Environmental Impact Assessment Report

Volume 1, Chapter 29: Greenhouse Gases

MarramWind Offshore Wind Farm

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MarramWind

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29. Greenhouse Gases

29.1 Introduction

29.1.1.1 This greenhouse gases (GHG) Chapter of the Environmental Impact Assessment (EIA) Report presents the results of the assessment of the likely significant effects of lifecycle GHG emissions that may arise from the construction, operation and maintenance (O&M) and decommissioning stages of the onshore and offshore components of the Project. It should be read in conjunction with the project description provided in **Chapter 4: Project Description** and the relevant parts of the following chapters and appendices:

- **Chapter 26 Traffic and Transport:** which considers the access proposals and potential traffic and transport effects associated with the construction and operation of the Onshore Transmission Works (OTW); and
- **Chapter 21 Air Quality:** which presents the results of the assessment of likely significant effects of the Project on air quality and potential implications for both human and ecological health.

29.1.1.2 This Chapter describes:

- the legislation, planning policy, guidance and other documentation that has informed the assessment (**Section 29.2: Relevant legislative and policy context**);
- the outcome of consultation and engagement that has been undertaken to date, including how matters relating to GHG have been addressed (**Section 29.3: Consultation and engagement**);
- the scope of the assessment for GHG (**Section 29.4: Scope of the assessment);**
- the data sources and methods used for gathering baseline data (**Section 29.5: Methodology for baseline data gathering);**
- the overall environmental baseline (**Section 29.6: Baseline conditions**);
- the basis for the EIA Report (**Section 29.7: Basis for the EIA Report**);
- methodology for the EIA Report (**Section 29.8: Methodology for the EIA Report**);
- the assessment of GHG effects (**Section 29.9: Assessment of effects: Construction, Section 29.10: Assessment of effects: O&M; Section 29.11: Assessment of effects: Decommissioning**);
- a summary of effects (**Section 29.12: Summary of effects**);
- **Section 29.13** details the carbon payback period and GHG intensity of the Project;
- consideration of transboundary effects (**Section 29.14: Transboundary effects**);
- consideration of inter-related effects and cumulative effects (**Section 29.15: Inter-related effects** and **Section 29.16: Assessment of cumulative effects**);
- a summary of residual effects for GHG (**Section 29.17: Summary of residual likely significant effects**);
- a reference list is provided (**Section 29.18: References)**; and
- a glossary of terms and abbreviations is provided (**Section 29.19: Glossary of terms and Abbreviations**).

29.2 Relevant legislative and policy context and technical guidance

29.2.1 Legislative and policy context

29.2.1.1 This Section sets out the relevant legislation and policy context that has informed the scope of the GHG assessment. Further information on policies relevant to the EIA and their status is set out in **Chapter 2: Legislative and Policy Context**.

29.2.1.2 Individual policies of specific relevance to this assessment and associated appendices have been taken into account.

29.2.1.3 The legislation relevant to GHG and climate change include:

- The Carbon Budget Order 2021 and other previous relevant orders (2016, 2011, 2009) (UK Government, 2021a);
- The Climate Change (Emissions Reduction Targets) (Scotland) Act, 2019.
- United United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement 2015 (UNFCCC, 2015);
- European Union (EU) Directive (2010/75/EU) of the European Parliament and of the Council on industrial emissions (integrated pollution prevention and control) later referred to as the Industrial Emissions Directive 2010 (European Parliament and Council, 2010);
- The Climate Change (Emission Reduction Targets) (Scotland) Act 2009 2024 (Scottish Government, 2024);
- The Climate Change Act 2008 (2050 Target Amendment) Order 2019; and
- UNFCCC Kyoto Protocol 1997 (UNFCCC, 1997).

29.2.1.4 The policies relevant to GHG and climate change include:

- Draft Sectoral Marine Plan for Offshore Wind Energy (Scottish Government, 2025);
- Carbon Budget and Growth Delivery Plan (UK Government, 2025);
- The Environment Strategy for Scotland 2020, and Progress Report 2024 (Scottish Government, 2020, updated 2024);
- 29th United Nations Climate Change Conference of the Parties (COP29), 2024 (UNFCCC, 2024);
- United Nations Climate Change Conference of the Parties (COP28) 2023 (UNFCCC, 2023);
- National Planning Framework 4 2023 (Scottish Government, 2023a);
- Department for Energy Security and Net Zero (DESNZ) EN-3 2023 National Policy Statement (NPS) for Renewable Energy Infrastructure (DESNZ, 2023b) (DESNZ, 2023b);
- Department for Energy Security & Net Zero (DESNZ) Overarching NPS for Energy EN-1 2023 (DESNZ, 2023a) (DESNZ, 2023c);
- Clean Power 2030 Action Plan: A new era of clean electricity (National Grid ESO, 2023);
- Carbon Budget Delivery Plan (2023) (DESNZ, 2023c) (DESNZ, 2023a);

- Aberdeenshire Local Development Plan 2023 (Aberdeenshire Council, 2023a);
- UNFCCC Glasgow Climate Pact 2021 (UNFCCC, 2021);
- Department for Business, Energy & Industrial Strategy (BEIS), UK Net Zero Strategy: Build Back Greener 2021 (BEIS, 2021);
- UK Climate Change Strategy 2021-2024 (UK Government, 2021b);
- The Climate Change Plan, Third Report on Proposals and Policies (2018-2032), Updated 2020 (Scottish Government, 2020);
- Energy white paper: Powering our net zero future 2020 (BEIS, 2020) (BEIS, 2020a);
- Offshore Transmission Network Review 2020 (BEIS, 2020b) (BEIS, 2020); and
- Scottish National Marine Plan 2015 (Scottish Government, 2015).

29.2.2 Relevant technical guidance

29.2.2.1 Other information and technical guidance relevant to the assessment undertaken for GHG include:

- NPF4 Planning Guidance, Policy 2 – Climate Mitigation and Adaptation (Scottish Government, 2025a);
- Planning Practice Guidance 2024 (UK Government, 2024);
- Scottish Government Draft Planning Guidance: Biodiversity (Scottish Government, 2023c);
- Royal Institution of Chartered Surveyors (RICS) Whole Life Carbon Assessment for the Built Environment (RICS, 2023);
- British Standards Institution (BSI), Carbon Management in Infrastructure and Built Environment - Publicly Available Standard (PAS) 2080: 2023 (BSI, 2023);
- EIA Guide to Assessing GHG Emissions and Evaluating their Significance (Institute of Environmental Management and Assessment (IEMA), 2022 (IEMA, 2022); and
- The GHG Protocol: A Corporate Accounting and Reporting Standard (GHG Protocol, 2004).

29.3 Consultation and engagement

29.3.1 Overview

29.3.1.1 This Section describes the consultation and stakeholder engagement undertaken on the Project in relation to GHG. This includes early engagement, the outcome of and response to the Scoping Opinions: Onshore Scoping Opinion (Aberdeenshire Council, 2023b) and Offshore Scoping Opinion (Scottish Government, 2023b) in relation to the GHG assessment, non-statutory consultation, and the findings of the Project's Statutory Consultation. An overview of engagement undertaken for the Project as a whole can be found in Section 5.5 of **Chapter 5: Approach to the EIA**.

29.3.2 Key issues

29.3.2.1 A summary of the key issues raised during statutory and non-statutory consultation, specific to GHGs, is outlined in **Table 29.1**, together with how these issues have been considered in the production of this EIA Report.

Table 29.1 Stakeholder issues responses – GHG

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
Aberdeenshire Council	112	22 March 2023 Aberdeenshire Council's Scoping Opinion (Aberdeenshire Council, 2023b).	*"The Council makes no comments on this Section."*	Noted.
Marine Directorate – Licencing Operations Team (MD-LOT)	287	12 May 2023 MD-LOT Scoping Opinion (Scottish Government, 2023b).	*"Contents of the EIA Report* *The Scottish Ministers welcome the Developer's approach in assessing climate change and Green House Gases ("GHG") throughout sections 7.1 and 7.2 of the Scoping Report. The Scottish Ministers are mindful that GHG emissions from all projects contribute to climate change. In this regard, the Scottish Ministers highlight the IEMA Environmental Impact Assessment Guide "Assessing Greenhouse Gas Emissions and Evaluating Their Significance" ("IEMA GHG Guidance"), which states that "GHG emissions have a combined environmental effect that is approaching a scientifically defined environmental limit, as a such any GHG emissions or reductions from a project might be considered significant." The Scottish Ministers have considered this together with the Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 and the requirement of the EIA Regulations to assess the significant effects of the Proposed Development on climate. For the avoidance of doubt, the Scottish Ministers therefore advise that the EIA Report must include a GHG Assessment which should be based on a Life Cycle Assessment approach, similar to that noted within plate 7.2.1 of the Scoping Report and note that the IEMA GHG Guidance provides further insight on this matter. The Scottish Ministers highlight however that this should include the pre-construction, construction, operation, and decommissioning phases, including consideration of the supply chain as well as benefits beyond the life cycle of the Proposed Development."*	The GHG chapter has considered for lifecycle approach throughout this assessment.

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
MD-LOT	378	12 May 2023 MD-LOT Scoping Opinion (Scottish Government, 2023b).	*"Scottish Ministers are content with the data sources included in Table 7.2.1 and the technical guidance included in Table 7.2.2 of the Scoping Report* (MarramWind Limited, 2023b) *regarding the GHG assessment. In line with section 3.5.1 of this Scoping Opinion, the Scottish Ministers advise the Developer to scope pre-construction GHG emissions into the GHG assessment."*	Pre-construction activities, such as preliminary studies, design, EIA, and cost planning, are expected to generate minimal GHG emissions. These desk-based tasks and surveys are subject to environmental monitoring by parties undertaking them and use small amounts of resources (whether fuel for energy or transport). On this basis, they are extremely small in relation to other lifecycle activities and are therefore not quantified in this assessment.
MD-LOT	379	12 May 2023 MD-LOT Scoping Opinion (Scottish Government, 2023b).	*"The Scottish Ministers acknowledge sections 7.2.43 and 7.2.44 that note the future baseline for GHG emissions and advise the Developer to consider the supply chain as well as to what extent carbon is offset throughout the production of green energy throughout the lifecycle of the Project. The Developer must fully address the representation from NatureScot in the EIA Report."*	The analysis presented includes consideration of wider supply chain emissions as noted (**paragraph 29.8.1.11**). It also provides explicit assessment of the wider benefits (in GHG terms) associated with lifetime energy production from the Project.
	877	19 December 2024 Aberdeenshire Council Pre-Application Report (Aberdeenshire Council, 2024)	*"Carbon and peat* *Comments from SEPA* *Where proposals are on peatland or carbon rich soils (CRS), the following should be submitted to address SEPA's requirements in relation to NPF4 Policy 5 to protect CRS and the ecosystem services they provide (including water and carbon storage). Peatland in near natural condition generally experiences low greenhouse gas emissions, is accumulating and may be*	Site Selection and design has sought to avoid areas of peat and carbon rich soils. Peat impacts are avoided through use of trenchless crossing. No further assessment of peat impacts is therefore provided.

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
			sequestering carbon, has high value for supporting biodiversity, helps to protect water quality and contributes to natural flood management, irrespective of whether that peatland is designated for nature conservation purposes or not. *It should be clearly demonstrated that the assessment has informed careful project design and ensured, in accordance with relevant guidance and the mitigation hierarchy in NPF4, that adverse impacts are first avoided and then minimised through best practice.* *The submission should include a series of layout drawings at a usable scale showing all permanent and temporary infrastructure, with extent of excavation required. These plans should be overlaid on the following:* *a) Peat depth survey showing peat probe locations, colour coded using distinct colours for each depth category. This must include adequate peat probing information to inform the site layout in accordance with the mitigation hierarchy in NPF4, which may be more than that outlined in the Peatland. Survey – Guidance on Developments on Peatland (2017);* *b) Peat depth survey showing interpolated peat depths;* *c) Peatland condition mapping – the Peatland Condition Assessment photographic guide lists the criteria for each condition category and illustrates how to identify each condition category.* *The detailed series of layout drawings above should clearly demonstrate that development proposals avoid any near natural peatland and that all proposed excavation is on peat less than 1m deep.* *Whilst there appear to be only small areas/pockets of peatland within the redline boundary (in the northern landfall and cable option), these peatland soils are relatively rare in this part of Aberdeenshire and therefore the potential impact could be significant if not mitigated against. Avoidance should be the first principle in mitigation and appears wholly possible in this case. If avoidance of peat can be demonstrated, then no bespoke peat management plan will be required.*	

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
			Therefore, the layout drawings should also demonstrate that peat excavation has been avoided. On sites where complete avoidance of peat and carbon rich soils is not possible, it should be clearly demonstrated that the deepest areas of peat have been avoided and the volumes of peat excavated have been reduced as much as possible, first through layout and then by design making use of techniques such as floating tracks and horizontal drilling. *The Outline Peat Management Plan (PMP) must include:* *a) A table setting out the volumes of acrotelmic, catotelmic and amorphous peat to be excavated. These should include a contingency factor to consider variables such as bulking and uncertainties in the estimation of peat volumes;* *b) A table clearly setting out the volumes of acrotelmic, catotelmic and amorphous excavated peat: (1) used in making good site specific areas disturbed by development, including borrow pits (quantities used in making good areas disturbed by development must be the minimum required to achieve the intended environmental benefit and materials must be suitable for the proposed use), (2) used in on and off site peatland restoration, and (3) disposed of, and the proposed means of disposal (if deemed unavoidable after all other uses of excavated peat have been explored and reviewed);* *c) Details of proposals for temporary storage and handling of peat - Good Practice during Wind Farm Construction (https://www.scottishrenewables.com/assets/000/000/453/guidance_-_good_practice_during_wind_farm_construction_original.pdf?1579640559) outlines the approach to good practice when addressing issues of peat management on site and minimising carbon loss;* *d) Suitable evidence that the use of peat in making good areas disturbed by development is genuine and not a waste disposal operation, including evidence on the suitability of the peat and evidence that the quantity used matches and does not exceed the requirement of the proposed use;*	

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
			e) Use of excavated peat in areas not disturbed by the development itself is now not a matter SEPA provides planning advice on. Please refer to Advising on peatland, carbon-rich soils and priority peatland habitats in development management | *NatureScot 2023 (https://www.nature.scot/doc/advising-peatland-carbon-rich-soils-and-priority-peatland-habitats-development-management), and the Peatland ACTION – Technical Compendium (https://www.nature.scot/doc/peatland-action-technical-compendium) which provides more detailed advice on peatland restoration techniques. Unless the excavated peat is certain to be used for construction purposes in its natural state on the site from where it is excavated, it will be subject to regulatory control. The use of excavated peat off-site, including for peatland restoration, will require the appropriate level of environmental authorisation. Excavated peat will be waste if it is discarded, or the holder intends to or is required to discard it. These proposals should be clearly outlined so that SEPA can identify any regulatory implications of the proposed activities. This will allow the developer and their contractors to tailor their planning and designs to accommodate any regulatory requirements. Further guidance on this may be found in the document Is it waste - Understanding the definition of waste (https://www.sepa.org.uk/media/154077/is_it_waste.pdf)"*	

29.4 Scope of the assessment

29.4.1 Overview

29.4.1.1 This Section sets out the scope of the GHG assessment. This scope has been developed as the Project's design has evolved and responds to stakeholder feedback received to-date, as set out in **Section 29.3**.

29.4.2 Spatial scope and study area

29.4.2.1 The spatial scope of the GHG assessment is informed by the spatial extent of the Project (as described in **Chapter 4: Project Description**) and the Red Line Boundary (illustrated in **Volume 2, Figure 1.1: Red Line Boundary**).

29.4.2.2 The scope includes design elements of the Project during its construction, O&M, and decommissioning stages, as well as the GHG emissions associated with transport movements, both onshore and offshore, to and from the Project in the construction stage, and transport movements offshore, in the O&M stage. The key components of the Project considered for this assessment are:

- Offshore infrastructure:
  - wind turbine generators (WTGs), including floating units (platforms and WTG station keeping system);
  - array cables;
  - subsea distribution centres (SDCs);
  - offshore substations, including both fixed foundation and topsides and subsea substations;
  - reactive compensation platform(s) (RCPs); and
  - offshore export cables to connect the offshore infrastructure to the landfall(s).
- Onshore infrastructure:
  - landfall(s) – the infrastructure associated with the landfall(s) located above mean low water springs;
  - underground onshore export cables running from the landfall(s) to the onshore substations;
  - onshore substations; and
  - underground grid connection cables (connecting the onshore substations to the grid connection point at Scottish and Southern Electricity Networks (SSEN) Netherton Hub)).

29.4.2.3 This assessment considers two WTG power outputs based on the characteristics of turbine models that are expected to be available at the time of procurement. These are described throughout the report as a ‘14 megawatts (MW) WTG’ and ‘25MW WTG’ and this Chapter therefore considers two design scenarios based on up to 225 turbines for the 14MW WTG and up to 126 turbines for the 25MW WTG.

29.4.2.4 However, the emissions for all lifecycle stages have been reported for only the maximum design scenario for instance, the design scenario which has the highest emissions.

29.4.3 Temporal scope

29.4.3.1 The temporal scope of the assessment of GHG is the entire lifetime of the Project, which therefore covers the construction, O&M, and decommissioning stages.

29.4.3.2 It is anticipated that the construction of the Project will commence in 2030, with the first phase becoming fully operational by 2037. It is anticipated that the second phase of the Project would become fully operational by 2040 and the third phase by 2043. The operational lifetime of the Project for each phase is expected to be 35 years.

29.4.4 Identified receptors

29.4.4.1 The global atmosphere is the receptor for the effects on the climate of GHG emissions arising from the Project. The impacts of GHG emissions relate to their contribution to global warming and climate change. These impacts are global and cumulative in nature, with every tonne of GHG emissions contributing to impacts on natural and human systems. GHG emissions result in the same global effects wherever and whenever they occur and, therefore, the sensitivity of different human and natural receptors is not considered.

29.4.5 Potential effects

29.4.5.1 Potential effects on GHG receptors that have been scoped in for assessment are summarised in **Table 29.2**.

29.4.5.2 This is based on lifecycle stages as defined within PAS 2080: Carbon Management in Infrastructure (BSI, 2023).

Table 29.2 Potential effects for GHG

Receptor	Activity or impact	Lifecycle Stage	Potential effect
Construction stage			
Global Atmosphere	Product stage (manufacture and transport of raw materials to suppliers) including WTG, foundations, onshore export cable corridor and onshore substations.	A1-A2-A3 – Product stage: raw material supply, transport and manufacture.	Embodied GHG emissions linked to the extraction and manufacturing of raw materials needed for Project construction.
	Transport of materials to the site (onshore and offshore).	A4 – Construction transport.	GHG emissions from fuel and electricity used in transport of installation materials and components (such as cables, WTGs and floaters) during the construction stage.
	Plant and equipment use during construction.	A5 – Construction: Installation process.	GHG emissions tied to installation activities, including emissions from offshore vessels movement during installation of equipment and helicopters associated with offshore movements.

Receptor	Activity or impact	Lifecycle Stage	Potential effect
			GHG emissions from fuel and energy used in onshore construction activities (e.g. preparation, construction of onshore substations, onshore export cable laying, etc.).
O&M stage			
Global Atmosphere	Consumables used in operations use, maintenance, repair and replacement and refurbishment of the Project.	B1-B5 – Maintenance, repair, replacement and refurbishment.	Emissions associated with the WTG consumables during operation stage and materials and activities used and performed during maintenance and repair, replacement and refurbishment of the Project.
Decommissioning stage			
Global Atmosphere	Decommissioning process and End-of-life transport and disposal of materials.	C1-4 – End of life.	Assumed to be the reverse of the construction stage (therefore equated to the sum of the construction process emissions, for instance A4 – Transport, and A5 – plant and equipment use).

29.4.6 Effects scoped out of assessment

29.4.6.1 A number of potential effects have been scoped out from further assessment, resulting from a conclusion of no likely significant effect. These conclusions have been made based on the knowledge of the baseline environment, the nature of planned works and the professional judgement on the potential for impact from such projects more widely. The conclusions follow (in a site-based context) existing best practice. Each scoped out activity or impact is considered in turn in **Table 29.3**.

Table 29.3 Activities or effects scoped out of assessment

Activity or impact	Rational for scoping out
Pre-construction stage (A0)	Pre-construction activities, such as preliminary studies, design, EIA, and cost planning, are expected to generate minimal GHG emissions. These desk-based tasks and surveys are not considered significant enough to include in the emissions assessment.
Land use, land use change and forestry like peatland excavation and restoration (A5)	Emissions from peat removal and restoration have been scoped out as no significant peat disturbance is anticipated; onshore works primarily traverse previously disturbed agricultural land with low potential for deep, intact peat layers.
Operational Energy (B6)	Emissions have been scoped out on the basis that emissions from energy and fuel use, including diesel generators in WTGs and the O&M facility, are expected to be negligible in magnitude.

Activity or impact	Rational for scoping out
Operational water use (B7)	These are the emissions resulting from the consumption of water required by the Project to operate and deliver its service. This stage has been scoped out as it has been considered that the GHG emissions associated with this stage will be negligible.
Other operational processes (B8)	GHG emissions arising from other operational process relate to those emissions arising from the Project to enable it to operate and deliver its service including management of operational waste. No other operational processes of the Project have been identified, additional to the transport of workforce associated with the maintenance and repair of materials, considered in stage B2-B5. This stage has been scoped out as it is not relevant to the Project.
User's utilisation of infrastructure (B9)	GHG emissions from user's utilisation are the carbon emitted as a result of activities associated with user's utilisation of the Project during the use stage. In this instance a user is not clearly defined. Instead, the output from the Project is supplied to the national grid as part of ongoing electricity supply. The net impact/benefit is therefore captured within life cycle stage D (benefits and loads outside the project boundary). Further details are included in **Section 29.12**.

29.5 Methodology for baseline data gathering

29.5.1 Overview

29.5.1.1 The current and future baseline conditions are presented in **Section 29.6: Baseline conditions**. For the purposes of the GHG emissions impact assessment, the baseline conditions are defined as a 'Do Nothing' scenario where the Project does not go ahead.

29.5.1.2 There are no surveys undertaken for this assessment.

29.5.2 Desk study

29.5.2.1 The emissions assessment has been carried out in alignment with the four steps set out in the NPF4 Planning Guidance on Policy 2 (Scottish Government, 2025a). Specifically:

- Step 1 Identify: primary project emissions and removals;
- Step 2 Clarify control: understanding what emissions and removals can be controlled or influenced by the Applicant;
- Step 3 Manage GHG emissions: minimising emissions and maximising removals; and
- Step 4 Report: Reporting on outcome and monitoring (where relevant).

29.5.2.2 The baseline comprises of existing carbon stocks and sources of GHG emissions which occur widely in the study area because of human and natural activity. This includes emissions related to energy consumption (fuel and power), industrial processes, land use and land use change. **Table 29.5** shows the contextual baseline for planning authority regional (Scotland) and UK emissions. The GHG assessment has only considered instances in which the Project results in additional or avoided emissions in comparison to the baseline scenario and its assumed evolution. The baseline therefore focuses on those emissions sources subject to change between the baseline and the Project. There is no development / activity on site at present. On this basis, the existing baseline emissions are considered zero.

29.5.2.3 The data sources that have been collected and used to inform this GHG assessment are summarised in **Table 29.4**.

Table 29.4 Data sources used to inform the GHG chapter

Source	Date	Summary	Coverage of study area
UK planning authority and regional GHG emissions statistics, 2005 to 2023, (DESNZ, 2024a).	Date accessed: 18 July 2025.	Baseline data for planning authority (Aberdeenshire), regional (Scotland) and UK emissions – from different sectors.	Full coverage of study area.

29.5.3 Data limitations

29.5.3.1 There are no known data limitations at the time of this study relating to GHG that affect the robustness of this EIA Report.

29.6 Baseline conditions

29.6.1 Current baseline

29.6.1.1 The assessment baseline for GHG emissions in Scotland is established from the Climate Change (Scotland) Act 2009, as amended by the Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 (Update to the Climate Change Plan 2018 – 2032, 2020) and the Climate Change (Emissions Reduction Targets) (Scotland) Act 2024 (Scottish Government, 2024). No additional data is gathered to inform the baseline. The scope covers existing GHG emissions before the construction, O&M, and decommissioning of the assessed Project.

29.6.1.2 Specific targets and allocations in Scotland include achieving net zero emissions by 2045 (Update to the Climate Change Plan 2018 – 2032, 2020).Proposed carbon budgets aligned with Climate Change Committee advice (Climate Change Committee, 2025) reduce average levels of emissions for Scotland (measured against 1990 levels) by 57% for the period 2026 to 2030; 69% for the period 2031 to 2035; 80% for the period 2036 to 2040; and 94% for the period 2041 to 2045.

29.6.1.3 The future baseline for GHG emissions in Scotland considers the impact of relevant Scottish Government policies throughout the Project's lifetime and aligns with the established carbon budget trajectory. This ensures that future emissions reductions are measured against a realistic scenario that reflects ongoing efforts towards decarbonization. Notably, the Scottish Government's commitment to decarbonization is evident through the Climate Change Plan update (2020), which includes ambitious renewable energy goals, the 2019 climate emergency declaration, and various strategic investments such as the £1.6 billion for heat decarbonisation and the £100 million Green Jobs Fund (Update to the Climate Change Plan 2018 – 2032, 2020). This has been reinforced with the revision of national reporting to reflect the introduction of specific carbon budgets in Scottish legislation (via the Climate Change (Emission Reduction Targets) (Scotland) Act 2024 (Scottish Government, 2024)). From a sectoral planning perspective, the Draft Updated Sectoral Marine Plan for Offshore Wind

Energy (Scottish Government, 2025) reflects the Scottish Government's latest strategic commitments. It provides a forward-looking framework that supports the transition to net zero emissions by integrating current leasing rounds and updated environmental baselines. These efforts ensure the baseline reflects a future with ongoing action towards achieving net zero emissions.

29.6.1.4 The current assessment focuses solely on GHG emissions originating from the Project itself. The change in GHG emissions associated with the Project is evaluated against national, regional, and local targets for decarbonization (the future baseline).

29.6.1.5 To provide a context for GHG emissions arising from the Project, baseline data for planning, regional and UK emissions is provided sourced from the UK planning authority and regional GHG emissions statistics, 2005 to 2023 (DESNZ, 2024a).

Table 29.5: Emission estimates for planning authority, Scotland and UK (2023)

Emissions Sources	Planning Authority: Aberdeenshire (ktCO_2e)	Scotland (ktCO_2e)	UK (ktCO_2e)
Industry electricity	40.3	626.2	8,959.2
Industry gas	36.2	1,492.6	12,571.0
Large industrial Installations	8.5	2,763.0	24,931.2
Industry 'other'	36.2	879.4	10,213.6
Industry total	**121.2**	**5,761.2**	**56,675.0**
Commercial electricity	45.3	1,255.8	15,762.2
Commercial gas	15.1	1,104.7	11,269.6
Commercial 'other'	7.5	193.6	2,558.6
Commercial total	**67.9**	**2,554.1**	**29,590.4**
Public sector electricity	9.6	271.8	3,003.5
Public sector gas	10.5	626.8	6,151.4
Public sector 'other'	3.4	109.7	1,224.9
Public sector total	**23.4**	**1,008.2**	**10,379.8**
Domestic electricity	85.4	1,542.8	17,625.4
Domestic gas	177.7	4,643.1	50,656.5
Domestic 'other'	146.7	892.0	8,614.7
Domestic total	**409.7**	**7,077.9**	**76,896.6**
Road transport (A roads)	319.3	4,094.6	43,809.2
Road transport (motorways)	0.0	1,755.3	23,588.3

Emissions Sources	Planning Authority: Aberdeenshire (ktCO_2e)	Scotland (ktCO_2e)	UK (ktCO_2e)
Road transport (minor roads)	258.1	3,706.3	40,976.7
Diesel railways	9.8	142.0	1,702.8
Transport 'other'	7.3	223.0	3,229.6
Transport Total	**594.5**	**9,921.2**	**1,13,306.6**
Landfill	70.0	914.0	14,450.1
Waste 'other'	19.5	483.5	5,388.1
Waste total	**89.5**	**1,397.5**	**19,838.2**
Other total (LULUCF and agriculture)	**1,395.6**	**10,063.9**	**49,407.4**
Grand Total*	**2,702**	**37,784**	**3,56,094**
*Note: individual emission entries have been rounded, so rounding errors may occur in combined totals.			

29.6.2 Future baseline

29.6.2.1 In terms of the future baseline, in the 'no development' scenario where the Project is not developed, the future baseline will be determined by the current GHG emissions. Since there is no physical development or activity within the Red Line Boundary in this scenario, GHG emissions from the Project before construction and O&M are considered **Negligible**.

29.7 Basis for the EIA Report

29.7.1 Maximum design scenario

29.7.1.1 The process of assessing using a parameter-based design envelope approach means that the assessment considers a maximum design scenario whilst allowing the flexibility to make improvements in the future in ways that cannot be predicted at the time of submission of the planning application, marine licences applications and s.36 consent.

29.7.1.2 The assessment of the maximum adverse scenario for each receptor establishes the maximum potential adverse effect and as a result effects of greater adverse significance would not arise should any other scenario (as described in **Chapter 4: Project Description**) to that assessed within this Chapter be taken forward in the final Project design.

29.7.1.3 The maximum design scenario parameters that have been identified to be relevant to GHG are outlined in **Table 29.6** and are in line with the project design envelope (**Chapter 4: Project Description**).

Table 29.6 Maximum design scenario for impacts on GHG

Impact / activity	Maximum design scenario parameter	Justification
Construction		
Impact C1: A1-A2-A3 – Product stage: raw material supply, transport and manufacture - Embodied GHG emissions associated with the raw material assets required to construct the Project, including WTGs, foundations, onshore export cable and offshore export cable, onshore and offshore substations, scour protection and concrete transition joint bays	Relevant design parameters relate to all onshore and offshore assets. This includes: • construction programme of the Project is 12 years split into three phases. Each phase will be up to a maximum of six years. **Offshore assets**: • up to 225 WTGs with power output of 14MW or up to 126 WTGs with power output of 25MW; • floating unit concept of semi-submersible type design with assumed 5,000 tonnes of steel per floater as worst-case scenario; • up to 45 SDCs with dimensions of 18 metres (m) x 8m x 5m weighing 50 tonnes with a contingency of 30%; • up to four subsea substations with dimensions of 22m x 20m x 16m weighing 900 tonnes with a contingency of 30%; • array cables with total length of up to 680 kilometres (km) with a maximum voltage of 145kV along with a rock placement protection of volume up to 1,122,000m^3; • up to four offshore substations with topside dimensions 106 m x 70 m weighing 25,000 metric tonnes with jacket foundations secured by driven piles (48 number of piles (12 per offshore substation), each up to 95m deep and diameter of 3m); • up to two RCPs with topsides above-surface dimensions of 50m x 50m, with driven pile foundations (8 number of piles, each up to 95m deep and diameter of 3m); and • five offshore export cable trenches, each approximately 140km in length carrying cables operating at voltage up to 525kV; • fibre optic cable bundled with offshore export cables along the same 140km route; and • total rock placement of 8,250 m^3/km assuming 20% of total trench length requires rock placement across the five offshore cable trenches. **Onshore assets:** • landfall with up to three primary construction compounds with maximum dimensions 125m x 125m;	Impacts assessed account for primary materials used in constructing the onshore and offshore elements of the Project.

Impact / activity	Maximum design scenario parameter	Justification
	• up to eight horizontal directional drilling (HDD) (or similar trenchless technique) ducts for the landfall(s) with length up to 1500m and assumed outer diameter of 0.2m and wall thickness of 0.02m; In relation to trenchless crossings, HDD (or similar trenchless technique) has been presented in the EIA. Whilst other trenchless methods are available, HDD (or similar trenchless technique) is presented herein as it is likely to have the largest construction footprint. • number of onshore export cables up to 19 cables between the landfall(s) and onshore substations, and up to 28 cables between the onshore substations and SSEN Netherton Hub; • onshore export cable corridor lengths approximately 11km (landfall(s) to onshore substations) and 2.35km (onshore substations to SSEN Netherton Hub); • underground cable voltage up to 525kV (HVDC) and 400kV (HVAC) depending on the transmission configuration; • up to eight transition joint bays, typically 12m long x 3.5m wide x 2.5m deep with a concrete lining thickness of assumed 0.25m; • onshore substations of permanent combined footprint of up to 15 hectares (ha) with maximum of 36 buildings and permanent access road approximately 700m long, 6m wide and 0.25m thick; onshore substations foundation depth of 0.6m; and • onshore grid connection cable corridor length approximately 2.35km long; underground cable voltage: up to 400kV.	
Impact C2: A4 – Construction transport: GHG emissions associated with the transport of materials, equipment and workers to onshore and offshore sites by road and sea routes	Relevant design parameters include: **Onshore transport**: • Heavy Goods Vehicles (HGVs) and Light Commercial Vehicles (LCVs) across all three phases of construction, with average lengths of trip up to 10km. **Offshore transport:** • movement of two floaters per vessel trip from the Far East (e.g., Japan) to the Integration Harbour and then on to the Option Agreement Area (OAA) • movement of WTGs from a pre-assembly or marshalling harbour in Northern Europe to the OAA.	Impacts assessed account for the transport emissions associated with the movement of primary materials used in constructing the onshore and offshore elements of the Project.

Impact / activity	Maximum design scenario parameter	Justification
Impact C3: A5 – Construction process stage: GHG emissions associated with the installation works including onshore on-site plant equipment, and GHG emissions associated with ships used for installation of offshore works, and helicopters associated with offshore worker movements	Relevant design parameters include: • construction and installation vessels for offshore outlined in Table 4.15 of **Chapter 4: Project Description**; • distance for vessels transit movements from construction port of Forth Green Freeport to OAA site is approximately 285km; and • no. of vessel trips from Forth Green Freeport and helicopter trips from Aberdeen airport for duration of the main offshore construction as listed in **Table 29.9.**	Impacts assessed account for the emissions associated with the construction activities linked with the onshore and offshore elements of the Project.
O&M		
Impact O1: B2-B5 – Maintenance, repair, replacement and refurbishment: Represents the works activities and new materials for the maintenance, repair, replacement and refurbishment of the infrastructure during the use stage / operation of infrastructure. This includes GHG emissions from the embodied carbon of raw materials required for replacement and onshore vehicle movements and offshore vessel and helicopter movements required for O&M activities	Relevant maximum design parameters relate to all offshore assets, this includes: **Offshore assets** • operational lifetime of 35 years for each phase of the Project; • O&M port – Forth Green Freeport, approximately 285km one-way transit distance to the Offshore Array Area; • O&M vessels as outlined in Table 4.26 of **Chapter 4: Project Description** and **Table 29.10** (including Service Operation Vessels (SOVs), guard vessels, and DSVs); • up to 225 WTGs with power output of 14MW or up to 126 WTGs with power output of 25MW; • 1.5 % replacement per year of mooring systems from year 5 onwards; anchors repositioned once per lifetime; • two port visits per lifetime for maintenance or repair of floaters, reflected under O&M vessel movements; • dynamic section of array cables replaced once per lifetime; 25 % of static section replaced; repair events totalling approximately 68 over 35 years; • 25 % replenishment of array and export cable rock protection over operational lifetime; • two J-tube replacement per WTG and twenty per offshore substation; • four lifetime repair events of approximately 600 m each for export cable; • five anode replacements and five ladder replacements per WTG; and component exchange events equivalent to 10 % of embodied carbon of WTG and offshore substations to account for partial replacements during operation.	Impacts assessed account for the emissions associated with maintenance activities as relevant to the offshore elements of the Project, with onshore maintenance excluded due to minimal expected emissions relative to offshore activities.

Impact / activity	Maximum design scenario parameter	Justification
	Onshore assets • onshore assets (landfall, onshore export cables, substations) not explicitly included in the O&M emissions assessment, as associated maintenance is limited to minor inspections and is expected to have negligible contribution relative to offshore activities.	
Decommissioning		
Impact D1: C1-C4 – End of life stage: deconstruction, transport, waste processing for recovery and disposal: Represents the on-site activities of deconstructing, dismantling and demolishing the infrastructure. GHG emissions associated with onshore and offshore decommissioning activities **All GHG emissions due to transport to disposal and / or until the end-of-waste state of waste materials arising. Activities associated with treatment and processing for recovery, reuse and recycling of waste materials arising from infrastructure. This is assumed to generally be the reverse of the construction sequence and involve similar activities**	Relevant design parameters include reverse of the processes as considered for the construction and installation works for both the onshore and offshore assets.	Impacts assessed account for the emissions associated with decommissioning stage activities as relevant to the onshore and offshore elements of the Project.
General		
Impact G1: D – Benefits and loads beyond the infrastructure life cycle: The GHG emissions	Relevant design parameters include: • up to 225 WTGs with power output of 14MW or up to 126 WTGs with power output of 25MW;	Benefits to be assessed need to account for the annual

Impact / activity	Maximum design scenario parameter	Justification
avoided from fossil fuel-based energy generation as a result of the Project	• design life of 35 years; • total generating capacity of the Project up to 3GW; and • annual generation capacity of up to 13,344 Gigawatts per hour (GWh/year).	energy generation from the Project.

29.7.2 Considered environmental measures

29.7.2.1 Embedded environmental measures, in the specific context of this GHG assessment, refer to the way in which design decisions consider GHG emissions. Such measures also reflect good practice which will be implemented during the construction and operational stages specifically, and flow through to the decommissioning stage of the Project.

29.7.2.2 GHG mitigation opportunities will continue to emerge as the design work progresses relating to the procurement of products and services for the construction, O&M and decommissioning stages. As detailed in **Table 29.7**, the project is committed to identifying and evaluating such opportunities throughout the project lifecycle and will seek to implement measures confirmed to be technologically and commercially viable. The current analysis recognises that such opportunities will provide further mitigation potential over and above the quantitative assessment presented herein. While inherent to the project lifecycle design process, the current assessment does not rely on these opportunities in its overall assessment of significance.

29.7.2.3 **Table 29.7** present's the Project's environmental measures that will aim to reduce GHG emissions.

Table 29.7 Relevant GHG considered environmental measures

ID	Environmental measure proposed	Project stage measure introduced	How the environmental measures will be secured	Potential GHG lifecycle stage impacted
M-079	GHG emissions reduction opportunities will be identified and considered throughout the Project life cycle and will be implemented where confirmed to be technologically and commercially viable. This could include measures such as operational efficiencies and selection of products and services with lower emissions.	Scoping Amended at EIA Report	Design approach to sustainability.	GHG emissions for the life cycle stages A1-A3, with a view to also consider through O&M and decommissioning stages.
M-098	Measures to minimise lifecycle GHG emissions from construction plant and equipment will be detailed in **Volume 4**: **Outline Construction Environmental Management Plan (CEMP)**. Potential options could include the use of efficient and well-maintained plant and equipment and using mains electricity, if available, rather than diesel-fuelled portable generators, to reduce GHG emissions from fuel and energy consumption.	Scoping Amended at EIA Report	**Volume 4: Outline CEMP**	GHG emissions for life cycle stage A5.
M-099	**Volume 4**: **Outline CEMP** will include measures to minimise emissions from construction traffic. This will include measures such as consolidating deliveries where possible. Consideration will be given towards the impact of construction traffic, road traffic and adjacent trunk roads. Sustainable modes of travel for the construction workforce will be promoted. Offshore vessel movements will be programmed to maximise vessel operational efficiencies.	Scoping Amended at EIA Report	**Volume 4: Outline CEMP** and planning conditions	GHG emissions for the life cycle stage A4.

29.7.2.4 Further detail on the embedded environmental measures in **Table 29.7** is provided in the **Volume 3, Appendix 5.2: Commitments Register**, which sets out how and where particular embedded environmental measures will be implemented and secured.

29.8 Methodology for the EIA Report

29.8.1 Introduction

29.8.1.1 The Project-wide approach to assessment is set out in **Chapter 5: Approach to EIA.** Whilst this has informed the approach that has been used in this GHG assessment, it is necessary to set out how this methodology has been applied, and adapted as appropriate, to address the specific needs of the GHG assessment.

29.8.1.2 The approach to the technical assessment is to quantify and contextualise the GHG emissions of the Project. The method aligns with best practice for carbon calculations including the Sustainability Joint Industry Programme (SUSJIP) methodology (SUSJIP, 2024). The GHG emissions sources considered in the assessment span the whole lifetime of the Project and include as follows:

- Product stage (A1–A3): GHG emissions associated with the extraction, manufacturing, and transport of materials used to construct the Project. This includes WTG floating units, anchors and moorings, WTGs (towers, nacelles, blades, components), array cables, SDCs and subsea substations, offshore substations, offshore export cables, scour and cable protection, landfall transition joint bays, HDD (or similar trenchless technique) ducts, onshore export cables, onshore substations, grid connection infrastructure, permanent access roads.
- Transport stage (A4): GHG emissions associated with the transport of raw materials, prefabricated components, equipment, and personnel to both onshore and offshore sites, including transport by road, sea, and air.
- Construction and installation stage (A5): GHG emissions associated with the construction and installation processes, including onshore energy use, vessel movements for offshore installation (for example, WTGs, foundations, export cables, onshore and offshore substations), and onshore transport movements for labour and materials.
- Use stage (B1–B5): GHG emissions associated with O&M activities. This includes the embodied carbon of consumables (for example, grease, hydraulic oil, gear oil, Sulphur Hexafluoride (SF_6)), replacement materials (for example, anodes, ladders, cables), and emissions from offshore vessel and helicopter movements for O&M tasks.
- End-of-life stage and decommissioning (C1-C4): GHG emissions associated with onshore and offshore decommissioning activities. These are assumed to largely mirror the construction stage in sequence and equipment type, with some materials left in-situ in accordance with design and regulatory guidance.
- Avoided GHG emissions: GHG emissions avoided through the displacement of fossil fuel-based electricity generation by the renewable energy produced by the Project.

29.8.1.3 Effects have been quantified by comparing the ‘with Project’ scenario and the ‘without Project’ scenario.

Quantification of GHG emissions

29.8.1.4 The approach to quantifying the GHG emissions associated with the Project considers the whole infrastructure life cycle.

29.8.1.5 This approach aligns with the latest IEMA guidance (IEMA, 2022), ensuring a comprehensive evaluation with a focus on a reasonable maximum design scenario.

29.8.1.6 GHG emissions have been calculated using the following equation:

$$Activity\ data\ X\ GHG\ emissions\ factor = GHG\ emissions\ value$$

29.8.1.7 In line with **paragraph 29.4.2.3**, relevant quantifiable data for the two design scenarios has been sourced from the Project design and relevant calculations were made to arrive at required inputs for GHG assessment.

29.8.1.8 Any assumptions made to characterise the likely activities associated with the Project and therefore enable GHG emissions to be determined have been included within the methodology.

29.8.1.9 GHG Emission Factors (EFs) have been sourced from relevant public data and reputable sources as listed in **Table 29.8**.

Table 29.8 EFs used in the GHG assessment

Material / Activity in the design	EF Name	Value	Unit	Source
WTG consumables – grease, hydraulic oil, gear oil, lubricants	Lubricants	2.75	$kgCO_2e/l$	DESNZ 2025 – UK Government GHG conversion Factors (DESNZ, 2025).
WTG consumables - transformer silicon / ester oil	Fuel oil	3.87	$kgCO_2e/l$	DESNZ 2025 – UK Government GHG conversion Factors (DESNZ, 2025).
WTG consumables	Nitrogen	0.43	$kgCO_2e/l$	EF report of Winnipeg Sewage Treatment Plant - Assumed Liquid Nitrogen with a density of 0.8kg/litre (Winnipeg Sewage Treatment Plant, 2012).
WTG consumables	Glycol / Coolants	4.14	$kgCO_2e/l$	EF report of Winnipeg Sewage Treatment Plant - Assumed Propylene glycol, C3H8O2 (Winnipeg Sewage Treatment Plant, 2012).
WTGs; landfall(s) and onshore substations consumables	SF_6	23,500	$kgCO_2e/kg$	DESNZ 2025 – UK Government GHG conversion Factors (DESNZ, 2025).
Floating unit concept; scour protection; array cables and	Stone	209.35	$kgCO_2e/m^3$	Inventory of Carbon and Energy (ICE) Data Base (DB) Educational V4.0 - Dec 2024 - EF for rock (stone, general)

Material / Activity in the design	EF Name	Value	Unit	Source
offshore export cables protection and rock replacement during O&M				Density of rock assumed to be 2650kg/m^3 (ICE, 2024).
Floating unit concept, offshore substation driven piles (if required), scour protection and anchors; landfall(s), transition joint bays concrete-lined pits; onshore substation site foundation	Concrete	246.00	kgCO_2e/m^3	ICE DB Educational V4.0 - Dec 2024 - EF for concrete (In-Situ Concrete - General) (ICE, 2024).
Floating unit steel structure; buoyancy modules; WTG j-tubes and ladder replacement; SDC; subsea substations; offshore substation platform and jacket; RCP; landfall(s), onshore substations	Steel	1.90	kgCO_2e/kg	ICE DB Educational V4.0 - Dec 2024 - EF for Steel (global seamless tube) (ICE, 2024).
WTG anode replacement	Aluminium	13.10	kgCO_2e/kg	ICE DB Educational V4.0 - Dec 2024 - EF for general aluminium (worldwide) (ICE, 2024).
Landfall(s) and onshore substations	Steel per m^2 of building	234.00	kgCO_2e/m^2	(Design Buildings, 2017).
Onshore substations	Steel (cold-rolled)	2.47	kgCO_2e/kg	ICE DB Educational V4.0 - Dec 2024 - EF for finished cold-rolled coil (ICE, 2024).
Onshore substations	Copper	2.71	kgCO_2e/kg	ICE DB Educational V4.0 - Dec 2024 - EF for EU Tube and Sheet (ICE, 2024).
Onshore substations	Naphtha liquid fuel	3,782.79	kgCO_2e/tonne	DESNZ 2025 – UK Government GHG conversion Factors (DESNZ, 2025).

Material / Activity in the design	EF Name	Value	Unit	Source
Array cables, offshore export cables, and onshore export cables (installation and repair)	400 kilovolt (kV) cable 2500 mm^2	134.00	$kgCO_2e/m$	National Grid - Capital Delivery Carbon Tool - 3.4.4 Carbon Interface Tool.
	132 kV cable 1000 mm^2	56.00	$kgCO_2e/m$	National Grid - Capital Delivery Carbon Tool - 3.4.4 Carbon Interface Tool.
	275 kV cable 2500 mm^2	134.00	$kgCO_2e/m$	National Grid - Capital Delivery Carbon Tool - 3.4.4 Carbon Interface Tool.
Landfall(s) HDD (or similar trenchless technique) ducts	High Density Polyethylene (HDPE) Pipe	2,394.00	$kgCO_2e/m^3$	ICE DB Educational V4.0 - Dec 2024 - EF for HDPE Pipe (plastics) (ICE, 2024) Conversion of EF from per kg to per m^3 using HDPE average density (Direct Plastics).
Offshore fibre optic cables bundled with export cables	Optical Fibre 14 mm diameter	406.00	$kgCO_2e/km$	(Cablescom, 2022).
14MW WTGs	WTG	6,370.00	tCO_2e /turbine	Vestas Life Cycle Assessment report for an offshore wind farm (Vestas, 2024).
25MW WTGs	WTG	12,986.73	tCO_2e per turbine	Environmental Product Declaration (EPD) for a SG14-222 WTG (Siemens Gamesa Renewable Energy, 2023).
Offshore vessel movements for construction and O&M	Marine Gas Oil	3.40	$kgCO_2e/L$	DESNZ 2025 – UK Government GHG conversion Factors (DESNZ, 2025).
Helicopter use for offshore construction	Aviation Turbine Fuel	3,840.16	$kgCO_2e/t$	DESNZ 2025 – UK Government GHG conversion Factors (DESNZ, 2025).
HGV movements for onshore construction	HGV all diesel, Rigid (>3.5 – 7.5 tonnes) Average laden	0.61	$kgCO_2e/km$	DESNZ 2025 – UK Government GHG conversion Factors (DESNZ, 2025).

Material / Activity in the design	EF Name	Value	Unit	Source
Light goods vehicle (LGV) movements for onshore construction	Vans, Class I (up to 1.305 tonnes)	0.19	$kgCO_2e/km$	DESNZ 2025 – UK Government GHG conversion Factors (DESNZ, 2025).
Permanent access road to onshore substation site	Asphalt	54.23	$kgCO_2e/tonne$	ICE DB Educational V4.0 - Dec 2024 - EF for Asphalt, 5% binder content (ICE, 2024).
Onshore substation foundation	Reinforced Concrete	278.38	$kgCO_2e/m^3$	ICE DB Educational V4.0 - Dec 2024 - EF for RC 28/35 (28/35 MPa) with 15% cement replacement - fly ash - typical concrete in reinforced foundations (ICE, 2024).

29.8.1.10 Detailed below in **paragraph 29.8.1.1** to **paragraph 29.8.1.48** is the overarching methodology for each defined PAS 2080 infrastructure lifecycle stage used to characterise the reported GHG emission sources.

A1-A3 – Product stage: raw material supply, transport and manufacture

29.8.1.11 The assessment of embodied carbon for the Project was carried out to understand the GHG emissions associated with the materials and components (considering the supply chain) used in constructing the Project's infrastructure. Embodied carbon refers to the emissions released throughout the lifecycle stages of raw material extraction, processing, manufacturing of construction products, and their transportation to site.

29.8.1.12 Material quantities were primarily estimated and in cases where direct experience or Project data was unavailable, assumptions and scaling were made using data from similar offshore wind developments of comparable scale and technology.

29.8.1.13 Embodied emissions were estimated for the Product Stage (A1–A3) following the RICS methodology (RICS, 2023), which multiplies the quantity of material by an appropriate emissions factor (expressed in tCO_2e per tonne of material).

$$\textit{Quantity of material (t) x emissions factor } (tCO_2e/t) = \textit{Emissions } (tCO_2e)$$

Wind turbine generators

29.8.1.14 As mentioned in **paragraph 29.4.2.3**, two layout scenarios have been assessed for the Project: (i) up to 225 smaller WTGs and (ii) up to 126 larger WTGs. To estimate embodied carbon emissions, EPDs relevant to each WTG size were used. These EPDs were adjusted based on the specific turbine configurations proposed in **Chapter 4: Project Description**. For the product stage (A1–A3), the adjusted EFs are 6,370 tCO_2e per smaller turbine (Vestas, 2024) and 12,987 tCO_2e per larger turbine (Siemens Gamesa Renewable Energy, 2023).

Floating units, moorings, and anchors of wind turbine generators

29.8.1.15 Floating unit concept of semi-submersible type design with three steel lateral columns (diameter of 15m) and an additional central steel tower column (diameter of 21m) has been assumed as the worst-case scenario. Column heights were taken as 55m, comprising 25m freeboard elevation above the waterline and 30m operational draft. Wall thicknesses of 60mm (tower) and 50mm (laterals) were applied to calculate inner diameters and steel volumes. Using these parameters, the total steel tonnage for both turbine layout options was derived, and associated GHG emissions were calculated by applying the DEFRA steel emission factor.

29.8.1.16 For the mooring system, including mooring lines and anchors, emissions were estimated by reference to other similar floating wind farm (Lotfizadeh, O. et al, 2025), which assessed comparable semi-submersible floating wind projects. Reported emission intensities were scaled to the Project’s lifetime energy generation of approximately 467 million megawatts per hour (MWh) over 35 years (based on an annual generation of 13,343,916MWh). This ensured that the mooring and anchoring emissions were aligned with the scale and operational profile of the Project.

Subsea distribution centres and subsea substations

29.8.1.17 Emissions from SDCs were calculated using the steel weight of 50 tonnes with a contingency of 30% based on Project design. Each SDC, estimated at 65 tonnes, was multiplied across 45 units, to estimate total emissions using a steel emissions factor (ICE, 2024). Similarly, for subsea substations, emissions were estimated based on a total steel weight of 900 tonnes per substation, rounded up from the design-provided weight of 835 tonnes (comprising approximately 685 tonnes for the transformer module and 150 tonnes for the foundation).

Array cables, scour protection, and buoyancy modules

29.8.1.18 Emissions from array cables were calculated using cable lengths corresponding to the WTG layout options. EFs from the Carbon Interface Tool were initially selected for 132 kV, 1000 mm² cables, then adjusted to match the actual voltage planned for the Project. For scour protection, volumes of rock placement were taken from Project data and converted to mass using standard density values. Emissions were calculated using ICE v4.0 EFs for general stone (ICE, 2024). Buoyancy modules, assumed to be steel-based, were assessed using water depth ranges to estimate mass. EFs for steel were applied to estimate overall emissions, with weight approximations sourced from CRP Subsea’s technical reference (CRP Subsea, 2024).

Offshore substations

29.8.1.19 The offshore substation(s) was assumed to consist entirely of steel. The topside weight was taken as 25,000 tonnes, based on design information. For jacket foundations, a conservative estimate of 10,000 tonnes of steel per jacket was assumed, reflecting the deep-water setting of Marram (80m to 130m) and the substantially larger topside weight compared with precedent projects (SSE Renewables, 2022). Pin pile foundations were evaluated by calculating concrete volumes using Project-specified pile dimensions and counts. The EF for reinforced concrete was used to estimate emissions (ICE, 2024). Scour protection around the foundations was assumed to comprise a 2:1 rock-to-concrete volume ratio (Chen, H., et al, 2014). Emissions were calculated using respective EFs for both materials.

Reactive compensation platform(s)

29.8.1.20 The same methodology used for the offshore substation was applied for the RCP. The platform structure was assumed to be steel-based and emissions were estimated based on scaled steel tonnage and known EFs. Pin pile foundations and associated scour protection followed the same concrete and rock-based estimation method.

Offshore export cables

29.8.1.21 Emission estimation for offshore export cables, including bundled fibre optic cables, followed the same methodology as for the array cables, including adjustments for voltage and scaling of total cable length. The assessment considered five offshore export cable trenches, each approximately 140km in length (total 700km of cable), representing the maximum design scenario. Rock protection volumes were calculated based on 20% of the total route length requiring protection, equating to 8,250 m³/km for each of the five trenches. The rock placement from crossings has not been included in the assessment. For fibre optic cables, an EF was sourced from an EPD (Cablescom, 2022) and used to estimate emissions per metre of cable length.

Landfall(s) infrastructure

29.8.1.22 The landfall(s) infrastructure included three elements: (i) the primary landfall(s) compound, (ii) HDD (or similar trenchless technique) ducts, and (iii) transition joint bay(s). The landfall(s) compound buildings were assumed to be steel warehouse-type structures, with an embodied carbon of 234 $kgCO_2e/m^2$ (Design Buildings, 2017). HDD (or similar trenchless technique) ducts were assumed to be made of HDPE, with an outer diameter of 0.2m and wall thickness of 0.02m. The volume of HDPE was calculated for 8 ducts of 1,500m each. Emissions were estimated using an EF for HDPE (ICE, 2024). Transition joint bay(s) were treated as concrete-lined underground pits. Emissions were calculated by determining the concrete volume per pit using design dimensions and applying the concrete EF across eight such units.

Onshore export cables

29.8.1.23 The onshore export cables were evaluated using the same EF methodology as for offshore and array cables. Two onshore export cable corridors were considered: (i) up to 19 onshore export cables from landfall(s) to the onshore substations, and (ii) up to 28 onshore export cables from onshore substations to the SSEN Netherton Hub. Emissions were calculated based on total cable lengths, adjusted EFs for voltage and material type, and any additional protection elements.

Onshore substations

29.8.1.24 The methodology for the onshore substations followed that of the landfall(s) compound but included more detailed material breakdowns. Key consumables such as silicon steel, copper, oil, and SF_6 gas were scoped in using material quantities derived from similar projects. Emissions were distributed across buildings like the Static Synchronous Compensator (STATCOM) Hall, Switch Capacitor Transformer (SCT) Buildings, Gas Insulated Switchgear (GIS) Halls, and Station Generator Transformer (SGT) Buildings. Building counts were based on the worst-case layout scenario (Scenario 1a – 800 MW High Voltage Alternating Current, all indoor). Permanent access roads were evaluated using an assumed asphalt composition (95 per cent aggregate, 5 per cent bitumen), standard road thickness (0.25m), and asphalt density of 2.4 t/m³. Substation foundations were calculated by estimating the concrete volume based on assumed coverage of the total substation footprint and applying an EF for reinforced concrete (C28/35) (ICE, 2024).

Grid connection cables

29.8.1.25 Grid connection cables were grouped under the onshore export cable assessment. The same emission estimation methodology was used, including scaling for cable length and voltage, with EFs applied to account for cable manufacturing and installation impacts.

A4 – Construction transport

Offshore construction transport

29.8.1.26 For the purpose of assessing A4 emissions, offshore construction transport was scoped to include movement of floaters from Far East (e.g. Japan) and the movement of WTGs from a pre-assembly or marshalling harbour in Northern Europe to the Project site. The production locations for the floaters and wind turbine elements are not yet determined; however, considering their size and scale, it is likely that some or all components will be produced outside the UK. Asia was selected as a conservative worst-case source due to its distance from the site. It is assumed that all elements are manufactured close to the coast and shipped to a marshalling/integration port in the East / Northeast of Scotland close to the OAA after which the elements will be shipped to the offshore location. As outlined previously, two layout scenarios were considered: one involving up to 225 smaller WTGs and the other with up to 126 larger WTGs. EFs for transport were derived from EPDs and secondary datasets, adjusted to reflect the specific turbine sizes, floater weights and voyage distances relevant to the Project. The methodology accounts for the number of vessel trips, transit distances, vessel type, installed power, service speed, fuel type, and fuel consumption to provide a representative approach for estimating upstream transport emissions for the offshore construction stage.

Onshore construction transport

29.8.1.27 The data for construction traffic movement included a count of HGVs and Light Commercial Vehicles and an average length of route (km) for the following construction elements:

- onshore substation site preparation works;
- onshore substation site construction, electrical installation and commissioning;
- onshore export cable preparation works;
- onshore export cable;
- joint bay construction, onshore export cable installation, commissioning, reinstatement; and
- landfall(s) construction.

29.8.1.28 Emissions from transportation movements across all stages of construction are calculated as follows:

$$\textit{Distance (km) x emissions factor } (tCO_2e/km) = \textit{Emissions } (tCO_2e)$$

29.8.1.29 The emissions from vehicles used during the onshore O&M stages have not been estimated. It is expected that the vehicles movements will be limited only to the onshore substations operation and any emissions associated as such will be **Negligible** compared to the overall Project emissions.

A5 – Construction and installation

Installation offshore vessel movements and associated fuel use

29.8.1.30 Offshore Project construction traffic has been calculated using the data relating to installation vessels used and respective return trips across the construction stage for the installation of:

- offshore substations installation;
- anchor installation;
- mooring line installation;
- WTG floating unit towage;
- WTG floating units installation / mooring hook up;
- cable installation for the array cables; and
- cable installation for the offshore export cables.

29.8.1.31 A list of vessels chosen for each activity along with indicative number and round trips as predicted in Project design is provided in **Table 29.9**.

Table 29.9 Indicative construction and installation offshore vessels used in emissions estimation along with their respective round-trip movements as per Project design

Construction and Installation Activity	Vessel type	Illustrative vessel	Indicative number	Round transits[1]
Offshore substations foundation installation	Heavy lift vessel	*SSCV Sleipnir*	1	12
	Support vessel	*North Sea Enabler*	5	90
	Barge (if required)	*DP-2 Deck Load Barge*	1	12
WTG floating units towage	Anchor Handling Tug Supply (AHTS) vessel	*Bourbon Orca*	3	675
WTG floating units installation / mooring hook up	AHTS vessel	*Seahorse*	5	1125
Cable installation for the offshore export cables	Survey vessel (pre- and post-lay)	*KOMMANDOR SUSAN*	1	20
	Cable lay vessel	*Fugro Global Symphony*	1	70
	AHTS vessel (for trenching / bounder removal / pre-lay grapnel run / Unexploded ordnance removal)	*Seahorse*	2	40
	Offshore construction / larger AHTS vessel (for sand wave clearance)	*DP2 OCV/DSV multi-role*	2	40

[1] A transit is defined as a single uninterrupted journey either from port to worksite or from worksite to port. Each leg of the journey constitutes one transit. Therefore, for a single operation where a vessel departs from port, performs work offshore, and returns to port, this would be classed as two transits. This definition applies to vessel movements only; helicopter movements are referred to separately as 'trips'. It is estimated that two helicopter trips per week may be required for duration of the main offshore construction; this is approximately 1,040 helicopter round trips during the offshore construction period.

Construction and Installation Activity	Vessel type	Illustrative vessel	Indicative number	Round transits[1]
	Rock placement vessel (to Norway)	*Fugro Global Symphony*	2	80
Cable installation for the array cables	Survey vessel (pre- and post-lay)	*KOMMANDOR SUSAN*	2	60
	Cable lay array	*Fugro Global Symphony*	2	50
	AHTS vessel (for trenching)	*Seahorse*	2	80
	Rock placement vessel (to Norway)	*Fugro Global Symphony*	2	30
Anchor installation	Offshore construction vessel / larger AHTS	*DP2 OCV/DSV multi-role*	2	675
Mooring line installation	Offshore construction vessel	*DP2 OCV/DSV multi-role*	2	144
	AHTS vessel	*Maersk Master*	2	675
Helicopter	Offshore construction	*Agusta Westland AW139*	1	1040

29.8.1.32 The following assumptions were applied to estimate GHG emissions associated with offshore construction and installation activities:

- vessel transit was assumed to operate at 100 per cent engine power, while idling during operational activities was assumed to use 28 per cent engine power;
- total activity time was calculated by multiplying the number of trips by the average duration of each specific activity; and
- transit time was estimated by dividing the total travel distance by the average vessel speed. Travel distances were determined using an online distance calculator (Nauticalculator) for the following operational scenarios:
  - transport from the Forth Green Freeport to the nearest onshore point near the offshore wind farm (Rattray Head), and from there to the offshore site for the installation of station-keeping systems such as anchors, suction piles, driven piles, or mooring systems – estimated at 285.26km;
  - the same route and distance (285.26km) were used for the integration of WTG floating units and WTGs; and
  - rock placement operations involving vessels traveling from Norway (assumed port: Bergen) were estimated to cover a distance of 512.5km.
- a specific fuel consumption (SFC) value of 0.226 litres per kilowatts per hour (l/kWh) was used;
- helicopter emissions during the construction stage were estimated based on the hourly fuel consumption of the AW139 model, sourced from Jettly (2024). It was assumed that the helicopter will be flying from Aberdeen airport;
- cable laying rates were assumed as follows: export cables at 1km/hour and array cables at 0.5km/hour, consistent with Project design estimates; and
- the duration of each construction activity was informed by benchmarks from similar offshore wind Projects:
  - installation of each WTG was assumed to require approximately 2 to 5 days, reflecting continuous 24-hour offshore operations;
  - support vessels were assumed to operate for 24 hours per day, consistent with offshore industry practice; and
  - hook-up durations include mooring line installation only; inter-array cable (IAC) hook-up is considered separately under cable installation.

29.8.1.33 GHG emissions from marine vessel operations were calculated using the following equation:

$$\textbf{\textit{GHG emissions (kgCO}}_2\textbf{\textit{e) = C × SFC × P × t}}$$

Where:

- C is the carbon EF ($kgCO_2e/l$);
- SFC is the specific fuel consumption (L/kWh);
- P is the total installed engine power of the vessel (kW); and
- t is the total time (hours) spent by the vessel, including both transit and on-site activity.

This formula was consistently applied across all vessel types and activities involved in the offshore construction stage.

Onshore activities - Energy use for onshore substations build, trenching, onshore export cable laying, etc.

29.8.1.34 In the absence of detailed data, the energy use during the onshore construction works has been assumed as 0.12 per cent of the GHG emissions from embodied carbon associated with the Project. This value is based on lifecycle carbon assessment of recent similar offshore wind farm (Rampion Extension Development Limited, 2024) similar to the Project.

A5- Land use, land use change and forestry

29.8.1.35 A review of soil maps indicates the presence of localised areas of 'peaty gley' soils within the onshore export cable corridor, primarily on arable farmland. Given that these soils have previously been disturbed and drained for agricultural use, the likelihood of encountering intact, deep peat layers are considered **low**. While there is some potential for subsurface peat to exist within alluvial deposits, such areas are generally avoided using trenchless techniques (for example, HDD (or similar trenchless technique)) for watercourse crossings.

29.8.1.36 As such, peat disturbance is not expected to be significant. In alignment with this, peat has been scoped out of the GHG assessment, and a separate peat management plan has not been proposed. However, good practice soil handling measures, including those for peaty soils, will be addressed within the Outline Soil Management Plan as part of the **Volume 4: Outline CEMP** to ensure minimal impact during excavation, stockpiling, and reinstatement.

B1-B5 - Maintenance, repair, replacement and refurbishment – O&M stage

29.8.1.37 For O&M, repair, refurbishment, and replacement throughout the use stage, an estimate of GHG emissions was made by scoping in WTG consumables, offshore O&M activities, and O&M materials, including maintenance on floaters, moorings, anchors, and offshore substations.

Wind turbine generator consumables (B1)

29.8.1.38 To estimate emissions from turbine consumables during the O&M stage, quantities of key materials – such as grease, hydraulic oil, gear oil, lubricants, nitrogen, water / glycerol mixture, transformer silicon / ester oil, and SF_6 gas – were referenced from previous offshore windfarm projects (Rampion Extension Development Limited, 2024). Separate sets of consumable quantities were identified for both smaller and larger turbine configurations. These values were then multiplied by the number of turbines in each layout option to estimate the total quantity consumed over the Project lifetime. Emissions were calculated by applying appropriate EFs for each consumable material as listed in **Table 29.8**.

O&M activities – offshore vessel movements

29.8.1.39 GHG emissions associated with offshore vessel movements, excluding helicopter support, were estimated using the same approach applied in the A5 (installation) stage. Assumptions for engine load during transit and idling, SFC, and vessel power ratings were retained for consistency. Operational vessel activity, such as trips for maintenance, repair, and component exchange, was estimated based on indicative round trips and typical vessel types for offshore O&M as stated in **Table 29.10.**

Table 29.10 Indicative O&M offshore vessels used in emissions estimation along with their respective round-trip movements as per Project design

O&M Activity	Vessel type	Illustrative vessel	Indicative number	Round trips
O&M vessels	Guard vessel	*Commodore P*	2	104
	SOV	*DP2 OCV/DSV multi-role*	2	104
	Diving support vessel	*Deep Discoverer (DP3 DSV)*	3	156

O&M materials – repairs, replacements, and exchanges (B2–B5)

29.8.1.40 For evaluation purposes, a number of maintenance event assumptions were made for respective sub-components. Where specific data for offshore substations, floaters, moorings, and anchors were not available, conservative worst-case assumptions were applied, with activities such as floater trips to port, anchor repositioning, and component exchanges reflected through the O&M vessel movements in **Table 29.10**:

- **Moorings:** Based on worst-case assumptions, 1.5% of moorings are expected to be replaced per year from year 5 onwards;
- **Anchors and floaters:** For suction or driven anchors, no change in lifetime is assumed; however, a single relay or repositioning of anchors is expected over the field lifetime, based on offshore oil and gas experience. Floaters are assumed to require two trips to port over their lifetime to allow for maintenance, repair, or replacement of either the floater or the associated WTG. These activities are captured within the O&M vessel movements outlined in **Table 29.10**;
- **Array cable repair:** The dynamic section of cables is assumed to be replaced once over the operational lifetime (136km for smaller turbines and 106km for larger turbines), while the static section of cables is assumed to require 25% replacement over the lifetime (680km to 136km for smaller turbines, 530km to 106km for larger turbines), consistent with seabed cable sections and rock protection assumptions. Emissions were calculated using the average EF for array cables;
- **Array and export cable – rock replacement:** it was assumed that 25 per cent of the rock protection around array and export cables may require replenishment during the O&M stage;
- **J-tube replacement (WTGs):** maintenance frequency for J-tube replacement was assumed at two events per WTG and twenty per substation over the operational lifetime;
- **Export cable repair:** export cable repair needs were assumed at four lifetime events, with each event covering approximately 600m;
- **WTG – anode replacement:** anodes made of aluminium were assumed to weigh 45kg each. Five replacements per turbine were considered across the operational life;
- **WTG – ladder replacement:** each turbine was assumed to require five ladder replacements over its lifetime. Ladder weight was based on standard technical data (14,393kg per turbine tower);
- **WTG – component exchange events:** a conservative factor of 10 per cent of the embodied carbon associated with the WTG (as estimated during the product stage) was assumed to account for partial component replacements over the Project's life. This

estimate covers unscheduled maintenance or replacements that do not involve the full turbine; and

- **Offshore substation – component exchange events:** similarly, 10 per cent of the embodied carbon associated with the offshore substation platform was scoped into account for exchange events, reflecting typical replacement requirements during long-term operation.

29.8.1.41 Each of these line items was calculated separately for the two turbine layout scenarios (smaller and larger turbines), enabling comparison of lifetime O&M emissions under each option. Material quantities and lifespans were based on data from previous offshore wind projects (Rampion Extension Development Limited, 2024) (Spiorad na Mara Limited, 2023). EFs were taken from the ICE v4.0 database (December 2024 version) (ICE, 2024) and Project-specific cable and component sheets.

C1 – Decommissioning stage

29.8.1.42 The decommissioning of an offshore wind farm involves the safe dismantling and removal of turbines, foundations, and associated infrastructure. Offshore, this process will require similar types and numbers of vessels and equipment as used during construction. Onshore, it will involve comparable labour, transport movements, and equipment, with some materials left in place to minimize environmental impacts.

29.8.1.43 Emissions from decommissioning activities, both on-site and off-site, are assumed to be similar to those during construction and installation. This includes energy consumption for plant use and transport emissions for materials and labour. The removal process is expected to follow the reverse sequence of construction.

29.8.1.44 Since decommissioning will take place far in the future, predicting the exact fate of materials and associated activities is challenging. As a result, GHG emissions estimates are based on current assumptions, with offshore decommissioning mirroring construction logistics and onshore electrical cables expected to remain in place, sealed, and buried.

29.8.1.45 The decommissioning stage of the Project is assumed to include the decommissioning and removal of all structures above the seabed or ground level. Following the approach set out in **Chapter 5: Approach to the EIA**, the decommissioning stage emissions assessment includes key elements under A4 and A5 to ensure a comprehensive evaluation of GHG impacts. For transport (A4), offshore emissions account for the movement of WTGs from the site back to a pre-assembly or marshalling harbour in Northern Europe. Onshore transport emissions include those from HGVs and LGVs used to transport recovered materials.

29.8.1.46 Under A5, offshore decommissioning emissions reflect energy use from vessel and helicopter operations involved in dismantling and removing WTGs, foundations, offshore export cables, and offshore substations. Onshore, energy use from deconstruction activities such as dismantling onshore substations and removing cables has been scoped in. Land use impacts – such as peatland excavation or restoration – were not considered in the decommissioning scope, as peat was scoped out of the overall GHG assessment.

C4 – End-of-life transport and disposal of materials

29.8.1.47 The end-of-life stage for an offshore wind farm involves transporting dismantled materials to disposal or recycling facilities. It is anticipated that a considerable amount of wind farm components would be recycled, repurposed, or incinerated for energy recovery at the end-of life stage, as opposed to being sent to landfill.

Avoided emissions

29.8.1.48 The carbon payback period has been calculated in **Section 29.13**. The Project is expected to offset its lifecycle emissions after five years of its operational life, with a carbon savings of 5,978,074 tCO_2e/year.

29.8.2 Other data limitations and assumptions

29.8.2.1 It is not known exactly which form of conventional electricity generation the Project will replace. The assessment of GHG emissions considers the carbon payback period of the Project relative to coal, oil, gas and other solid fuels, including non-renewable waste generation mechanisms. Despite the limitations, the assessment has followed the approach of modelling a 'worst-case' scenario.

29.8.2.2 As WTG technology is continually evolving, it is difficult to definitively predict the generating capacity and model of WTG that will be commercially available at the point of procurement for construction. As such, the size and capacity of the WTG for the Project will be determined during the final Project design stage prior to construction. The final WTG design will be selected in accordance with the parameters set out in the design.

29.8.3 Significance evaluation methodology

Overview

29.8.3.1 Any magnitude of emitted or avoided GHG emissions makes a cumulative contribution to climate change. As there is only one receptor, 'the global atmosphere', it has a consistent sensitivity (**high**) no matter the location of the emissions source.

Significant evaluation

29.8.3.2 Significance of GHG impacts is assessed in line with IEMA Guidance: "*a development's emissions should be based on its net impact over its lifetime, which may be adverse, beneficial or negligible*". The evaluation of significance is not solely based on the magnitude of GHG emissions but whether the Project contributes to reducing GHG emissions relative to a comparable baseline consistent with achieving net zero by 2050 (IEMA, 2022).

29.8.3.3 With regards to assigning significance, IEMA Guidance provides five distinct levels of significance. Major or moderate adverse effects and beneficial effects are considered significant; minor adverse and negligible effects are not significant:

- **Major adverse** (**Significant**): the Project's GHG impacts are not mitigated or are only compliant with do-minimum standards set through regulation, and do not provide further reductions required by existing local and national policy for projects of this type. A project with major adverse effects is locking in emissions and does not make a meaningful contribution to the UK's trajectory towards net zero.
- **Moderate adverse** (**Significant**): the Project's GHG impacts are partially mitigated and may partially meet the applicable existing and emerging policy requirements but will not fully contribute to decarbonisation in line with local and national policy goals for projects of this type. A project with moderate adverse effects falls short of fully contributing to the UK's trajectory towards net zero.
- **Minor adverse** (**Not Significant**): the Project's GHG impacts will be fully consistent with applicable existing and emerging policy requirements and good practice design standards for projects of this type. A project with minor adverse effects is fully in line with measures necessary to achieve the UK's trajectory towards net zero.

- **Negligible** (**Not Significant**): the Project's GHG impacts will be reduced through measures that go well beyond existing and emerging policy and design standards for projects of this type, such that radical decarbonisation or net zero is achieved well before 2050. A project with negligible effects provides GHG performance that is well 'ahead of the curve' for the trajectory towards net zero and has minimal residual emissions.
- **Beneficial** (**Significant**): the Project's net GHG impacts are below zero and it causes a reduction in atmospheric GHG concentration, whether directly or indirectly, compared to the without project baseline. A project with beneficial effects substantially exceeds net zero requirements with a positive climate impact.

29.8.3.4 In order to provide context to the GHG emissions, and as set out in the IEMA guidance (IEMA, 2022), the estimated GHG emissions arising from the Project will be compared with the respective UK Carbon Budgets where appropriate, noting that based on recommendations from the Climate Change Committee the Scottish Government is currently seeking to establish five-yearly carbon budgets for limits on the amount of GHGs emitted, to provide a reliable framework for emissions reduction to achieve Net Zero target by 2045.

29.9 Assessment of effects: construction stage

29.9.1.1 The GHG emissions associated with the construction stage of the Project are summarised in **Table 29.11**. The results presented reflect the maximum design scenario (as noted previously in **paragraph 29.4.2.4**).

Table 29.11 Construction stage emissions

Lifecycle stage	Design element / activity	Emissions ($ktCO_2e$)
A1-A3 (Embodied carbon)	WTGs	1,433
	WTG floating units	2,138
	Moorings and anchors	486
	SDCs and subsea substations	13
	Array cables	277
	Offshore substations	274
	RCP(s)	12
	Offshore export cables	365
	Landfall(s)	11
	Onshore export cables	267
	Onshore substations	414
	Onshore export cables	62
Total embodied carbon		5,752
A4 (Material transport to site)	Offshore	1,250

Lifecycle stage	Design element / activity	Emissions (ktCO_2e)
	Onshore	1
Total transport emissions		1,251
A5 (Construction and installation process)	Offshore vessel movements and energy use	2,495
	Onshore energy use	690
Total A5		3,185
Total Construction Emission		10,188

29.9.1.2 Embodied content of materials is a key contributor to construction stage emissions (primarily related to the material used in WTGs and WTG floating units). Marine vessel movements for offshore construction processes and installation of structures is another major contributor.

Comparison against relevant UK carbon budgets

29.9.1.3 In line with IEMA guidance (IEMA, 2022), the GHG impacts of the construction stage have been compared against the UK Government's five-year carbon budgets in **Table 29.12**.

29.9.1.4 The construction is planned across three-stages starting from 2030 through to 2043, and the comparison has been made for the total construction emissions across these stages.

29.9.1.5 These fall across the Fifth Carbon Budget (2028-2032), Sixth Carbon Budget (2033-2037) and the Seventh Carbon Budget (2038-2042).

Table 29.12 Comparison with UK carbon budgets

Carbon budget period	UK carbon budget	Emissions from construction stage (tCO_2e)	% of respective carbon budget
Carbon budget 5 (2028-2032) *Project **construction** duration **= 3 years***	1,725,000,000	1,698,031	0.10%
Carbon budget 6 (2033-2037) *Project construction duration **= 5 years***	965,000,000	2,830,052	0.29%
Carbon budget 7 (2038-2042) *Project construction duration **= 5 years***	535,000,000	2,830,052	0.53%

Magnitude of impact

29.9.1.6 As the emissions from the construction stage of the Project have a negligible contribution to the UK Carbon Budgets, construction of the Project is unlikely to affect the UK's ability to meet its future carbon targets. On this basis the significance of effect is assessed as Minor Adverse (**Not Significant**).

29.10 Assessment of effects: O&M stage

29.10.1.1 The GHG emissions associated with the O&M stage of the Project are summarised in **Table 29.13**.

Table 29.13 O&M stage emissions

Lifecycle stage	Design element / activity	Emissions ($ktCO_2e$)
B1	WTGs - consumables	141
B2-B5	O&M activities – offshore vessel movements	96
	O&M materials	549
Total O&M emissions		786

29.10.1.2 The major contributors to these emissions are the embodied carbon in the replacement parts and marine vessel movements for repairs and maintenance of offshore elements.

Comparison against relevant UK carbon budgets

29.10.1.3 In line with IEMA guidance (IEMA, 2022), the GHG impacts of the O&M stage have been compared against the UK Government's five-year carbon budgets in **Table 29.14**.

29.10.1.4 The Project will be operational for up to 35 years from the installation and commissioning of offshore components.

29.10.1.5 These fall partly within Sixth Carbon Budget (2033-2037) and the Seventh Carbon Budget (2038-2042).

Table 29.14 Comparison with UK carbon budgets

Carbon budget period	UK carbon budget	Emissions from construction stage (tCO_2e)	% of respective carbon budget
Carbon budget 6 (2033-2037) *Project operation duration = 1 years*	965,000,000	22,453	0.002%
Carbon budget 7 (2038-2042) *Project operation duration = 5 years*	535,000,000	112,265	0.021%

29.10.1.6 It is to be noted that the Project will continue to offset GHG emissions throughout its operational life and therefore make a positive contribution to the UK Government target to reach net zero emissions in 2050. The carbon savings associated with the Project have been presented in **Section 29.13**.

Magnitude of impact

29.10.1.7 As GHG emissions resulting from the O&M stage of the Project have a negligible contribution to the 6th and 7th carbon budget periods, O&M stage of the Project is unlikely to affect the UK's ability to meet its future carbon targets. On this basis the significance of effect is assessed as Minor Adverse (**Not Significant**).

29.11 Assessment of effects: decommissioning stage

29.11.1.1 The GHG emissions associated with the decommissioning stage of the Project are summarised in **Table 29.15**. The results below in **Table 29.15** have been presented for the maximum design scenario in line with **paragraph 29.4.2.4**.

Table 29.15 Emissions from decommissioning stage

Lifecycle stage	Design element / activity	Emissions (ktCO2e)
C	Decommissioning activities	4,436

29.11.1.2 As detailed in **paragraph 29.8.1.42**, it is anticipated that a considerable amount of wind farm components would be recycled or repurposed, which, although involving some emissions from processing, is expected to result in a net reduction in GHG emissions compared to disposal or use of virgin materials.

Magnitude of impact

29.11.1.3 As such, the effect on climate change is considered to be Minor Adverse (**Not Significant**) relative to a no-project baseline, but represents a more sustainable end-of-life approach. Further quantification of the impacts and mitigations emission reduction potential should be undertaken as the decommissioning plan is developed further.

29.12 Summary of effects

29.1.1.1 A summary of the effects arising from the construction, O&M and decommissioning stages of the Project in relation to GHG are summarised in **Table 29.16.**

Table 29.16 Summary of construction, O&M and decommissioning stage assessment

Receptor	Sensitivity / value	Activity and potential effect	Embedded environmental measures	Magnitude of effect	Significance of effects
Construction					
Global atmosphere	**High**	Direct impacts on global atmosphere.	M-079 M-098 M-099	**Minor adverse**.	**Not Significant**.
O&M					
Global atmosphere	**High**	Direct impacts on global atmosphere.	M-079	**Minor adverse**.	**Not Significant**.
Decommissioning					
Global atmosphere	**High**	Direct impacts on global atmosphere.	M-079	**Minor adverse**.	**Not Significant**.

29.12.1 Benefits and loads beyond the system boundary

29.12.1.1 The use of electricity generated by the Project is a benefit that is reported beyond the lifecycle stages included within the construction, O&M and decommissioning stages summarised in **Table 29.16**. Details of this benefit are provided in **Section 29.14**.

29.12.1.2 The benefit of the lifetime electricity generation of the Project is larger than the emissions arising from the construction, O&M and decommissioning stages. In other words, the net outcome of the Project will be a reduction in overall GHG emissions.

29.12.1.3 On this basis the significance of effect of the entire Project is assessed as Beneficial (**Significant**).

29.13 Carbon payback period and GHG intensity of the Project

29.13.1.1 The carbon payback period represents the time required before displaced GHG emissions equal the life cycle GHG emissions for the Project, (i.e., the Project has saved more GHG emissions relative to electricity production by other means than will be produced by its construction, O&M and decommissioning).

29.13.1.2 The GHG intensity and the payback period of the Project are estimated based on the available information, using the whole life GHG emissions and anticipated electricity generated by the wind farm across the operational life.

29.13.1.3 As set out in **Table 29.18**, the Project is expected to deliver significant lifecycle carbon savings through low-emission renewable electricity generation. Based on the estimated generation, the wind farm will have offset its lifecycle GHG emissions after approximately 100,067 GWh of electricity production. This milestone would be reached after approximately 21 per cent of operational lifetime or around 90 months (~7.5 years) from full capacity operational as shown in **Table 29.18**.

29.13.1.4 The GHG intensity estimated for the Project is 33 tCO_2e/GWh, which is substantially lower than conventional fossil-fuel-based generation methods. The GHG intensity of gas-fired conventional generation plants are typically estimated to be around 382 tCO_2e/GWh. A comparison of the carbon intensity of generation from a range of different electricity generation sources is provided in **Table 29.17**. Carbon intensity figures for these alternative generation sources are based on details reported in the Digest of UK Energy Statistics**.**

Table 29.17 Key parameters of the Project including capacity, generation estimates, GHG emissions, and intensity based on maximum design scenario assumptions

Parameter	Value	Data source
Total generation capacity of the Project (MW)	3,000	Aligned with Project design parameters.
Predicted annual generation of the Project (GWh/yr)	13,344	Aligned with Project design parameters.
Design life (yrs)	35	Aligned with Project design parameters.
Predicted lifetime generation of the Project (GWh)	467,037	-

Parameter	Value	Data source
GHG emission of the Project (tCO_2e)	15,410,262	GHG assessment results
GHG intensity of the Project (tCO_2e/GWh)	33	GHG assessment results

Table 29.18 Comparison of GHG emissions from the Project against conventional fuel sources (coal, gas, and others), including annual and lifetime carbon reductions and carbon payback period

Fuel source for generation	Carbon intensity (tCO_2e/GWh)	Estimated annual GHG emissions from generation (tCO_2e/GWh)	Estimated operational lifetime emissions from generation (tCO_2e)	Net difference vs Project (tCO_2e/yr)	Net operational lifetime difference vs. Project (tCO_2e)
Project	33	440,293	15,410,262	N/A	N/A
Coal	919	12,263,059	429,207,058	11,822,766	413,796,796
Gas	382	5,097,376	178,408,157	4,657,083	162,997,895
All non-renewable fuels*	448	5,978,074	209,232,603	5,537,781	193,822,341
All fuels (including nuclear and renewables)**	154	2,054,963	71,923,707	1,614,670	56,513,445
Carbon Payback Period (GWh) – All fuels (including nuclear and renewables)					100,067
% of operational lifetime – All fuels					21%
Payback period (months) – All fuels					90

** Coal, oil, gas and other solid fuels, including non-renewable waste.*
*** All fuels listed in DUKES Table 5.6 excluding net pumped storage supply and supply from net imports.*

29.14 Transboundary effects

29.14.1.1 Based on the knowledge of the baseline environment, the nature of planned works and the wealth of evidence on the potential for impact from such projects more widely, there are not considered to be any transboundary effects relating to GHG emissions.

29.15 Inter-related effects

29.15.1.1 Emissions of GHGs to the atmosphere have the potential to contribute to climate change, and therefore the effects are global and cumulative in nature. No inter-related effects are therefore identified.

29.16 Assessment of cumulative effects

29.16.1.1 A description and assessment of the cumulative effects arising from the Project on GHG is provided in **Chapter 33: Cumulative Effects Assessment**.

29.16.1.2 The global atmosphere is the receptor for the GHG assessment. Emissions of GHGs to the atmosphere have the potential to contribute to climate change, and therefore the effects are global and cumulative in nature. This is considered in defining the receptor (for instance, the global atmosphere) as **high** sensitivity.

29.16.1.3 The IEMA guidance (IEMA, 2022) states that effects of GHG emissions from specific cumulative projects should not be individually assessed, as there is no basis for selecting which projects to assess cumulatively over any other. The GHG assessment is therefore considered to be inherently cumulative, and no additional consideration of cumulative effects is required.

29.17 Summary of residual likely significant effects

29.17.1.1 There are no residual likely significant adverse effects on GHG receptors identified in this assessment.

29.17.1.2 The electricity generation from the Project will provide a net benefit in supporting ongoing efforts to decarbonisation generation on the UK national electricity network. The displaced GHG emissions across its operational lifetime are greater than the reported emissions in its construction, O&M and decommissioning.

29.17.1.3 On this basis there is a residual significant beneficial effect of the Project.

29.18 References

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29.19 Glossary of terms and abbreviations

29.19.1 Abbreviations

Acronym	Definition
AHTS	Anchor Handling Tug Supply
BEIS	Department for Business, Energy & Industrial Strategy
BSI	British Standards Institution
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
CEMP	Construction Environmental Management Plan
DB	Data Base
DESNZ	Department for Energy Security and Net Zero
EF	Emission Factors
EIA	Environmental Impact Assessment
EPD	Environmental Product Declaration
EU	European Union
GHG	Greenhouse Gases
GWh	Gigawatts per hour
HDD	Horizontal Directional Drilling
HDPE	High Density Polyethylene
HGV	Heavy Goods Vehicle
ICE	Inventory of Carbon and Energy
IEMA	Institute of Environmental Management & Assessment
KM	Kilometre
$ktCO_2e$	Kilo tonnes of Carbon Dioxide Equivalent
KW	Kilowatts
LGV	Light Goods Vehicle
M	Metres
MD-LOT	Marine Directorate Licencing Operations Team
MW	Megawatts

Acronym	Definition
MWh	Megawatts per hour
No.	Number
NPS	National Policy Statement
O&M	Operation and Maintenance
OAA	Option Agreement Area
OTW	Onshore Transmission Works
PAS	Publicly Available Standard
RCP	Reactive Compensation Platform
RICS	Royal Institution of Chartered Surveyors
SDC	Subsea Distribution Centre
SF_6	Sulphur Hexafluoride
SFC	Specific Fuel Consumption
SOV	Service Operation Vessel
UK	United Kingdom
UNFCCC	United Nations Framework Convention on Climate Change
WTG	Wind Turbine Generator

29.19.2 Glossary of terms

Term	Definition
Carbon dioxide equivalent (CO_2e)	Carbon dioxide equivalent (CO_2e) is a term for describing different GHGs in a common unit. For any quantity and type of GHG, CO_2e represents the amount of carbon dioxide (CO_2) which would have the equivalent global warming impact.
Carbon payback period	The period required before displaced GHG emissions equal the life cycle GHG emissions for the Project.
Embodied carbon	The embodied carbon describes the carbon footprint of a material, allowing for the sum of the energy required in resource extraction, and any processing required, as well as the transport and supply logistics to the factory gate (prior to transport to the Project for use), to be accounted for within the overall GHG estimation.
Emissions Factor	An emission factor is a coefficient that describes the rate at which a given activity releases GHGs into the atmosphere. It allows for the conversion of

Term	Definition
	activity data into GHG emissions and is often referred to as a conversion factor or emission intensity
GHG emissions	GHG emissions are determined by the Kyoto Protocol (1997) to include six categories of gases: carbon dioxide, methane, nitrous oxide, F-gases (hydrofluorocarbons and perfluorocarbons), sulphur hexafluoride and nitrogen trifluoride. To provide consistent reporting of these gases, each is weighted by its global warming potential and converted to a carbon dioxide equivalent (CO_2e).
GHG emission factor	The GHG emissions factors relate a given level of activity, or amount of fuel, energy or materials used, to the mass of GHGs released as a consequence. It is measured in the amount of GHG emissions (in gCO_2e, tCO_2e, $ktCO_2e$, $MtCO_2e$, etc.) relative to the activity unit (for example, tonnes, km, kgs etc.).
Heavy Goods Vehicle	A commercial vehicle with a gross weight exceeding 3.5 tonnes.
Institute of Environmental Management and Assessment	International membership organisation for environment and sustainability professionals.
Light Commercial Vehicle	A commercial vehicle with a gross weight of less than 3.5 tonnes.
ScottishPower Renewables UK Limited	Part of the Iberdrola group and 100% owner of MarramWind Limited.

MarramWind