead | 1.67 | 13,644 |
| | Copper | 2.71 | 45,252 |
| | Steel | 2.34 | 54,864 |

| Item | Material | Emissions factor (kgCO ₂ e/kg) | Emissions (tCO ₂ e) |
|---|---------------|---|--------------------------------|
| | Polypropylene | 3.96 | 56,445 |
| Interconnector cable protection | Concrete | 0.103 | 32,417 |
| Localised interconnector cable protection | Iron (cast) | 2.03 | 181 |
| Interconnector cable crossings | Rock | 0.00747 | 1,140 |
| Total | | | 3,126,228 |

Offshore substation platform plant

6.2.2.2 The LCA listed manufacturing GWP per MW (see paragraph 6.2.1.5) was scaled by the current anticipated output capacity of 1,500MW to give an estimated embodied emission value of 3,285tCO₂e for the plant at Morven North.

Vessel, helicopter and onshore movements

6.2.2.3 Emissions associated with vessel, helicopter and onshore movements were calculated in line with the methodology detailed at 6.2.1.6 to 6.2.1.9, and total 383,472tCO₂e for Morven North (of which 255,377tCO₂e comprises transport emissions at the Morven Site, and 128,095tCO₂e associated with material transport to the construction port).

6.2.3 Morven South

Wind turbines, offshore substation platforms and cables

6.2.3.1 Table 6.5 summarises the relevant material emission intensities sourced from the ICE data base (Jones and Hammond, 2024), and corresponding emissions values for Morven South.

Table 6.6: Construction phase embodied carbon emissions for Morven South

| Item | Material | Emissions factor (kgCO ₂ e/kg) | Emissions (tCO ₂ e) |
|---|--------------|---|--------------------------------|
| Wind turbines (blades, towers and nacelles) | Steel | 2.34 | 287,731 |
| | Glass fibre | 8.10 | 71,410 |
| | Cast iron | 2.03 | 156,531 |
| | Aluminium | 6.67 | 12,826 |
| | Copper | 2.71 | 7,513 |
| | Polyethylene | 2.54 | 4,449 |
| | Wood | 0.49 | 309 |
| | Carbon fibre | 19.85 | 82,894 |

| Item | Material | Emissions factor (kgCO ₂ e/kg) | Emissions (tCO ₂ e) |
|---|-------------------------|---|--------------------------------|
| | Polyurethane rigid foam | 4.26 | 2,224 |
| | Epoxy resin | 5.70 | 65,988 |
| Wind turbines (foundations, including scour protection) | Steel | 2.34 | 1,316,407 |
| | Concrete | 0.10 | 1,211 |
| | Aluminium | 6.67 | 39,065 |
| | Epoxy resin | 5.70 | 33,391 |
| | Scour protection | 0.01 | 34,429 |
| OSPs (topside) | Steel | 2.34 | 282,219 |
| OSPs (foundation) | Steel | 2.34 | 404,601 |
| | Concrete | 0.103 | 373 |
| | Aluminium | 6.67 | 12,030 |
| | Coating (epoxy resin) | 5.70 | 10,283 |
| | Scour protection | 0.01 | 7,716 |
| Inter-array cables | Aluminium | 6.67 | 4,201 |
| | Copper | 2.71 | 20,434 |
| | Steel | 2.34 | 21,256 |
| | Polypropylene | 3.96 | 21,874 |
| Inter-array cable protection | Concrete | 0.10 | 18,838 |
| Localised inter-array cable protection | Concrete | 0.10 | 942 |
| Inter-array cable crossings | Rock | 0.00747 | 1,140 |
| Interconnector cables | Lead | 1.67 | 7,442 |
| | Copper | 2.71 | 24,683 |
| | Steel | 2.34 | 29,926 |
| | Polypropylene | 3.96 | 30,788 |
| Interconnector cable protection | Concrete | 0.10 | 17,682 |
| Localised interconnector cable protection | Polyurethane | 4.26 | 119 |
| | Steel | 2.34 | 18 |

| Item | Material | Emissions factor (kgCO ₂ e/kg) | Emissions (tCO ₂ e) |
|--------------------------------|----------|---|--------------------------------|
| Interconnector cable crossings | Rock | 0.00747 | 1,140 |
| Total | | | 3,034,083 |

Offshore substation platform plant

6.2.3.2 The LCA listed manufacturing GWP per MW (see paragraph 6.2.1.5) was scaled by the current anticipated output capacity of 1,500MW to give an estimated embodied emission value of 3,285tCO₂e for the plant at Morven South.

Vessel, helicopter and onshore movements

6.2.3.3 Emissions associated with vessel and helicopter movements were calculated in line with the methodology detailed at paragraphs 6.2.1.6 to 6.2.1.9, and total 406,703tCO₂e for Morven South (of which 280,695tCO₂e comprises transport emissions at the Morven Site, and 126,009tCO₂e associated with material transport to the construction port).

6.3 Summary

6.3.1.1 Table 6.7 summarises the calculated construction phase emissions associated with Morven North and Morven South.

Table 6.7: Summary of construction phase carbon emissions for Morven North and Morven South

| Item | Emissions (tCO ₂ e) | |
|---|--------------------------------|--------------|
| | Morven North | Morven South |
| Wind turbines (blades, towers and nacelles) | 691,874 | 691,874 |
| Wind turbines (foundations including scour protection) | 1,424,503 | 1,424,503 |
| OSPs (topside) | 285,504 | 285,504 |
| OSPs (foundations) | 435,003 | 435,003 |
| Inter-array cables | 67,766 | 67,766 |
| Inter-array cable protection | 19,779 | 19,779 |
| Inter-array cable crossings | 1,140 | 1,140 |
| Interconnector cables | 170,205 | 92,839 |
| Interconnector cable protection | 32,599 | 17,819 |
| Interconnector cable crossings | 1,140 | 1,140 |
| Transport | 255,377 | 280,695 |
| Transport (material transport to the construction port) | 128,095 | 126,009 |

| Item | Emissions (tCO ₂ e) | |
|--------------|--------------------------------|------------------|
| | Morven North | Morven South |
| Blue carbon | 29,540 | 25,311 |
| Total | 3,542,526 | 3,469,383 |

7 Assessment of operations and maintenance effects

7.1 Blue carbon

7.1.1 Morven North

7.1.1.1 The long-term temporary (35-year) footprint of Morven North has the potential to affect the sequestration of blue carbon over its 35-year operations and maintenance lifetime. However, as mentioned in Section 4.2, evidence on sequestration rates in offshore sediments indicates little to no sediment accumulation in some areas of the North Sea (Cunningham and Hunt, 2023). Therefore, it is assumed that there will be negligible effects to blue carbon storage over Morven North's 35-year lifetime. No further quantitative assessment has been undertaken.

7.1.2 Morven South

7.1.2.1 The potential for sediment accumulation and associated sequestration of blue carbon for Morven South is consistent with that set out in paragraph 7.1.1.1 for Morven North. Therefore, it is assumed that there will be negligible effects to blue carbon storage over Morven South's 35-year lifetime. No further quantitative assessment has been undertaken.

7.2 Avoided emissions

7.2.1.1 The magnitude of impact of Morven North and Morven South is determined by the quantity of marginal electricity generation sources it displaces and associated GHG impacts. The marginal energy generation displaced is determined by the total annual energy output values for Morven North and Morven South (see Table 7.1). The associated GHG emissions are determined by the GHG intensity of the displaced sources of generation.

7.2.1.2 Given the anticipated output capacity is consistent for both Morven North and Morven South, the calculation of avoided emissions will also be consistent. Therefore, the following assessment is applicable to both Morven North and Morven South and has not been repeated for each project individually.

7.2.1.3 Table 7.1 sets out the parameters for Morven North and Morven South and the associated annual energy output. The values presented in Table 7.1 relate to either Morven North or Morven South and do not present an assessment of both combined.

Table 7.1: Energy flows from Morven North or Morven South

| Parameter | Value per array | Unit | Source |
|--|-----------------|------|---|
| Input parameter – anticipated rated power | 1,500 | MW | Volume 1, Chapter 3: Project Description, of the Morven North EIA Report and Volume 1, Chapter 3: Project Description, of the Morven South EIA Report |
| Input parameter – capacity factor | 39.7 | % | DESNZ (2023b) |
| Input parameter – degradation factor | 1.6 | % | Stafell <i>et al.</i> (2014) |
| Input parameter – total annual operating hours | 8,766 | hrs | Volume 1, Chapter 3: Project Description, of the Morven North EIA Report and Volume 1, Chapter 3: Project Description, of the Morven South EIA Report |

| Parameter | Value per array | Unit | Source |
|--|-----------------|------|---|
| Output parameter – annual energy output (year 1) | 5,222,544 | MWh | Volume 1, Chapter 3: Project Description, of the Morven North EIA Report and Volume 1, Chapter 3: Project Description, of the Morven South EIA Report |

- 7.2.1.4 The input and output figures for the operations and maintenance phases of Morven North and Morven South are then calculated against the assumptions stated within the DESNZ long-run marginal (DESNZ, 2023a). This allows for a direct presentation of the cumulative GHG emissions avoided throughout the operational lifetime of Morven North and Morven South and therefore, how Morven North and Morven South contribute towards reaching net zero targets in the UK and Scotland.
- 7.2.1.5 The marginal source displaced may in practice vary from moment to moment depending on the operation of the capacity market (i.e. led by commercial considerations and National Grid’s needs at any given time). For the purpose of this assessment, longer-term trends (annual averages) have been used as it is not possible to predict shorter-term variations with confidence. It should be noted that as the UK and Scotland move towards their 2050 and 2045 net zero carbon targets, respectively, the marginal source of electricity generation will likely become a combination of renewables (predominately solar and wind) and storage. It is important to note therefore that from circa 2035 onwards, long-run marginal projections assume that there is no unabated fossil fuel generation, in line with UK Government policy. As such, comparing Morven North and Morven South’s GHG impacts with the marginal source of generation is likely to represent an underestimation of its true avoided emissions.
- 7.2.1.6 The DESNZ long-run marginal grid carbon intensity factors do not properly consider the embedded construction phase GHG impacts of the sources of generation. It is therefore not a like-for-like comparison to compare the lifetime carbon impacts of Morven North and Morven South with the DESNZ long-run marginal or grid average source.
- 7.2.1.7 Table 7.2 displays the annual power output and emissions avoidance of Morven North and Morven South when comparing the abated fossil fuel generation using the DESNZ (2023a) long-run marginal carbon intensity for the future UK Grid. Because the anticipated capacity of each is the same, avoided emissions will be likewise and thus, the figures below are true for both Morven North and Morven South. The values presented in Table 7.2 are anticipated for either Morven North or Morven South, and do not represent an assessment of both combined.

Table 7.2: Operational greenhouse gas impacts of Morven North or Morven South

| Year of operation | Year | Output (MWh) | DESNZ long-run marginal | Avoided emissions (tCO ₂ e) | Cumulative avoided emissions (tCO ₂ e) |
|-------------------|------|--------------|-------------------------|--|---|
| 1 | 2038 | 5,222,544 | 0.01 | -52,225 | -52,225 |
| 2 | 2039 | 5,138,983 | 0.008 | -41,112 | -93,337 |
| 3 | 2040 | 5,056,759 | 0.006 | -30,341 | -123,678 |
| 4 | 2041 | 4,975,851 | 0.006 | -29,855 | -153,533 |
| 5 | 2042 | 4,896,238 | 0.004 | -19,585 | -173,118 |

| Year of operation | Year | Output (MWh) | DESNZ long-run marginal | Avoided emissions (tCO ₂ e) | Cumulative avoided emissions (tCO ₂ e) |
|-------------------|------|--------------|-------------------------|--|---|
| 6 | 2043 | 4,817,898 | 0.003 | -14,454 | -187,572 |
| 7 | 2044 | 4,740,811 | 0.002 | -9,482 | -197,053 |
| 8 | 2045 | 4,664,958 | 0.001 | -4,665 | -201,718 |
| 9 | 2046 | 4,590,319 | 0.001 | -4,590 | -206,309 |
| 10 | 2047 | 4,516,874 | 0.001 | -4,517 | -210,825 |
| 11 | 2048 | 4,444,604 | 0.001 | -4,445 | -215,270 |
| 12 | 2049 | 4,373,490 | 0.001 | -4,373 | -219,643 |
| 13 | 2050 | 4,303,514 | 0.001 | -4,304 | -223,947 |
| 14 | 2051 | 4,234,658 | 0.002 | -8,469 | -232,416 |
| 15 | 2052 | 4,166,904 | 0.002 | -8,334 | -240,750 |
| 16 | 2053 | 4,100,233 | 0.002 | -8,200 | -248,951 |
| 17 | 2054 | 4,034,630 | 0.002 | -8,069 | -257,020 |
| 18 | 2055 | 3,970,075 | 0.002 | -7,940 | -264,960 |
| 19 | 2056 | 3,906,554 | 0.002 | -7,813 | -272,773 |
| 20 | 2057 | 3,844,049 | 0.002 | -7,688 | -280,461 |
| 21 | 2058 | 3,782,545 | 0.002 | -7,565 | -288,026 |
| 22 | 2059 | 3,722,024 | 0.002 | -7,444 | -295,470 |
| 23 | 2060 | 3,662,471 | 0.002 | -7,325 | -302,795 |
| 24 | 2061 | 3,603,872 | 0.002 | -7,208 | -310,003 |
| 25 | 2062 | 3,546,210 | 0.002 | -7,092 | -317,095 |
| 26 | 2063 | 3,489,471 | 0.002 | -6,979 | -324,074 |
| 27 | 2064 | 3,433,639 | 0.002 | -6,867 | -330,942 |
| 28 | 2065 | 3,378,701 | 0.002 | -6,757 | -337,699 |
| 29 | 2066 | 3,324,642 | 0.002 | -6,649 | -344,348 |
| 30 | 2067 | 3,271,447 | 0.002 | -6,543 | -350,891 |
| 31 | 2068 | 3,219,104 | 0.002 | -6,438 | -357,329 |
| 32 | 2069 | 3,167,599 | 0.002 | -6,335 | -363,665 |
| 33 | 2070 | 3,116,917 | 0.002 | -6,234 | -369,898 |

| Year of operation | Year | Output (MWh) | DESNZ long-run marginal | Avoided emissions (tCO ₂ e) | Cumulative avoided emissions (tCO ₂ e) |
|-------------------|------|--------------|-------------------------|--|---|
| 34 | 2071 | 3,067,046 | 0.002 | -6,134 | -376,033 |
| 35 | 2072 | 3,017,974 | 0.002 | -6,036 | -382,069 |

7.2.2 Sensitivity analysis

- 7.2.2.1 The long-run marginal figures, which have been used in Table 7.2, are dynamic and show year-on-year decarbonisation of the UK Electricity Grid towards the UK's committed net zero 2050 pledge. The long-run marginal carbon intensity figures account for variations over time for both generation and consumption activity reflecting the different types of power plants generating electricity across the day and over time, each with different emissions factors.
- 7.2.2.2 However, as discussed in Section 3.3, long-run marginal figures should be treated as indicative projections rather than prescriptive targets, and the projections assume abatement of fossil fuel generation sources within the UK Electricity Grid. By the time Morven North and Morven South are anticipated to be operational (indicatively from 2038), the UK is expected to have made significant progress towards a low carbon electricity Grid, with the current Government policy target year of 2030. Nevertheless, the UK Government has highlighted that some 'transition' fossil fuels will continue to play a part in the UK's energy supply. Therefore, it is likely that the true value of the avoided emissions displaced as a result of Morven North and Morven South's contribution to the UK Electricity Grid would be higher than that of avoided emissions detailed above.
- 7.2.2.3 As such, a sensitivity analysis has been carried out using the current UK Electricity Grid carbon intensity (222.9kgCO₂e/MWh, including scope 3 but as generated, (i.e. excluding transmission and distribution losses)) and current estimated intensity from electricity supplied for 'all non-renewable fuels' (437kgCO₂e/MWh).
- 7.2.2.4 Although the use of the current UK Electricity Grid average and DESNZ 'non-renewable fuels' carbon intensities would conclude greater avoided emissions and an ultimate reduction in carbon payback period, these are static baselines and do not account for future UK Electricity Grid decarbonisation. Further, as Morven North and Morven South's generation output would be dictated by day-to-day demand alongside commercial factors and the National Grid's needs, the benefit of provision of additional low carbon electricity capacity cannot be used to quantify avoided emissions. As such, the long-run marginal provides a conservative quantification of avoided emissions for the purpose of this assessment.
- 7.2.2.5 Table 7.3 below details the potential avoided emissions for the assessment scenario (DESNZ long-run marginal) and two alternative scenarios as part of the sensitivity analysis (current UK Electricity Grid average as of 2024, and DESNZ "non-renewable fuels" intensity as of 2024). These are presented for the entire assumed lifetime of 35-years for the purpose of the GHG calculations (whole life). The true avoided emissions value for Morven North and Morven South is likely to lie between the upper and lower limits shown in Table 7.3 below. As explained previously, because the output is identical for both Morven North and Morven South, the estimated avoided emissions will also be consistent across each.
- 7.2.2.6 Table 7.3 therefore represents the sensitivity analysis of Morven North or Morven South and not a combined assessment.

Table 7.3: Sensitivity analysis for Morven North or Morven South

| Operating years | Output (MWh) | DESNZ long-run marginal avoided emissions (tCO ₂ e) | Current UK Grid average avoided emissions (tCO ₂ e) | DESNZ 'non-renewable fuels' avoided emissions (tCO ₂ e) |
|-----------------|--------------|--|--|--|
| 35 | 140,803,609 | -382,069 | -31,385,124 | -61,531,177 |

7.2.2.7 Additionally, variations in load factors could have a similar effect on the avoided emissions in addition to other quantifications of emissions. Any change in the load factors would vary the MWh output accordingly. As the output has been used as the base for the calculation of avoided emissions, any increase in emissions or avoided emissions would be proportionately similar to that of the above.

7.3 Fuel, energy and material use during operations and maintenance activities

7.3.1.1 The primary purpose of the operational stage of a wind farm is to avoid the need for fossil fuel generation assets and reduce the national grid carbon intensity. Emissions during the operational phase of Morven North and Morven South refer to activities contributing to the high-level management of the asset such as remote monitoring, environmental monitoring, electricity sales, etc. Maintenance typically accounts for the largest portion and can be divided into preventative maintenance and corrective maintenance:

- Preventative maintenance: proactive repair to, or replacement of, known wear components based on routine inspections or monitoring systems;
- Corrective maintenance includes the reactive repair or replacement of failed or damaged components. It may also be performed batch-wise when serial defects or other problems occur.

7.3.1.2 Morven North and Morven South maintenance activities largely involve inspection, repainting, major and minor item repair and replacement, removal of marine growth, reburial of cables, and geophysical surveys. Emissions associated with such activities are largely captured with transport movements. Where materials are used (i.e. new paint and coatings, fuses, access ladders etc), associated emissions are negligible and immaterial and as such have not been assessed further.

7.3.1.3 Emissions associated with the proposed maintenance vessel movements for both Morven North and Morven South follow the methodology detailed in paragraphs 6.2.1.6 to 6.2.1.8. This consists of the number of movements undertaken by vessels across the operational period for maintenance activities. The number of movements were scaled by the distance travelled and fuel consumption to provide total fuel consumption. This value was then scaled by the emission factor for marine gas oil (0.258kgCO₂e/kWh, or 3,245kgCO₂e/tonne) (DESNZ and DEFRA, 2025).

7.3.1.4 Throughout Morven North and Morven South lifetimes, major plant equipment such as transformers will be replaced up to once every three years for each OSP (as informed by Volume 1, Chapter 3: Project Description, of the Morven North EIA Report, and Volume 1, Chapter 3: Project Description, of the Morven South EIA Report). This corresponds to a maximum of 11 replacements per OSP over the lifetime of Morven North and Morven South given their 35-year lifetime. As such, the embodied carbon emissions associated with the OSP plant (calculated using the methodology detailed at paragraph 6.2.1.5) have been scaled up by a factor of 11 for both Morven North and Morven South to provide the operations and maintenance emissions for the OSP plant. Though it is unlikely that all electric plant will need to be replaced once every three years per OSP, this is treated as the most conservative (maximum design) scenario.

- 7.3.1.5 It is anticipated that two inter-array cable repair events will take place every five years, with typically 2km of cable repaired per event. Furthermore, it is anticipated that 14 interconnector cable repair events will take place over the lifetime of Morven North and Morven South, with typically 2km of cable repaired per event. Emissions associated with the replacement of such cables were calculated using the methodology detailed at paragraph 6.2.1.4.
- 7.3.1.6 It is anticipated that 4% of the inter-array cable length and interconnector cable length for Morven North and Morven South will be reburied every five years. Emissions associated with the replacement of cable protection were calculated using the methodology detailed paragraph 6.2.1.4.
- 7.3.1.7 Emissions associated with the transport of materials and products from maintenance and repair activities to the likely base port were calculated in line with the methodology detailed at paragraph 6.2.1.9, informed by the material quantities required for maintenance and repair events (as outlined above).

7.3.2 Morven North

- 7.3.2.1 Consistent with the methodology outlined at paragraph 7.3.1.3 and 7.3.1.7, emissions associated with maintenance vessel movements and product transport movements total 877,056tCO_{2e} for Morven North over its lifetime.
- 7.3.2.2 Consistent with the methodology outlined at paragraph 7.3.1.4, emissions associated with major plant replacement total 36,135tCO_{2e} for Morven North over its lifetime.
- 7.3.2.3 Consistent with the methodology outlined at paragraph 7.3.1.5, total emissions from inter-array and interconnector cable replacement over Morven North's lifetime were calculated to be 2,409tCO_{2e} and 9,847tCO_{2e}, respectively.
- 7.3.2.4 Consistent with the methodology outlined at paragraph 7.3.1.6, total emissions from cable protection over Morven North's lifetime were calculated to be 170,238tCO_{2e}.

7.3.3 Morven South

- 7.3.3.1 Consistent with the methodology outlined at paragraph 7.3.1.3 and 7.3.1.7, emissions associated with maintenance vessel movements and product transport movements total 968,148tCO_{2e} for Morven South over its lifetime.
- 7.3.3.2 Consistent with the methodology outlined at paragraph 7.3.1.4, emissions associated with major plant replacement total 36,135tCO_{2e} for Morven South over its lifetime.
- 7.3.3.3 Consistent with the methodology outlined at paragraph 7.3.1.5, total emissions from inter-array and interconnector cable replacement over Morven South's lifetime were calculated to be 2,409tCO_{2e} and 9,847tCO_{2e}, respectively.
- 7.3.3.4 Consistent with the methodology outlined at paragraph 7.3.1.6, total emissions from cable protection over Morven South's lifetime were calculated to be 128,277tCO_{2e}.

7.4 Summary

- 7.4.1.1 Table 7.4 summarises the calculated operations and maintenance phase emissions associated with Morven North and Morven South. Note that negative values represent avoided emissions (i.e. emissions that would have occurred without Morven North and Morven South).

Table 7.4: Operations and maintenance phase emissions for Morven North and Morven South

| Item | Emissions (tCO2e) | |
|----------------------|---|---|
| | Morven North | Morven South |
| Avoided emissions | -382,069 (long-run marginal) to -61,531,177 (non-renewables mix) | -382,069 (long-run marginal) to -61,531,177 (non-renewables mix) |
| Transport | 877,056 | 968,148 |
| Material replacement | 218,629 | 176,668 |
| Blue carbon | n/a | n/a |
| Total | 713,617 to -60,435,491 | 762,747 to -60,386,362 |

8 Decommissioning

- 8.1.1.1 The majority of emissions during the decommissioning phase for both Morven North and Morven South relate to the use of plant/equipment for decommissioning, disassembly, transportation to a waste site, and ultimate disposal and/or recycling of the equipment and other site materials.
- 8.1.1.2 It is anticipated that all wind turbines (including foundations) and OSPs (including foundations) will be removed; inter-array and interconnector cables will be removed where possible and appropriate to do so, cable and scour protection will be removed.
- 8.1.1.3 The components of the wind turbines are considered to be highly recyclable. When disposing of wind turbines, recycling is the preferred solution. This not only prevents the materials from being sent to landfills but also reduces the need for the extraction of primary materials. Material which cannot be recycled might be used for incineration or energy from waste. It is considered the same approach can be applied to all OSPs (and foundations), inter-array and interconnector cables, and associated cable and scour protection retrieved during decommissioning. Any elements left in situ during decommissioning will not result in additional emissions during this phase. As such, emissions associated with the disposal of materials at the end of their lifetime for both Morven North and Morven South are considered to be immaterial and may even result in future avoided emissions. This impact is not assessed further.
- 8.1.1.4 In the absence of detailed information regarding onshore and offshore transport movements during the decommissioning phase, it has been assumed that such emissions equal those associated with the construction phase (excluding those emissions associated with product transport to the construction port). Given that carbon emissions associated with use of plant and fuel are expected to have achieved good levels of decarbonisation at the decommissioning phase of both Morven North and Morven South, this is likely to present a conservative MDS.
- 8.1.1.5 Given the negligible rates of sediment accumulation and associated carbon sequestration in the Morven North Climate Change Study Area and Morven South Climate Change Study Area, there is not anticipated to be any material change to the blue carbon stocks over Morven North and Morven South operational lifetimes (as detailed in paragraphs 4.2.1.1 and 7.1.1.1). As such, any disturbance to the seabed and blue carbon habitats that may result from infrastructure removal at the decommissioning phase is not likely to result in the release of additional emissions not captured by the range of likely emissions presented in the assessment of construction effects. Therefore, this impact is not assessed further.

8.2 Morven North

- 8.2.1.1 Consistent with paragraph 8.1.1.3 emissions associated with the disposal of materials at the end of their lifetime are considered to be immaterial and may even result in future avoided emissions. This impact is not assessed further.
- 8.2.1.2 Consistent with the methodology detailed at paragraph 8.1.1.4, emissions associated with decommissioning transport movements total 255,377tCO₂e.
- 8.2.1.3 Consistent with paragraph 8.1.1.5, emissions associated with disturbance to the seabed and blue carbon habits during the decommissioning phase is not likely to result in the release of additional emissions not captured within the assessment of construction effects. This impact is not assessed further.

8.3 Morven South

- 8.3.1.1 Consistent with paragraph 8.1.1.3 emissions associated with the disposal of materials at the end of their lifetime are considered to be immaterial and may even result in future avoided emissions. This impact is not assessed further.

-
- 8.3.1.2 Consistent with the methodology detailed at paragraph 8.1.1.4, emissions associated with decommissioning transport movements total 280,695tCO₂e.
- 8.3.1.3 Consistent with paragraph 8.1.1.5, emissions associated with disturbance to the seabed and blue carbon habits during the decommissioning phase is not likely to result in the release of additional emissions not captured within the assessment of construction effects. This impact is not assessed further.

9 Whole life emissions

9.1.1.1 Table 9.1 presents a summary of the lifetime net emissions of both Morven North and Morven South.

Table 9.1: Summary of lifetime emissions for Morven North and Morven South

| | Morven North | Morven South |
|---------------------------|--------------------------|--------------------------|
| Construction emissions | 3,542,526 | 3,469,383 |
| Operational emissions* | 713,617 to -60,435,491 | 762,747 to -60,386,362 |
| Decommissioning emissions | 255,377 | 280,695 |
| Net Emissions (total)* | 4,511,520 to -56,637,588 | 4,512,824 to -56,636,284 |

* Range presented accounts for the avoided emissions calculations, as informed by the DESNZ long-run marginal emissions factors and DESNZ non-renewable fuels emissions factor.

10 Cumulative assessment

- 10.1.1.1 It is important to note that Morven North and Morven South cannot deliver the avoided emissions detailed in Section 7.2 without the MHPGC Project and MBAGC Project to enable connection of both to the Grid. The MHPGC Project and MBAGC Project have associated emissions for their construction, operations and maintenance and decommissioning phases that must be considered within the cumulative assessment for climatic effects.
- 10.1.1.2 There are four distinct Morven developments which, together, comprise the Morven Programme: Morven North, Morven South, MHPGC Project and MBAGC Project. The MHPGC Project and MBAGC Project comprise export cable and onshore substation elements of the Morven Programme and are considered within this section.
- 10.1.1.3 Detailed design parameters for MHPGC Project and MBAGC Project are not available at the time of writing. As such, the calculations presented below represent a high-level estimate of total emissions with a high degree of uncertainty. Such emissions estimates have been informed by assumptions based on indicative parameters provided by the Applicant for Morven North and Morven South alongside available design information for MHPGC Project and MBAGC Project. As the future MHPGC Project and MBAGC Project and respective applications are brought forward, the assessment presented below will be enhanced and refined. These updated assessments will be detailed within the future climate change chapters of the MHPGC Project and MBAGC Project EIA Reports.
- 10.1.1.4 Major elements of the MHPGC Project and MBAGC Project will comprise:
- offshore export cable;
 - onshore export cable;
 - onshore land substation.
- 10.1.1.5 Throughout this assessment, it has been assumed that the total operational lifetime for the MHPGC Project and MBAGC Project is the same as both Morven North and Morven South (35-years).

10.2 Morven Hawthorn Pit Grid Connection Project

- 10.2.1.1 The total length of the offshore export cable corridor(s) between the Morven North Boundary and Morven South Boundary and the landfall location is circa 341km, and up to six offshore export cables may be required. The construction and operations and maintenance phase emissions for the offshore export cables associated with the export cable corridor(s) have been calculated based on the methodology in Sections 6.2 and 7.3. It has been assumed that the offshore export cable(s) will have the same cable protection requirements as the inter-array and interconnector cables per kilometre, as detailed in Section 6.2. Total emissions during the construction phase are shown in Table 10.1.
- 10.2.1.2 Six cables are anticipated to be required for the Onshore MHPGC Export Cable Corridor, over an indicative worst case cable length of 15km. The construction and operations and maintenance phase emissions for the Onshore MHPGC Export Cable have been calculated based on the methodology in Sections 6.2 and 7.3. Total emissions during the construction and operations and maintenance phases are shown in Table 10.1.
- 10.2.1.3 A substation is planned for the proposed onshore infrastructure, with an indicative power of 1,500MW. Electrical equipment, such as transformers, busbars, etc. are anticipated to comprise the majority of embodied emissions for the converter stations. As such, the emissions for the electrical equipment required for the converter stations have been calculated based on the methodology in Section 6.2. Total emissions during the construction phase are shown Table 10.1. Maintenance schedules for these are not available at this stage, however it is anticipated that emissions

associated with operations and maintenance of the converter stations would be captured within transport emissions, detailed in paragraph 10.2.1.5, below.

- 10.2.1.4 Grid connection cables are also anticipated to be required from the converter stations to the National Grid substations. A total of 24 cables are anticipated to be required, with an indicative worst case length of 5km each. The construction and operations and maintenance phase emissions for the cables have been calculated based on the methodology in Section 6.2. Total emissions during the construction and operations and maintenance phases are shown in Table 10.1.
- 10.2.1.5 Transport emissions (including product and material transport) have been calculated to make up approximately 12% of total construction emissions, and approximately 82% of total operations and maintenance emissions (excluding avoided emissions) for Morven North and Morven South. Corresponding uplifts have therefore been applied to the total construction and operations and maintenance emissions respectively, associated with the MHPGC Project, in the absence of detailed transport information.
- 10.2.1.6 The calculation of emissions resulting from disturbance of blue carbon associated with the construction of the offshore export cable(s) has been informed by benthic surveys undertaken for Morven North and Morven South (see Sections 6.1.2 and 0). It has been assumed that the blue carbon content across the Morven North Climate Change Study Area and Morven South Climate Change Study Area is comparable to the blue carbon present along the offshore export cable corridor. An average blue carbon content of 4.19tCO_{2e} was scaled by an estimated 20km² (area of the seabed is likely to be disturbed). Resultant emissions are presented within Table 10.1.
- 10.2.1.7 As stated in Section 7.1, there is not anticipated to be any material change in the blue carbon stocks over the operational lifetime of Morven North and Morven South. This is also assumed for the proposed offshore export cable(s) in the absence of further detailed information. As such, it is not anticipated that there will be additional disturbance (and associated emissions) to blue carbon habitats for the proposed offshore export cable corridor(s) during the operations and maintenance, and decommissioning phases, as activities are not likely to disturb blue carbon habitats additional to those accounted for during the construction phase.
- 10.2.1.8 As detailed in Section 8, the majority of emissions during the decommissioning phase relate to the use of plant/equipment for decommissioning, disassembly, transportation to a waste site, and ultimate disposal and/or recycling. The materials likely to be used are considered to be highly recyclable, with recycling the preferred solution. Such emissions associated with the disposal of materials at the end of their lifetime are considered to be immaterial and are not assessed further. Decommissioning emissions associated with transport are assumed to be equal to construction transport emissions for Morven North and Morven South, and this assumption has also been applied to the MHPGC Project for the purposes of the cumulative assessment. Resultant emissions are presented within Table 10.1.

10.3 Morven Branxton Area Grid Connection Project

- 10.3.1.1 Limited information is available regarding the MBAGC Project. As such, assumptions have been informed by information available for the MHPGC Project, namely, it was assumed that key elements of the MBAGC Project are the same as for the MHPGC Project. In addition, approximate offshore and onshore cable corridor distances and landfall location were estimated for the MBAGC Project. It should be noted that the information provided below is indicative and represents a high-level estimate of total emissions with a high degree of uncertainty for use within the cumulative assessment.
- 10.3.1.2 An assumption has been taken on the total estimated length of the offshore export cable corridor(s) between the Morven North Boundary and Morven South Boundary and the estimated landfall location for the MBAGC Project of circa 113km, and up to six offshore export cables may be required. At present, there is uncertainty as to whether connection would be to the existing substation, or if a new substation would be built. Therefore, the location of the substation is still undetermined, and the

length of cable used to inform this assessment is indicative for the purposes of this report. The construction and operations and maintenance phase emissions for the offshore export cables associated with the export cable corridor(s) have been calculated based on the methodology in Sections 6.2 and 7.3. It has been assumed that the offshore export cable(s) will have the same cable protection requirements as the inter-array and interconnector cables per kilometre, as detailed in Section 6.2. Total emissions during the construction phase are shown in Table 10.1.

- 10.3.1.3 Up to six cables are assumed to be required for the onshore export cable corridor over an assumed distance of 2km. At present, the exact location of onshore infrastructure has not yet been determined. As such, this distance is indicative for the purposes of this report. The construction and operations and maintenance phase emissions for the onshore export cables have been calculated based on the methodology in Sections 6.2 and 7.3. Total emissions during the construction and operations and maintenance phases are shown in Table 10.1.
- 10.3.1.4 A substation is planned for the proposed onshore infrastructure, with an indicative power of 1,500MW. Electrical equipment, such as transformers, busbars, etc are anticipated to comprise the majority of embodied emissions for the converter stations. As such, the emissions for the electrical equipment required for the converter stations have been calculated based on the methodology in Section 6.2. Total emissions during the construction phase are shown in Table 10.1. Maintenance schedules for these are not available at this stage, however it is anticipated that emissions associated with operations and maintenance of the converter stations would be captured within transport emissions, detailed in paragraph 10.3.1.6, below.
- 10.3.1.5 Grid connection cables are also anticipated to be required from the converter stations to the National Grid substations. Up to 24 cables are anticipated to be required, with an assumed length of 1km each. Given that the location of the substation is unknown at the time of writing, this length has been determined based on reasonable assumptions for the purposes of this assessment. The construction and operations and maintenance phase emissions for the cables have been calculated based on the methodology in Section 6.2. Total emissions during the construction and operations and maintenance phases are shown in Table 10.1.
- 10.3.1.6 Transport emissions have been calculated to make up approximately 12% of total construction emissions, and approximately 82% of total operations and maintenance emissions (excluding avoided emissions) for Morven North and Morven South combined. Corresponding uplifts have therefore been applied to the total construction and operations and maintenance emissions respectively, associated with the MBAGC Project, in the absence of detailed transport information.
- 10.3.1.7 The calculation of emissions resulting from disturbance of blue carbon associated with the construction of the offshore export cable has been informed by benthic surveys undertaken for Morven North and Morven South (see Sections 6.1.2 and 0). It has been assumed that the blue carbon content across the Morven North Climate Change Study Area and Morven South Climate Change Study Area is comparable to the blue carbon present along the offshore export cable corridor. An average blue carbon content of 4.19tCO₂e was scaled by an estimated 7km² (area of the seabed likely to be disturbed). Resultant emissions are presented within Table 10.1.
- 10.3.1.8 As stated in Section 7.1, there is not anticipated to be any material change in the blue carbon stocks over the operational lifetime of Morven North and Morven South. This is also assumed for the proposed offshore export cable(s) in the absence of further detailed information. As such, it is not anticipated that there will be additional disturbance (and associated emissions) to blue carbon habitats for the proposed offshore export cable corridor(s) during the operations and maintenance and decommissioning phases, as activities are not likely to disturb blue carbon habitats additional to those accounted for during the construction phase.
- 10.3.1.9 As detailed in Section 8, the majority of emissions during the decommissioning phase relate to the use of plant/equipment for decommissioning, disassembly, transportation to a waste site, and ultimate disposal and/or recycling. The materials likely to be used are considered to be highly recyclable, with recycling the preferred solution. Such emissions associated with the disposal of materials at the end of their lifetime are considered to be immaterial and are not assessed further.

Decommissioning emissions associated with transport are assumed to be equal to construction transport emissions for Morven North and Morven South, and this assumption has also been applied to the MBAGC Project for the purposes of the cumulative assessment. Resultant emissions are presented within Table 10.1.

10.4 Summary

10.4.1.1 Table 10.1 summarises the calculated emissions associated with the MHPGC Project and MBAGC Project.

Table 10.1: Summary of calculated emissions as a result of the cumulative infrastructure

| Item | Emissions (tCO ₂ e) | |
|-----------------------------------|---|---|
| | Morven Hawthorn Pit Grid Connection Project | Morven Branxton Area Connection Project |
| Construction | | |
| Offshore export cables | 718,905 | 238,427 |
| Onshore cable corridor | 31,650 | 4,220 |
| Grid connection export cables | 42,200 | 8,440 |
| Cable protection | 1,012 | 336 |
| Converter stations | 3,285 | 3,285 |
| Transport | 112,972 | 36,153 |
| Blue carbon | 31,407 | 10,416 |
| Sub-total | 941,430 | 301,277 |
| Operations and maintenance | | |
| Cable repair and replacement | 18,786 | 5,950 |
| Transport | 85,579 | 27,105 |
| Sub-total | 104,365 | 33,055 |
| Decommissioning | | |
| Transport | 75,314 | 24,102 |
| Total | 1,121,109 | 358,435 |

11 References

- ABB. (2003). Environmental Product Declaration: Power transformer TrafoStar 500 MVA. Available at: <https://library.e.abb.com/public/566748ad75116903c1256d630042f1af/ProductdeclarationStarTrafo500.pdf>. Accessed on: 03 February 2024.
- Cunningham, C. and Hunt, C. (2023). Scottish Blue Carbon – a literature review of the current evidence for Scotland’s blue carbon habitats. NatureScot Research Report 1326. Available at: <https://www.nature.scot/doc/naturescot-research-report-1326-scottish-blue-carbon-literature-review-current-evidence-scotlands>. Accessed on: February 2024.
- DESNZ. (2023a). Valuation of Energy Use and Greenhouse Gas: Supplementary guidance to the HM Treasury Green Book [online]. Available at: <https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal>. Accessed: February 2024.
- DESNZ. (2023b). Digest of UK Energy Statistics, Load factors for renewable electricity generation. Available at: <https://www.gov.uk/government/statistics/renewable-sources-of-energy-chapter-6-digest-of-united-kingdom-energy-statistics-dukes> Accessed: February 2024.
- DESNZ. (2024) Clean Power 2030 Action Plan. Available at: <https://www.gov.uk/government/publications/clean-power-2030-action-plan> Accessed: January 2025
- DESNZ and DEFRA. (2025). Greenhouse gas reporting: conversion factors 2025. Available at: <https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2025> Accessed: June 2025.
- IEMA. (2022). Environmental Impact Assessment Guide to: Assessing Greenhouse Gas Emissions and Evaluating their Significance. 2nd Edition. Available at: <https://www.iema.net/resources/blog/2022/02/28/launch-of-the-updated-eia-guidance-on-assessing-ghg-emissions> accessed: February 2024.
- IPCC. (2013). Climate Change 2013: The Physical Science Basis. Available at: <https://www.ipcc.ch/report/ar5/wg1/> Accessed: February 2024.
- IPCC. (2021). Climate Change 2021: The Physical Science Basis, Chapter 5: Global Carbon and other Biogeochemical Cycles and Feedbacks. Available at: <https://www.ipcc.ch/report/ar6/wg1/chapter/chapter-5/> Accessed: February 2024.
- Jones and Hammond. (2024). Inventory of Carbon and Energy (ICE) Database. Available at: <https://circularecology.com/embodyed-carbon-footprint-database.html> Accessed: June 2024
- National Grid ESO. (2024). Future Energy Scenarios. Available at: <https://www.nationalgrideso.com/future-energy/future-energy-scenarios> Accessed: February 2024.
- RICS (2024) Whole life carbon assessment for the built environment. Available at: https://www.rics.org/content/dam/ricsglobal/documents/standards/Whole_life_carbon_assessment_PS_Sept23.pdf. Accessed July 2025
- Smeaton, C., Austin, W. and Turrel, W. (2020). Re-Evaluating Scotland’s Sedimentary Carbon Stocks. Marine Scotland Science Research Report, Scottish Marine and Freshwater Science, 11 Available at: <https://data.marine.gov.scot/sites/default/files//SMFS%201102.pdf> Accessed: February 2024
- Smeaton, C. and Austin, W. (2022) Quality not Quantity: Prioritising the Management of Sedimentary Organic Matter Across Continental Shelf Seas. Geophysical Research Letters, 49 Available at: <https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2021GL097481>. Accessed: February 2024
- Staffell, I. and Green, R. (2014). How does wind farm performance decline with age? Volume 66, Renewable Energy. Available at: <https://www.sciencedirect.com/science/article/pii/S0960148113005727> Accessed: February 2024.
- United Nations Framework Convention on Climate Change. (1997). Kyoto Protocol to the United Nations Framework Convention on Climate Change. Available at: <https://unfccc.int/documents/2409>. Accessed: April 2025.

WRI and WBCSD. (2004). A Corporate Accounting and Reporting Standard. Available at: <https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf>. Accessed: February 2024.