MachairWind Offshore Windfarm

Chapter 19 Greenhouse Gas Assessment

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GLOSSARY OF ACRONYMS

Term	Definition
BSI	British Standards Institution
CCC	Climate Change Committee
CCR	Carbon Capture Ready
CCS	Carbon Capture and Storage
CEA	Cumulative Effects Assessment
CfD	Contract for Difference
CO_2e	Carbon Dioxide equivalent
COP	Conference of the Parties
DESNZ	Department for Energy Security and Net Zero
DUKES	Digest of United Kingdom Energy Statistics
ECC	Export Cable Corridor
EEA	European Economic Area
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
GBS	Gravity-based structure
GHG	Greenhouse Gas
GloMEEP	Global Maritime Energy Efficiency Partnerships Project
GW	Gigawatt
GWP	Global Warming Potential
HFC	Hydrofluorocarbons
IAC	Inter-array cables
ICE	Inventory of Carbon and Energy
IEMA	Institute of Environmental Management and Assessment
ISEP	Institute of Sustainability and Environmental Professionals
LCA	Lifecycle Assessment
LDP	Local Development Plan
LSE	Likely Significant Effects
MD-LOT	Marine Licensing and Operations Team
MH4	Methane
N_2O	Nitrous Oxide
NETS	National Electricity Transmission System
NF_3	Nitrogen Trifluoride

Term	Definition
NPF4	Scotland's fourth National Planning Framework
OnTDA	Onshore Transmission Development Area
OSP	Offshore Substation Platform
PFC	Perfluorocarbons
PLGR	Pre-Lay Grapnel Run
POA	Plan Option Area
SCADA	Supervisory Control and Data Acquisition
SF_6	Sulphur Hexafluoride
SMP-OWE	Sectoral Marine Plan for Offshore Wind Energy
UNFCCC	United Nations Framework Convention on Climate Change
UXO	Unexploded Ordnance
WDA	Windfarm Development Area
WTG	Wind Turbine Generator

GLOSSARY OF TERMS

Term	Definition
Cable protection	Protective measure to minimise the effects of scour and hazards along the offshore cables (e.g. to prevent cable exposure or snagging of vessel anchors or fishing gear), as well as for protecting these cables at infrastructure crossing points.
Climate Change Impact	Climate Change Impact is defined as an impact from a climate hazard, such as asset damage or failure, which affects the ability of the receptor to maintain its function or purpose.
Development Area	Application boundary for consenting purposes which, for the Project, consists of a Windfarm Development Area, Offshore Export Cable Corridor, and Onshore Transmission Development Area. Separate consent and marine licence applications will be submitted for each Development Area where applicable.
Embedded mitigation measure	Mitigation measures, including industry good practice measures, that are directly incorporated into the design for the MachairWind Windfarm Development Area to avoid or reduce environmental effects.
Environmental Impact Assessment (EIA)	The process of evaluating the likely significant environmental effects of a proposed development over and above the existing circumstances (or 'baseline').
Environmental Impact Assessment (EIA) Regulations	A collective term referring to The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017 and The Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017.
Greenhouse gas	A gas in the Earth's atmosphere that traps heat by absorbing and emitting infrared radiation, a process known as the greenhouse effect. Also known by the collective shorthand "carbon".
Inter-array cables (IACs)	Armoured cable containing electrical and fibre optic cores which link the wind turbine generators to each other and to the offshore substation platform(s).
MachairWind Offshore Windfarm	An offshore windfarm capable of exporting around 2 GW of renewable energy to the National Electricity Transmission System. MachairWind Offshore Windfarm comprises three Development Areas: • The Windfarm Development Area (WDA) – located on the west coast of Scotland to the northwest of Islay and west of Colonsay; • The Offshore Export Cable Corridor – a preliminary boundary extending from the WDA to mean high water springs at a landfall location near Girvan, South Ayrshire; and • The Onshore Transmission Development Area – a preliminary boundary which extends landward from mean low water springs and includes the land required for the landfall of the offshore export cables and their route up to but not including the proposed high voltage direct current switching station which will be developed and constructed by Transmission Owner, ScottishPower Transmission. Separate consent and licence applications will be submitted for each Development Area.
National Electricity Transmission System	The high-voltage electricity power transmission network serving Great Britain which receives electricity from generators (such as offshore windfarms) and transmits that electricity to anywhere on the National Electricity Transmission System to satisfy demand.
Offshore export cable	Armoured cable containing electrical cores between the offshore substation platform(s) and landfall. Offshore export cables will include bundled fibre optic cables. The offshore export cables are subject to Marine Licence applications under the Marine (Scotland) Act 2010. The portion of the offshore export cable(s) located within the WDA is assessed as part of this MachairWind WDA EIA and a marine licence application to construct, alter or improve this portion has been submitted alongside the WDA application. A separate marine licence application will be submitted for the portion of the offshore export cable(s) from the WDA boundary to Mean High Water Springs.

Term	Definition
Offshore Export Cable Corridor (ECC)	The preliminary boundary extending from the WDA to mean high water springs near Girvan, South Ayrshire and within which the offshore export cable(s) will be located. A separate marine licence application will be submitted for the offshore export cable(s) located within the Offshore ECC.
Offshore Substation Platform (OSP)	An offshore platform with a fixed foundation located within the WDA which houses electrical equipment such as transformers, switchgear, protection and control systems, and enables the windfarm's renewable electricity to be collected via inter-array cables and exported to the National Electricity Transmission System via offshore export cables.
Offshore Substation Platform (OSP) link cables	Electrical cables which link OSPs (if more than one OSP is required). These cables will include fibre optic cores or bundled fibre optic cables. OSP link cables will be wholly located within the WDA.
Onshore Transmission Development Area (OnTDA)	The preliminary boundary which extends landward from mean low water springs and includes the land required for the landfall of the offshore export cables and their route up to but not including the proposed high voltage direct current switching station which will be developed and constructed by Transmission Owner, ScottishPower Transmission. This Transmission Owner is responsible for consenting the high voltage direct current switching station. Onward connections to the National Electricity Transmission System will be consented by National Grid Electricity Transmission and ScottishPower Transmission. Where relevant, these are considered as part of cumulative effects assessment in the EIA.
Operational life	The operational life is the expected length of time from final commissioning of the WDA until the cessation of commercial operations. This is anticipated to be 35 years.
Pre-construction works	Pre-construction works are activities undertaken prior to formal commencement of construction. Examples include survey works such as geotechnical and geophysical surveys and seabed preparation activities.
Scour protection	Protective measures to avoid sediment being eroded away from the base of the wind turbine generator foundations as a result of the flow of water.
The Applicant	The legal entity submitting consent applications for the MachairWind Offshore Windfarm, namely MachairWind Limited.
The Project	MachairWind Offshore Windfarm including all its Development Areas and associated infrastructure.
Windfarm Development Area (WDA)	The application boundary within the OAA where consent will be sought for the proposed WDA infrastructure. The WDA infrastructure is subject to Section 36 consent and marine licence applications (generation and transmission) which are being applied for separately from the Offshore ECC infrastructure and OnTDA infrastructure.
WDA infrastructure	The offshore generation and transmission infrastructure located within the WDA including but not limited to: WTGs, WTG fixed foundations (and associated scour protection), OSP(s), OSP fixed foundations (and associated scour protection), IACs, OSP link and offshore export cable(s) and their associated external cable protection (insofar as these are located within the WDA) and fibre optic cables.
Wind Turbine Generator (WTG)	A wind turbine generator which converts wind energy into electrical energy. Each wind turbine generator is a complex system composed of a high number of components. Typically, the main components include the rotor assembly (composed of three blades and a hub); the nacelle (containing a generator, shaft and gearbox, power electronic converter and transformer); and the tower (containing lifting equipment and the switchgear).

19 GREENHOUSE GAS ASSESSMENT

19.1 INTRODUCTION

1. This chapter presents an assessment of potential effects and likely significant effects (LSE) on the environment in relation to greenhouse gas (GHG) emissions from the construction (including pre-construction activities), operation and maintenance (O&M), and decommissioning of the MachairWind Windfarm Development Area (WDA) infrastructure. Recognising that the grid connection location for the Project was only confirmed in August 2025, following delays stemming from the National Electricity System Operator's 2022 Holistic Network Design (HND) process, separate consent and marine licence applications will be sought for the Offshore Export Cable Corridor (ECC) and Onshore Transmission Development Area (OnTDA). Consequently, this topic chapter considers the WDA Study Area and existing environment only. A combined assessment of the construction (including pre-construction activities), O&M and decommissioning of the WDA activities, Offshore Export Cable Corridor (ECC) and Onshore Transmission Development Area activities (OnTDA) (commensurate with the level of detail that is available at the time of carrying out that assessment) is also provided. This approach ensures that a meaningful, proportionate and holistic view is undertaken in relation to the GHG effects of the entire MachairWind Offshore Windfarm including all its Development Areas and associated infrastructure (the Project). To inform the combined assessment, a set of assumptions were developed which includes a preliminary boundary for the Offshore ECC and OnTDA, anticipated project components and associated construction methods and timelines. These are set out in **Chapter 3 Project Description**, Sections 3.7 and 3.8.

2. This chapter considers the following infrastructure: wind turbine generators (WTGs), associated fixed foundations and scour protection, inter-array cables (IACs), associated cable protection, Offshore Substation platforms (OSPs), OSP link cables and the portion of the export cable located within the WDA. As noted in **Chapter 1 Introduction**, the assessment of potential effects on all receptors associated with the Project's Offshore ECC and OnTDA will be presented in individual EIARs, which will be submitted separately in accordance with the relevant EIA Regulations.

3. This chapter of the WDA EIAR has been prepared to provide the Marine Directorate Licensing and Operations Team (MD-LOT) (on behalf of the Scottish Ministers) and stakeholders with sufficient information to determine the potential effect(s) of the Project on the environment in relation to GHG.

4. This chapter presents a GHG assessment (i.e. carbon assessment) which evaluates the WDA's impact on climate change. This assessment quantifies the GHG emissions released from activities during the construction (including pre-construction activities), O&M, and decommissioning phases of the Project. In addition, the assessment evaluates the contribution of the WDA to national and regional GHG emissions in Scotland and the UK, and compares its net effect against a 'Do Nothing' baseline scenario. The main focus of the GHG assessment is the WDA infrastructure, however the offshore and onshore transmission infrastructure (which will be developed in the Offshore ECC and OnTDA, respectively) are required to supply renewable energy and contribute to the decarbonisation of the UK's National Electricity Transmissions System (NETS); therefore, GHG emissions associated with the Project (WDA, Offshore ECC and OnTDA together) in its entirety require consideration. Initial details of the Offshore ECC and OnTDA are provided in **Chapter 3 Project Description,** with full details of the design of the Offshore ECC and OnTDA to be provided in their respective future EIAR's. Therefore, a high-level estimation of GHG emissions from the offshore and onshore transmission infrastructure of the Project is presented as part of a whole Project assessment in **Section 19.7**.

5. In addition, a Blue Carbon Assessment has been carried out, which assesses the potential effects on Blue Carbon habitats and the release of stored carbon caused by disturbance or loss of seabed habitat / sediments. The assessment, which focuses solely the WDA infrastructure is presented in **Appendix 19.2 Blue Carbon Assessment**. The Blue Carbon Assessment is distinct from this chapter as its methodology is standalone, and there are considerable uncertainties with regard to the pathway for the release of emissions to the global atmosphere. In addition, the Blue Carbon Assessment considers the impact on the functionality of blue carbon habitats, which is a different receptor to the GHG assessment.

6. This chapter should be read in conjunction with the **Chapter 20 Climate Change Risk Assessment**.

7. Key inter-relationships between this chapter and the chapter listed above will be considered where relevant and presented in this chapter.

8. Additional information to support the GHG assessment includes:

- Appendix 19.1 Greenhouse Gas Assessment Methodology.

9. This chapter was prepared by Haskoning.

19.2 LEGISLATION, POLICY AND GUIDANCE

10. The overarching policy and legislation relevant to the EIA is described in **Chapter 2 Policy and Legislative Context**. **Table 19.1** sets out the relevant legislation, policy and guidance that informs the assessment for GHGs.

Table 19.1 Summary of relevant legislation, policy and guidance for Greenhouse Gases

Relevant Policy or Guidance	Relevance to the Assessment
Legislation	
The United Nations Framework Convention on Climate Change (UNFCCC), 1992	The United Nations Framework Convention on Climate Change (UNFCCC) is an international treaty which established a global climate governance framework and solidified climate change as an agenda item for future agreements and policies. The United Nations Framework Convention on Climate Change facilitated intergovernmental climate change negotiations such as the Conference of the Parties (COP).
The Kyoto Protocol, 1997	Following the United Nations Framework Convention on Climate Change, the Kyoto Protocol committed industrialised countries to limit and reduce their GHG emissions in accordance with individual targets to reduce the rate and extent of global warming. Annex A of the Kyoto Protocol defined key GHGs as follows: • Carbon dioxide; • Methane; • Nitrous oxide; • Hydrofluorocarbons; • Perfluorocarbons; • Sulphur Hexafluoride; and • Nitrogen Trifluoride.
The Climate Change Act 2008, the Climate Change Act 2008 (2050 Target Amendment) Order 2019.	The Climate Change Act 2008 provides the legal basis for the UK's long-term response to tackling climate change. The 2050 Target Amendment Order introduced in 2019 revised the UK's target to net zero by 2050. The Act requires the UK Government to set legally binding carbon budgets to limit GHG emissions in a given

Relevant Policy or Guidance	Relevance to the Assessment
	time period. These budgets are set by the Climate Change Committee (CCC) in five-year periods, as illustrated below in **Table 19.2**.
Climate Change (Scotland) Act 2009, Climate Change (Emissions Reduction Targets) (Scotland) Act 2019.	Scotland has its own distinct climate change legislation, the Climate Change (Scotland) Act 2009, which was amended by the Climate Change (Emissions Reduction Targets) (Scotland) Act in 2019. Scotland has committed to achieving net zero by 2045, with a series of interim and annual targets that are more ambitious than the UK's targets. The interim targets have now been superseded by the targets set out in the Climate Change (Emissions Reduction Targets) (Scotland) 2024, as detailed below.
The Climate Change (Emissions Reduction Targets) (Scotland) 2024 Act	The Climate Change (Emissions Reduction Targets) (Scotland) Act 2024 modifies the Climate Change (Scotland) Act 2009 to introduce limits on the amount of GHGs emitted in Scotland over a five-year period. This replaces the requirements for annual targets outlined in the Climate Change (Emissions Reduction Targets) (Scotland) Act 2019. Scotland's five-yearly carbon budgets are illustrated below in **Table 19.3**. The contribution of the WDA infrastructure to Scotland's statutory commitments in respect of GHG emissions is assessed in this chapter.
The Climate Change (Scotland) Act 2009 (Scottish Carbon Budgets) Amendment Regulations 2025	The Climate Change (Scotland) Act 2009 (Scottish Carbon Budgets) Amendments Regulations 2025, legally set Scotland's five-yearly carbon budgets introduced by the Climate Change (Emissions Reduction Targets) (Scotland) 2024 Act. These carbon budgets are illustrated below in **Table 19.3.**
The Paris Agreement 2015	The Paris Agreement entered into force in 2016 and was ratified by the UK Government at COP 22. It is a legally binding international treaty with an overarching goal of 'holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels'. The Paris Agreement requires countries to submit national climate action plans known as Nationally Determined Contributions, with each successive Nationally Determined Contributions reflecting increasing decarbonisation ambitions.
Marine (Scotland) Act 2010	This act provides a framework for marine planning and conservation in Scottish waters, including the protection of marine habitats and ecosystems. Potential impacts to blue carbon stores within marine habitats are evaluated in **Appendix 19.2 Blue Carbon Assessment**.
Policy	
National Planning Framework 4 (Scottish Government, 2023)	The National Planning Framework 4 (NPF4) sets out Scotland's spatial principles, regional priorities, national developments and national planning policy. NPF4 presents Sustainable Places, Liveable Places and Productive Places to achieve national outcomes including benefits to the environment, communities, and health. NPF4 contains a notable focus on tackling both the climate and nature crises. **The key references are:** **Policy 1: Tackling the Climate and Nature Crises** – *"When considering all development proposals significant weight will be given to the global climate and nature crises…"* **Policy 2: Climate Mitigation and Adaptation** – *"Development proposals will be sited and designed to minimise lifecycle greenhouse gas emissions as far as possible…"* **Policy 11: Energy** – *"Development proposals for all forms of renewable, low-carbon and zero emissions technologies will be supported…"*

Relevant Policy or Guidance	Relevance to the Assessment
The Scottish Government National Marine Plan (Scottish Government, 2015)	The following general policies apply to this climate change assessment: **The key reference is:** **GEN 5: Natural heritage:** *"Marine planners and decision makers must act in the way best calculated to mitigate, and adapt to, climate change. Development and users of the marine environment should seek to address climate change through:* - ***Mitigation**: Marine planners and decision makers should seek to facilitate a transition to a low carbon economy. They should consider ways to reduce emissions of carbon and other greenhouse gases…* - ***Adaptation**: Marine planners and decision makers should be satisfied that developers and users have sufficient regard to the impacts of a changing climate and, where appropriate, provide effective adaptation to its predicted effects…"*
Sectoral Marine Plan for Offshore Wind Energy (Scottish Government, 2020a) and Draft Updated Sectoral Marine Plan for Offshore Wind Energy (Scottish Government, 2025b)	The Sectoral Marine Plan for Offshore Wind Energy (SMP-OWE) establishes a sector-specific plan focused on the development of offshore wind energy in Scotland, aligned with the overarching framework for the sustainable use of Scotland's marine environment outlined in the Scottish Marine Plan. The SMP-OWE also outlines requirements for plan options to be subject to the Strategic Environmental Assessment (SEA). The WDA is located in the Plan Option Area (POA), W1, as identified in the SMP-OWE. The Draft Updated SMP-OWE, published in 2025, presents the outcome of the SEA for all plan options including the W1 POA, which acknowledged the pressures from global GHG emissions and the impact of climate change. It evaluated the effects of GHG emissions resulting from the support of a diverse and decarbonised energy and concluded that developments in W1 could positively contribute to a decarbonised energy sector and help reduce emissions.
Scotland's Climate Change Plan (Scottish Government, 2020b) and Scotland's Draft Climate Change Plan – 2026-2040 (2025c)	The Scottish Government publishes Climate Change Plans to set out the pathway to achieving its GHG emissions reduction targets via the Climate Change (Scotland) Act 2009. The most recent version, the 2018-2032 update was published in December 2020 sets out the Scottish Government's approach to tackling the climate emergency which was declared in 2019. Scotland's draft Climate Change Plan for 2026-2040 is an updated proposal to the existing plan. It outlines the policies and measures the Scottish Government will implement to ensure its carbon budgets are met between 2026 and 2040.
The UK Net Zero Strategy 2021 and British Energy Security Strategy, 2022	The UK Net Zero Strategy and British Energy Security Strategy apply to Scotland and provide a national commitment to the provision of low-carbon, secure and affordable energy sources, including an ambition to deliver up to 50 Gigawatts (GW) of offshore wind capacity by 2030.
UK Climate Change Strategy 2021 – 2024 (UK Government, 2021a)	The latest UK Climate Change Strategy aids UK exporters and suppliers through the transition to net zero by increasing support to clean growth and climate adaptation, reducing GHG emissions and understanding and mitigating climate-related financial risks. The Strategy highlights the importance of transforming the financial system to boost innovation and transition away from high carbon sectors.
Argyll and Bute Local Development Plan 2 (Argyll and Bute Council, 2024)	The Argyll and Bute Local Development Plan 2 (LDP2) 2024 outlines the council's willingness to support renewable energy developments that are consistent with the principles of sustainable development and demonstrate no adverse effect on the environment. LDP2 also outlines the criteria that all wind turbine developments will be assessed against. **The key references are:** **Policy 4: Sustainable Development –** *"In preparing new development proposals, developers should seek to demonstrate the following sustainable*

Relevant Policy or Guidance	Relevance to the Assessment
	development principles, which the planning authority will also use in deciding whether or not to grant planning permission…" **Policy 6: Green and Blue Infrastructure –** *"Where appropriate new non householder developments shall adequately demonstrate how green and blue infrastructure has been integrated into the design of the proposal from the outset. In particular, but not limited to, proposals should demonstrate…"* **Policy 9: Sustainable Design –** *"Development proposals should demonstrate consideration of and where possible utilisation of: Renewable sources of energy; and sustainable design and construction methods in terms of embodied energy; conversion and re-use; and adaptability…"* **Policy 30: The Sustainable Growth of Renewables –** *"The Council will support renewable energy developments where these are consistent with the principles of sustainable development and it can be adequately demonstrated that there would be no unacceptable environmental effects, whether individual or cumulative, on local communities, natural and historic environments, landscape character and visual amenity, and that the proposals would be compatible with adjacent land use."* **Policy 55: Flooding –** *"Development on the functional flood plain (land with greater than 0.5% (1 in 200) probability of flooding in any year) will be considered contrary to the objectives of this plan, except in the limited circumstances set out in part c) of this policy. Development elsewhere will be subject to assessment as set out in parts a) and b) of this policy, as relevant…"* **Policy 56: Land Erosion –** *"Within land erosion risk areas, new development, other than the categories specified in (i) and (ii) below shall be resisted; exceptions may be made if the proposal successfully demonstrates that the level of risk is acceptable having regard to the nature of the development proposed, operational considerations and land erosion remedial measures…"*
Guidance	
Assessing Greenhouse Gas Emissions and Evaluating their Significance (Institute of Environmental Management and Assessment's (IEMA)[1], 2022)	The guidance document presents guidelines for undertaking GHG assessments, evaluating the significance of a development's GHG emissions in an EIA context, and an approach to mitigation.
PAS2080: Carbon Management in Buildings and Infrastructure (BSI, 2023)	The British Standards Institution (BSI) guidance document provides specifications for the management of whole-life carbon for built environment projects and best practice measures to enable further emission reductions.
The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (World Resource Institute and World Business Council for Sustainable Development, 2015)	The guidance document provides requirements for the preparation of GHG emissions inventories and the consideration of direct and indirect GHG emissions (Scope 1, 2 and 3 emissions).
Global Maritime Energy Efficiency Partnerships Project (GloMEEP): Port Emissions Toolkit (2018)	The guidance document provides a methodology for calculating vessel emissions during various operating modes, such as in transit and manoeuvring.

[1] Now the Institute of Sustainability and Environmental Professionals (ISEP)

Relevant Policy or Guidance	Relevance to the Assessment
The Offshore Wind Industry Product Carbon Footprinting Guidance (The Carbon Trust, 2024)	This guidance document provides specific guidelines for assessing the product-level footprint of an offshore wind development, considering different lifecycle modules of infrastructure developments and enabling a consistent GHG calculation approach within the industry. These defined lifecycle modules are used in the GHG assessment presented in **Section 19.7** and support the identification of emission "hotspots".

11. As discussed in **Table 19.1**, the UK has established Carbon Budgets, which provide a legally binding five-year limit for GHG emissions in the UK. There are currently six Carbon Budgets that have been placed into legislation and will run up to 2037 as outlined in **Table 19.2**. The UK is currently in the fourth carbon budget period. The CCC recommended the limit for the seventh Carbon Budget in May 2025, but at the time of writing this has not been legally adopted by the Government (Climate Change Committee, 2025a).

Table 19.2 UK carbon budgets (2008 to 2042)

Budget	Period	Carbon Budget Level (Mt CO_2e)	Reduction Below 1990 Levels	
			UK Targets	Achieved by the UK
1st Carbon Budget	2008 to 2012	3,018	25%	30%
2nd Carbon Budget	2013 to 2017	2,782	32%	38%
3rd Carbon Budget	2018 to 2022	2,544	38% by 2020	44%
4th Carbon Budget	2023 to 2027	1,950	52% by 2025	-
5th Carbon Budget	2028 to 2032	1,725	58% by 2030	-
6th Carbon Budget	2033 to 2037	965	78% by 2035	-
7th Carbon Budget	2038 to 2042	535	87% by 2040	-
Net Zero Target by 2050			**100%**	

12. The Scottish Carbon Budgets, which are enforced through the Climate Change (Scotland) Act 2009 (Scottish Carbon Budgets) Amendment Regulations 2025, are outlined in **Table 19.3**.

Table 19.3 Scottish carbon budget (2026 to 2045)

Budget	Period	Carbon Budget Level (Mt CO_2e)	Carbon budget (average % of Baseline)
1st Carbon Budget	2026 to 2030	175	43%
2nd Carbon Budget	2031 to 2035	126	31%
3rd Carbon Budget	2036 to 2040	81	20%
4th Carbon Budget	2041 to 2045	24	6%

19.3 CONSULTATION

13. Consultation undertaken to date for the WDA infrastructure relevant to climate change has been undertaken in line with the general process described in **Chapter 5 EIA Methodology**. Key consultation pertinent to this chapter is provided in **Table 19.4** below.

Table 19.4 Summary of consultation relevant to Greenhouse Gases

Consultee	Date/Engagement Activity	Stakeholder Comment	Applicant Response
Scoping Opinion			
MD-LOT	January 2025: MD-LOT Scoping Opinion	The Scottish Ministers are largely content with the Developer's approach in assessing Green House Gases ("GHG") and climate change effects within Section 19 of the Scoping Report, noting that the IEMA Environmental Impact Assessment Guide "Assessing Greenhouse Gas Emissions And Evaluating Their Significance" provides further insight on this matter. The Scottish Ministers have considered this together with the Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 and the requirement of the EIA Regulations to assess significant effects from the Proposed Development on climate. The Scottish Ministers highlight that the GHG assessment 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 NatureScot representation regarding climate change and carbon costs should be fully addressed by the Developer within the EIA Report.	The GHG assessment, provided in **Section 19.7**, presents a calculation of GHG emissions arising from the construction (including pre-construction activities), operation and decommissioning phases of the Project. Upstream emissions from the supply chain, particularly from activities which encompass 'embodied' carbon in materials as discussed in **Section 19.4.1**, have been accounted for in the assessment. The benefits of the Project, in terms of avoided emissions from other forms of electricity generation, have also been calculated.
MD-LOT	January 2025: MD-LOT Scoping Opinion	The Scottish Ministers direct the Developer to the NatureScot representation in relation to blue carbon assessment. The Scottish Ministers advise that consideration should be given to impacts on blue carbon as a result of the Proposed Development as well as an expanded assessment for benthic ecology focusing on potential impacts on marine sediments and coastal habitats.	The Blue Carbon assessment presented in **Appendix 19.2 Blue Carbon Assessment** considers potential impacts on blue carbon habitats and sediments from activities within the WDA.
NatureScot	January 2025: MD-LOT Scoping Opinion	The impact of climate change effects should be considered, both in futureproofing the proposal design as well as how certain climate stressors may work in combination with potential effects from the proposed wind farm. The EIA Report should also consider the carbon cost of the wind farm (including supply chain) and to what extent this is offset through the production of green energy. We note the intention to provide a climate change assessment as part of the WDA EIA Report, with further details provided within Chapter 19 of the Scoping Report, which is welcomed.	The GHG assessment, provided in **Section 19.7**, presents the calculated GHG emissions during the construction (including pre-construction activities), operation and decommissioning phases of the Project. Upstream emissions from the supply chain, particularly from activities which encompass 'embodied' carbon in materials as discussed in **Section 19.4.1**, have been accounted for in the assessment. The benefits of the Project, in terms of avoiding emissions from

Consultee	Date/Engagement Activity	Stakeholder Comment	Applicant Response
			other forms of electricity generation, have also been calculated. The potential effects of climate change to the WDA infrastructure are considered in **Chapter 20 Climate Change Risk Assessment.**
NatureScot	January 2025: MD-LOT Scoping Opinion	In addition to the climate change assessment outlined in Chapter 19, we recommend that consideration is given to impacts on blue carbon and whether or not an assessment can be undertaken. This should expand on the information and assessment conducted for benthic ecology to focus on the potential impacts of the proposal on marine sediments and coastal habitats.	The Blue Carbon assessment presented in **Appendix 19.2 Blue Carbon Assessment** considers potential impacts on blue carbon habitats and sediments from activities within the WDA.

19.4 SCOPE OF THE ASSESSMENT

19.4.1 Study Area

14. All GHG emissions will affect the same receptor, the global atmosphere, as opposed to directly affecting any specific local receptor. Emissions which are released or avoided due to the WDA infrastructure will have the same effect on atmospheric GHG concentrations and its net effect on climate regardless of where they occur. Accordingly, the Study Area of the GHG assessment is not geographically defined, in accordance with IEMA[1] guidance (IEMA, 2022).

15. The scope of the WDA GHG assessment includes quantifying direct and indirect GHG emissions arising over its full lifecycle: construction (including pre-construction activities) and 'upstream' emissions associated with embodied carbon from materials used to construct the WDA infrastructure), O&M, and decommissioning. As the Project will supply renewable energy to the UK's NETS, the GHG assessment also accounts for emissions savings from the displacement of electricity which would have otherwise been generated from an alternative source. Downstream emissions beyond the provision of the UK's NETS are outside of the system boundary for the assessment, as there are no prescribed end uses of electricity generated by the WDA infrastructure. Therefore, emissions associated with activities from the consumption of electricity generated by the WDA infrastructure have not been considered in the assessment.

16. The emission sources across each phase have been categorised in accordance with the PAS 2080:2023 life cycle modules (BSI, 2023) in **Section 19.5.2.2.1**.

17. The key components of the WDA, as set out in **Chapter 3 Project Description**, are summarised below:

- WTGs and associated fixed foundations and scour protection;
- OSPs and associated fixed foundations and scour protection;
- IACs and associated cable protection;
- OSP link cables and associated cable protection;
- The portion of the offshore export cable(s) located within the WDA, and associated cable protection.

19.4.1.1 Whole Project Assessment

18. As outlined in **Section 19.1**, the WDA, Offshore ECC and OnTDA together (referred to in this chapter as the Project) are required to supply electricity to the UK's NETS. Therefore, to fully assess the potential impacts, emissions arising from activities associated with the Project were considered in a 'whole Project' GHG assessment. The Offshore ECC consists of the offshore export cable(s) from the WDA to landfall, while the key components of the OnTDA, as set out in **Chapter 3 Project Description**, are detailed below:

- Landfall(s);
- Onshore export cable(s);
- Transition joint bays;
- Telecom/Supervisory Control and Data Acquisition (SCADA) infrastructure including vehicular access;
- Joint bays;
- Links boxes; and
- Temporary construction compounds.

19. As detailed information on the Offshore ECC and OnTDA are not available at this stage, only indicative information and assumptions are used in the whole Project GHG assessment. The

assumptions used in the whole Project GHG assessment are outlined in **Section 19.5.1.2** and **Appendix 19.1 Greenhouse Gas Assessment Methodology**.

19.4.2 Realistic Worst-Case Scenarios

20. The realistic worst-case scenarios for the GHG assessment are summarised in **Table 19.5** below. These scenarios take into account the parameters and activities during the construction (including pre-construction activities), O&M, and decommissioning phases of the WDA infrastructure that are expected to generate the highest level of GHG emissions, while remaining feasible based on the available information at this stage of the design. These parameters are based on the design of the WDA infrastructure as described in **Chapter 3 Project Description**.

Table 19.5 Realistic worst-case scenarios for impacts on climate change

Impact	Realistic Worst-Case Scenario	Rationale
Pre-construction		
Indicative pre-construction programme	Pre-construction duration: • Site investigation survey (Geotechnical and Geophysical) – approximately 360 days • Support vessels – approximately 360 days • Unexploded Ordnance (UXO) clearance – approximately 180 days • Boulder clearance - approximately 180 days • Pre-Lay Grapnel Run (PLGR) – 180 days	Pre-construction activity periods are based on the maximum duration of the pre-construction vessel on site.
Pre-construction vessel movements	Vessel movements during pre-construction for the WDA: • Site investigation survey vessel – 40 vessel return trips; • Support vessels – 40 vessel return trips; • UXO clearance survey vessels – 20 vessel return trips; • Boulder clearance vessels - 20 vessel return trips; • PLGR vessels – 20 vessel return trip	Based on the maximum number of vessels required for the pre-construction activities.
Construction		
Indicative construction programme	• 5-year offshore construction programme WDA infrastructure construction duration is based on the maximum duration of vessels on site: • Foundation installation – approximately 274.5 days • WTG installation – approximately 137.25 days • OSP installation – approximately 137.25 days • Cable installation – approximately 274.5 days	An indicative construction duration is provided at this stage considering that the construction timeline is influenced by various factors, including weather conditions. For the foundation installation, it is assumed that the construction vessels will be on-site from April to September (inclusive) for a period of two years, accounting for a 25% reduction in time due to weather-related downtime. Similarly, the installation of the WTGs and OSPs is expected to have a duration comparable to the foundation installation but will take place over just one year, from April to September.
Infrastructure	Installation of: • 144 WTG foundations (suction bucket) • 144 WTGs with a nominal output of 15 MW • Scour protection volume per WTG – 57,256 m^3	For the WTGs, the worst-case scenario in terms of embodied carbon is the highest number of WTGs (144) as detailed in Section 1.6 of **Chapter 3 Project Description**, in combination with the suction bucket foundation. This is because suction bucket foundations require a larger

Impact	Realistic Worst-Case Scenario	Rationale
	• Total WTG (suction bucket foundation) scour protection volume – 8,244,796 m^3 • 2 OSPs • 2 OSP foundations (gravity based structure) • Total OSP foundation scour protection volume – 360,000 m^3 • Total length of IACs – 572 km • Total IAC scour protection volume – 2,312,700 m^3 • Total length of OSP link cables – 272 km • Total OSP link cable scour protection volume – 557,400 m^3 • Total length of offshore export cable within the WDA – 200 km • Total offshore export cable (within the WDA) scour protection volume – 195,000 m^3	volume of scour protection, compared with other foundation options, which significantly increases the embodied carbon in materials. For the OSPs, the worst-case scenario is the gravity-based structure foundation type as it has the highest material volumes compared to the other foundation types.
Construction vessel movements	Vessel movements during construction of the WDA infrastructure: • 5,699 vessel return trips; and • 117 vessels	Based on the maximum number of vessels required. **Appendix 19.1 Greenhouse Gas Assessment Methodology** presents additional detail on the different types of vessels associated with each construction activity.
Operation and Maintenance		
Indicative O&M programme	• Operational life – 35 years O&M vessel movements: • 423 trips per year; and • 13 vessels O&M of helicopter movements: • 576 trips per year • 1 helicopter Spare parts (information derived from literature)	Based on the maximum number of vessel and helicopter movements. Spare part information is derived from literature, as detailed design information is not yet available, but the literature numbers are suitably robust. This assessment includes the use of helicopters to reflect a conservative scenario, ensuring potential impacts are fully understood should their use be required.
Decommissioning		
GHG emissions	A decommissioning programme will be developed at a later stage. It is recognised that legislation and industry best practices change over time.	Specific details and activity data surrounding decommissioning activities are not known at this stage, hence proxy data have been used in the

Impact	Realistic Worst-Case Scenario	Rationale
	However, decommissioning activities will be carried out in accordance with relevant legislation, and existing good industry practice, as outlined in Section 3.6.15 of **Chapter 3 Project Description.** For the GHG assessment, a worst-case scenario assumes full removal of all above-seabed infrastructure (excluding scour protection and cable protection) and the removal of all offshore cables. The assessment assumes that emissions from marine vessels during decommissioning, are equivalent to those from constructing the WDA infrastructure. It is anticipated that end-of-life capabilities will have advanced by the time the WDA infrastructure is decommissioned. Current landfill assumptions therefore reflect present-day limitations, while recognising that recycling and repurposing options are expected to improve significantly by the time decommissioning occurs. On this basis, the GHG assessment assumes that recovered infrastructure components will be reused and recycled where practicable. However, given existing constraints in recycling and repurposing certain materials, 10% of the recovered above-ground components and 5% of the recovered cables are currently assessed as being sent to landfill during the decommissioning phase. The basis for these proportions is presented in Section 1.2.5 of **Appendix 19.1 Greenhouse Gas Assessment Methodology**. The detail and scope of the decommissioning works will be determined by the relevant legislation and guidance at the time of decommissioning and will be agreed upon with the regulator.	assessment. The assumption that emissions from marine vessels during decommissioning are equivalent to those in construction is a worst case approach, as it is anticipated that the marine sector will decarbonise towards the UK's 2050 Net Zero target and beyond. Recycling and repurposing rates for materials and infrastructure have been obtained from existing literature. Additional details are provided in **Appendix 19.1 Greenhouse Gas Assessment Methodology**.

19.4.3 Embedded Mitigation

21. This section outlines the embedded mitigation relevant to the climate change assessment (as shown in **Table 19.6** below).

Table 19.6 Embedded mitigation measures relevant to the GHG Assessment

Mitigation ID	Parameter	Embedded Mitigation Measure(s)	Mitigation Type	Securing Mechanism
M-52	Removal of Gravity Base Structure (GBS) foundations for WTGs from Project design envelope	Since scoping, and following site-specific engineering development and design refinement, GBS foundations for WTGs have been removed from the design envelope which results in a large reduction in the worst-case seabed preparation requirements and seabed footprint of the WDA infrastructure. This reduces embodied emissions.	Primary	Secured through Project design specifications in the generation marine licence.

22. The Project will continue to explore GHG emission reduction opportunities throughout its life cycle, with potential measures investigated at each Project stage. Measures that are technically feasible and commercially viable will be considered and implemented where appropriate. These may include selecting products and services with lower embodied emissions, optimising logistics and operations for efficiency, and adopting technologies that support emissions reductions. The Outline Carbon Management Plan presented in **Appendix 14 Outline Carbon Management Plan**, outlines potential areas where mitigation measures could be established for the WDA.

19.5 ASSESSMENT METHODOLOGY

19.5.1 Existing Data Sources

23. **Table 19.7** sets out the information and data sources that have been used to inform this chapter.

Table 19.7 Summary of key datasets and information sources

Dataset	Description	Citation
GHG Assessment		
Department for Energy Security and Net Zero's (DESNZ) Greenhouse Gas Reporting Conversion Factors	Emission factors suitable for UK-based operations for various activities, such as fuel consumption	DESNZ, 2025a
DESNZ's Digest of UK Energy Statistics (DUKES)	Up-to-date statistics for the UK power sector, including the operational GHG intensity of each fuel or generation source and load factors for renewable electricity generation.	DESNZ, 2025b, 2025c
UK Carbon Budgets	National carbon budgets are used to contextualise the WDA infrastructure GHG emissions.	UK Government, 2009, 2011, 2016, 2021b
CCC's The Seventh Carbon Budget	Proposed UK Seventh Carbon Budget	CCC, 2025a
CCC's Scotland Carbon Budgets	The recommended Scotland's carbon budgets are used to contextualise the WDA infrastructure GHG emissions	CCC, 2025b
CCC's Reducing the UK's Carbon Footprint Report	Estimated lifecycle carbon intensity of various forms of electricity generation.	CCC, 2013
Inventory of Carbon and Energy (ICE) Database v4.0	Emission factors for embodied carbon in materials used during construction and replacement or repair activities.	Circular Ecology and University of Bath, 2024
Dolan and Heath, Life Cycle Greenhouse Gas Emissions of Utility Scale Wind Power	GHG emissions benchmarks for offshore wind projects to inform assumptions used in the GHG assessment regarding the likely contribution of emission sources to the WDA infrastructure GHG footprint.	Dolan and Heath, 2012
Thompson and Harrison, Life Cycle Costs and Carbon Emissions of Offshore Wind Power		Thompson and Harrison, 2015
DESNZ's UK Territorial Greenhouse Gas Emissions National Statistics	Estimates of annual GHG emissions from activities occurring within the UK's borders.	DESNZ, 2025d
Scottish Greenhouse Gas and Energy Statistics	Statistical publication relating to energy and GHG emissions in Scotland.	Scottish Government, 2025b

19.5.1.1 Site-specific Survey Data

24. No site-specific surveys have been undertaken for the GHG assessment. This is because receptor information and data related to these assessments can be readily collected through desktop study, consultation with relevant stakeholders, and suitable data is currently available throughout the west Scotland region.

19.5.1.2 Assumptions and Limitations

25. A number of assumptions are made in the GHG assessment, as set out in **Table 19.8**. Further details on the methodology adopted to quantify GHG emissions from the WDA infrastructure and the Project are presented in **Appendix 19.1 Greenhouse Gas Assessment Methodology**.

Table 19.8 Assumptions and limitations of the GHG Assessment

Assumption / Limitation	Further Detail / Discussion
Availability and quality of activity data used for GHG emissions calculations	Due to the maturity of the design at the time of the assessment, details regarding the activities that will take place during the construction, O&M, and decommissioning phases are not fully known. Where information gaps exist, conservative assumptions are made based on preliminary design information or proxy information from previous projects, professional judgment and/or published literature. The design process is ongoing and will continue between the submission of the application and during detailed design post-consent.
Lifecycle Assessment (LCA)	Although considered appropriate and proportionate for the purposes of the MachairWind WDA EIAR, this GHG assessment should not be taken as a comprehensive, detailed LCA of the WDA infrastructure or the Project. It is not possible to fully define the supply chain, detailed design, material and technology specifications for the WDA infrastructure and undertake the relevant detailed assessment at this stage. Therefore, assumptions and simplifications to the GHG emissions calculation methodology are made in certain areas.
Lack of emission factors for future year activities, such as fuel consumption and material extraction	The most recent and available emissions factors are used in the assessment to provide a precautionary assessment, as the emissions factors may change over time with the availability of new data and updated technology.
The construction and O&M ports are unknown at this stage, with multiple ports being considered	To adopt a conservative approach in the GHG assessment, a port with an assumed distance of 400 km to the WDA is considered. While several ports are under consideration, as outlined in Section 1.6 of the **Chapter 3 Project Description**, the selection of a port at a distance greater than 400 km is unlikely.
The location of the heliport to be used during the O&M of the WDA is unknown	To adopt a conservative approach in the GHG assessment, a heliport/airport with an assumed distance of 140 km to WDA is considered. While the heliport/airport is unknown at this stage, the assumption is based on a representative airport location within the central belt of Scotland.
The anticipated electricity generation capacity of the WDA is unknown at this stage	To address this uncertainty, the average capacity factor from the last five years of operational windfarms from the Digest of UK Energy Statistics (DUKES) has been assumed for the WDA infrastructure (DESNZ, 2025c).
Uncertainty regarding O&M emissions due to anticipated decarbonisation	Many sectors are anticipated to decarbonise over the next 35 years, and during the O&M phase, it is likely that the emissions intensity of producing materials and the movement of marine vessels would be less than the

Assumption / Limitation	Further Detail / Discussion
	present day. Emission factors used in the assessment are representative of present-day activities, therefore GHG emissions predicted in this assessment for the O&M phase of the WDA infrastructure are likely to be an overestimation.
Construction vessel activities at the WDA	It is assumed that vessels are operational 24 hours per day at the WDA during the construction phase. Further details on the calculation of emissions associated with vessels are shown in Section 1.2.2 of **Appendix 19.1 Greenhouse Gas Assessment Methodology.**
O&M SF_6 emissions	In the absence of actual data, it is assumed based on proxy data that each WTG contains 110 kg of SF_6 in its switchgear with a leakage rate of 0.5%.
Decommissioning emissions	Emissions from decommissioning activities are based on proxy data in the absence of a detailed inventory of activities during this phase, as discussed in **Table 19.5**.
Electricity displaced by the Project would otherwise be generated using natural gas with carbon capture	This assumption is used to determine the Project's avoided emissions from the supply of renewable energy to the UK's NETS. This aligns with national energy policies, which are further explained in **Section 19.6.2**.
The Offshore ECC construction and, O&M vessel use	The use of vessels considered in the assessment for the construction and O&M phases of the WDA infrastructure is considered to be inclusive of the Offshore ECC requirements.

19.5.2 Impact Assessment Methodology

26. **Chapter 5 EIA Methodology** provides a summary of the general impact assessment methodology applied in the MachairWind EIA. For the GHG assessment, a topic-specific assessment is undertaken following the methodology and approach which is aligned with best practice guidance such as 'Assessing Greenhouse Gas Emission and Evaluating their Significance' (IEMA, 2022).

19.5.2.1 Scope

27. **Table 19.9** sets out the impacts that have been scoped into and out of the WDA EIA, in line with the Scoping Opinion.

Table 19.9 Potential impacts scoped in and out of the EIA for climate change

Potential Impact	Construction		O&M		Decommissioning	
	WDA Scoping Report	WDA Scoping Opinion	WDA Scoping Report	WDA Scoping Opinion	WDA Scoping Report	WDA Scoping Opinion
Whole lifecycle GHG impacts	✓	✓	✓	✓	✓	✓

19.5.2.2 GHG Assessment

28. In this assessment, the term 'GHG' or 'carbon' encompasses CO_2 and the six other gases as referenced in the Kyoto Protocol (CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3). The results in the assessment are expressed in carbon dioxide equivalent (CO_2e), which recognises that different gases have notably different global warming potentials (GWP)[2].

29. GHG emissions arising from the construction, O&M, and decommissioning phases of the WDA infrastructure have been assessed with the Study Area outlined in **Section 19.4.1**. GHG emissions are quantified using a standard calculation-based methodology, which involves multiplying activity data gathered for the WDA infrastructure with the relevant emission factors, and where applicable, calorific and GWP factors. Where full details of activity data were not available, industry benchmarks and assumptions using professional judgement have been utilised.

30. GHG emissions were calculated from the following source groups:

- Embodied carbon in materials;
- Marine vessels;
- Helicopters;
- Fugitive emissions; and
- Decommissioning.

31. To support the determination of the significance of effect of GHG emissions associated with the WDA (as discussed in **Section 19.7**), the following parameters are calculated to help contextualise the associated GHGs emitted:

- GHG emissions avoided by the WDA infrastructure:
  - This provides the avoided GHG emissions as a result of the WDA infrastructure, over the O&M phase.
- Comparison to the UK and Scotland's recommended Carbon Budgets:
  - The estimated proportion of GHG emissions arising from the WDA infrastructure relative to the UK and Scotland's recommended Carbon Budgets, calculated over the construction and O&M phases, where applicable.

32. In addition, to determine the significance of the Project, the following parameters are calculated relative to GHG emissions emitted in the whole Project GHG assessment:

- Overall GHG intensity of the Project:
  - The amount of GHG emissions released per unit of electricity generated, expressed as kg of CO_2e per MWh.

19.5.2.2.1 GHG Emissions Calculation

33. To account for all the relevant emission sources within the Study Area for the WDA infrastructure, emission sources have been categorised in accordance with the PAS 2080:2023 life cycle modules (BSI, 2023). PAS 2080:2023 is a specification for whole-life carbon management when delivering infrastructure projects and aligns with the approach advocated in The Carbon Trust's guidance (2024).

[2] Global Warming Potential (GWP) of a GHG is a measure of how much heat is trapped by a certain amount of gas in the atmosphere relative to carbon dioxide.

34. GHG emissions sources arising from the WDA infrastructure have been categorised by lifecycle module, and divided by source type within each module, as detailed in **Table 19.10**.

Table 19.10 GHG emissions sources considered in the GHG Assessment

Project Phase	Lifecycle Module	Source and detail
Pre-construction (included as part of the construction phase emissions total)	A0 – pre-construction surveys and site preparation works	Fuel and electricity consumption for pre-construction surveys and activities, including site preparation works (e.g., vehicles and vessels).
Construction	A1 – Material supply, A2 – Material transport, A3 – Manufacturing energy	Embodied emissions within materials used to construct the WDA infrastructure comprise GHG emissions released throughout the supply chain (i.e., WTG, offshore export cable(s)). This includes the extraction of raw materials, transport, manufacturing and assembly.
	A4 – Transportation to / from site	Fuel consumption in marine vessels travelling to / from their origin location to the marshalling port(s) for the construction phase. Fuel consumption in helicopters used during construction of the WDA infrastructure.
	A5 – Construction	Fuel consumption in vessels undertaking construction activities for the WDA infrastructure.
O&M	B1 – Use	Fugitive emission (i.e., sulphur hexafluoride (SF_6)) leakages) from electrical equipment.
	B2 – Maintenance, B3 – Repair, B4 – Replacement	Fuel consumption in marine vessels used during the O&M phase of the WDA infrastructure. Fuel consumption in helicopters used during the O&M phase of the WDA infrastructure. Embodied carbon in materials used for spare parts during the O&M phase of the WDA infrastructure.
Decommissioning	C1 – Deconstruction and demolition, C2 – Transport to / from site, C3 – Waste processing / recovery, C4 – Disposal.	Fuel consumption in marine vessels, End-of-life emissions from disposal of materials used in the WDA infrastructure.
Benefits and loads beyond the Project boundary	D2 – Avoided emissions	Avoided emissions from the provision of renewable energy by the WDA infrastructure to the UK's NETS. This is calculated to estimate the level of avoided emissions during the O&M phasee of the WDA infrastructure in a 'Do Nothing' scenario, which assumes that the WDA infrastructure is not constructed.

35. The following lifecycle modules from the PAS 2080:2023 specifications were not considered in the assessment:

- B5 – 'Refurbishment' - the WDA infrastructure is unlikely to undergo refurbishment during its operational lifetime. Should repowering or lifetime extension options be considered, this would be subject to a separate consent;
- B6 – 'Operational energy use' - energy requirements of the WDA infrastructure during the O&M phase are likely to be minimal (e.g., temporary generators for WTG startup) and are assumed to be offset by the electricity that is generated;
- B7 – 'Operational water use' – there is anticipated to be minimal operational water consumption by the WDA infrastructure;
- B8 – 'Other Operational Emissions' – not applicable to the WDA infrastructure; and
- C5 – 'Relandscaping' not applicable to the WDA infrastructure; and
- D1 – 'Reuse, recycling, energy recovery' – outside the boundary of the WDA infrastructure and uncertainty associated with the determination of associated emissions.

36. The approach to calculating the GHG emissions arising from the WDA infrastructure for each of these source groups is detailed in **Appendix 19.1 Greenhouse Gas Assessment Methodology**.

37. Avoided emissions (category D2) have been estimated for the O&M phase only, as the emission factors used for the 'Do Nothing' scenario (see **Section 19.6.2**) is representative of operational emissions (as opposed to lifecycle values which include upstream activities).

38. As outlined in **Table 19.8**, the methodology for the assessment in this chapter is deemed suitable for an impact assessment and aligns with the approach outlined in IEMA[1] guidance, Assessing Greenhouse Gas Emissions and Evaluating their Significance (IEMA, 2022), but does not form a complete LCA for the WDA infrastructure. The principles of other guidance documents such as Carbon Trust's Offshore Wind Industry Product Carbon Footprinting Guidance (Carbon Trust, 2024) and PAS 2080:2023 have been used to estimate emissions arising from each source group, but certain aspects of the methodology, including the adoption of realistic worst case scenarios and other conservative assumptions (**Section 19.4.2**) are aligned with the impact assessment process rather than an LCA.

19.5.2.3 Definitions of Sensitivity and Magnitude

19.5.2.3.1 Sensitivity

39. The receptor for the GHG assessment is the global atmosphere. As such, it is affected by all global sources of GHGs and is therefore considered to be of high sensitivity to additional emissions, given the cumulative contribution of all GHG emissions and their widespread impact (IEMA, 2022).

19.5.2.3.2 Magnitude

40. The magnitude of impact is not defined, as the effect significance for the GHG assessment is not determined by the magnitude of GHG emissions alone (IEMA, 2022). However, GHG emissions during the construction, O&M, and decommissioning phases have been calculated as part of the assessment, by individual phases and combined over the whole lifecycle.

41. The impact of GHG emissions is, by nature, global and long-term, with low reversibility, owing to the long atmospheric lifetime of GHGs and their prolonged effect on the climate system.

19.5.2.4 Effect Significance

42. The IEMA[1] guidance (IEMA, 2022) recognises "when evaluating significance, all new GHG emissions contribute to a negative environmental impact; however, some Projects will replace existing development or baseline activity that has a higher GHG profile. The significance of a project's emissions should therefore be based on its net impact over its lifetime, which may be positive, negative or negligible".

43. The IEMA[1] guidance (IEMA, 2022) recommends that significance criteria align with the Paris Agreement, the UK's Carbon Budgets and net zero commitments: *"the crux of significance is not whether a project emits GHG emissions, nor even the magnitude of GHG emissions alone, but whether it contributes to reducing GHG emissions relative to a comparable baseline consistent with a trajectory towards net zero by 2050"*.

44. The IEMA[1] guidance (IEMA, 2022) provides significance descriptions to assist assessments of GHG emissions specifically in the EIA context. Section VI of the guidance describes five distinct levels of significance which are not solely based on whether a project emits GHG emissions alone, but how the project makes a relative contribution towards achieving a decarbonisation trajectory towards net zero. These are presented below in **Table 19.11**.

Table 19.11 Effect significance criteria for the GHG Assessment

Significance	Definition
Major adverse	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 Scotland and the UK's trajectory towards net zero.
Moderate adverse	The project's GHG impacts are partially mitigated and may partially meet the applicable existing and emerging policy requirements but would 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 Scotland and the UK's trajectory towards net zero.
Minor adverse	The project's GHG impacts would 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 Scotland and the UK's trajectory towards net zero.
Negligible	The project's GHG impacts would 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 Scotland and the UK's targets of 2045 and 2050, respectively. 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	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.

45. The effect significance of GHG emissions associated with the WDA infrastructure is first evaluated for each phase of the WDA infrastructure: construction (including pre-construction activities), O&M and decommissioning.

46. The pre-construction phase will begin before the construction phase and will include survey works such as geotechnical and geophysical surveys and seabed preparation activities. For the construction phase, the earliest anticipated start date is the second half of 2030. Therefore, the

magnitude of emissions is compared to the UK's fifth and sixth Carbon Budget (2028 to 2032 and 2033 to 2037, respectively), and Scotland's first and second recommended Carbon Budget (2026 to 2030 and 2031 to 2035, respectively). Significance is then determined by determining whether the WDA would affect the UK's and Scotland's ability to meet their future carbon budgets and, by proxy, the emission reduction needed to achieve their international climate commitments and their long-term net zero targets.

47. For the O&M and decommissioning phases, the WDA infrastructure operational lifetime extends beyond the latest year the UK and Scotland's recommended Carbon Budgets currently extend to, and 2050, the year which the UK commits to achieving net zero. Therefore, the effect significance for these phases is determined by considering the WDA infrastructure effect on the UK's and Scotland's ability to achieve and maintain their net zero status in the long term. The O&M phase is expected to commence in second half of 2035 therefore the first eight years of the WDA infrastructure O&M phase aligns with the UK's sixth and seventh Carbon Budgets (2033 to 2037 and 2038 to 2042, respectively), and the first eleven years aligns with Scotland's second, third and fourth recommended Carbon Budgets (2031 to 2035, 2036 to 2040 and 2041 to 2045, respectively). GHG emissions over these budget periods have also been compared to provide further context.

48. As discussed in **Section 19.6.2**, the level of avoided emissions when compared to a 'Do Nothing' scenario during the O&M phase also forms part of the significance criteria for this stage.

49. In addition to evaluating effect significance by each phase of the WDA infrastructure, overall effect significance is also determined by estimating the whole Project's lifecycle emissions. The GHG intensity of electricity produced across the lifecycle of the whole Project compared to other forms of generation has then been estimated to determine the overall effect significance.

50. Likely significant effects identified in the GHG assessment as major/moderate adverse or beneficial are deemed to be significant in EIA terms. Whilst only one level of significance criteria is provided where there is a net reduction in emissions, further context on the avoided emissions and the associated carbon benefits is provided in the assessment.

19.5.3 Cumulative Effects Assessment Methodology

51. The cumulative effects assessment (CEA) considers the impacts arising from the activities and infrastructure associated with the WDA infrastructure as well as cumulatively with other relevant plans, project and activities. The general approach to CEA for climate change includes identifying potential cumulative effects, identifying a short list of plans and projects for consideration and evaluation the significance of cumulative effects. **Chapter 5 EIA Methodology** provides further details on the general approach to CEA.

52. All development which emits, avoids or sequesters GHG emissions affects global atmospheric concentrations irrespective of their location. Therefore, the effects of GHG emissions are global and cumulative by nature. This is considered in defining the receptor sensitivity of the global atmosphere as 'high'. The inclusion of the whole Project assessment ensures that all emission activities related to the Project are accounted for. The IEMA[1] guidance (IEMA, 2022) states that the cumulative effects of GHG emissions from other projects should therefore not be individually assessed, as there is no basis for selecting which projects to assess cumulatively over any other. Therefore, cumulative effects in relation to GHG emissions from other projects or developments are not assessed as part of a CEA. The topic-specific approach differs from the general approach to CEA presented in **Chapter 5 EIA Methodology**.

19.5.4 Transboundary Effects Assessment Methodology

53. The transboundary effect assessment considers the potential for effects to occur as a result of the WDA infrastructure on receptors within one European Economic Area (EEA) state's[3] territory affects the environment of another EEA state(s). As noted above for cumulative effects, the receptor for the GHG assessment is the global atmosphere, and therefore, GHG emissions have an indirect transboundary effect. As the GHG emissions are assessed in the context of the UK and Scotland Carbon Budgets, long-term net zero targets and international climate agreements, the WDA infrastructure effects on the climate commitments of other EEA Member States are inherently considered in the GHG assessment. In addition, it is likely that some of the emission activities considered in the assessment, such as embodied carbon in materials, and the movement of marine vessels will take place outside of the UK's territorial boundary. Emission values have however been contextualised in relation to the UK and Scotland's emission reduction targets, and therefore the assessment is inherently transboundary in nature.

19.6 EXISTING ENVIRONMENT

19.6.1 Existing Baseline

54. There is currently no development or significant activity taking place within the WDA that is resulting in GHG emissions.

19.6.2 Predicted Future Baseline

55. To help determine the significance and contextualise the outcomes of the GHG assessment, consideration of a baseline or 'Do Nothing' scenario, which assumes that the WDA infrastructure is not constructed, is required.

56. The UK's NETS consists of energy generated from a number of different sources, including gas, nuclear, onshore and offshore wind, bioenergy, solar and hydroelectric. However, it is recognised that the growth of renewable energy, coupled with a transition away from electricity generated using fossil fuels, is key to both Scotland's and the UK's Energy Strategy, net-zero targets and delivering renewable electricity. Therefore, a 'Do Nothing' scenario is established for the GHG assessment, which presents a different future baseline environment based on the energy and climate policies adopted.

57. To evaluate the impact of the WDA infrastructure, it is assumed that the electricity produced displaces electricity that would be generated from 'natural gas' sources, as this is the most common form of energy source in new fossil fuel combustion plants (DESNZ, 2025e). This scenario is considered to be representative of the UK's transition from fossil fuel-based generation sources to renewables. It is however recognised that all new combustion power stations (at or above 300 MW) need to be constructed Carbon Capture Ready (CCR). Therefore, it was assumed that the natural gas generating sources were equipped with Carbon Capture and Storage (CCS).

58. The adoption of this scenario is in line with the UK energy policy, which requires a step change in the decarbonisation of the UK's energy system, and to *"drastically increase the energy supplied from low carbon sources*" to replace fossil fuel generation (DESNZ, 2024a).

[3] Following the exit of the UK from the EU in December 2020, the UK is no longer an EEA state. However, for the purposes of assessing potential transboundary effects, the approach outlined above has been followed for the WDA.

19.6.2.1 Electricity Produced by the WDA Infrastructure

59. The anticipated electricity produced by the WDA infrastructure, both on an annual basis and over its 35-year lifetime, has been quantified in accordance with the approach outlined in the Carbon Trust's offshore wind guidance (The Carbon Trust, 2024). This method is similar to the approach advocated by RenewableUK (2024) for offshore windfarms. **Equation 1** and **Equation 2** provide the methodology for quantifying the net electricity generated by the WDA infrastructure over its lifetime and deliver to the UK's NETS.

Equation 1

$$Energy\ produced\ per\ year\ (MWh) = Installed\ Capacity\ (MW)\ \times Operational\ hours\ per\ year\ \times\ Capcity\ Factor\ (\%) \times (1 - Electrical\ Losses\ in\ the\ System\ Boundary\ (\%))$$

Equation 2

$$Energy\ produced\ over\ the\ Project's\ lifetime\ (MWh) = Electricity\ produced\ per\ year\ (MWh)\ x\ 35\ years\ (lifetime)$$

60. For the purposes of the assessment, the capacity factor for the WDA infrastructure is anticipated to be 40.2%. This is based on the average load factor from operational offshore windfarms over the last five years (DESNZ, 2025b), which provides the predicted capacity factor for new build offshore windfarms (delivery years 2026-2031).

61. The WDA infrastructure is anticipated to have an availability factor of, 97% meaning the potential operational hours per year are 8,497. This is based on a typical year of 8,760 hours (365 days), with the availability factor applied to reflect the expected downtime. In addition, the electrical losses are estimated to be approximately 4%.

62. In accordance with **Equation 1** and **Equation 2**, the total energy generated by the WDA infrastructure is predicted to be:

$$Electricty\ produced\ per\ year:$$

$$2{,}000\ MW\ \times 8{,}497\ hours\ \times 40.2\%\ \times (1 - 0.04) = 6{,}564{,}850\ MWh$$

$$Electricity\ produced\ over\ the\ lifetime\ of\ the\ Project: 6{,}564{,}850\ MWh \times 35\ years = 229{,}769{,}756\ MWh$$

19.6.2.2 GHG Emissions from the 'Do Nothing' Scenario

63. GHG emissions from the generation of electricity in the 'Do Nothing' scenario are presented in **Table 19.2**. This has been quantified by multiplying the proportion of anticipated electricity generated by the WDA infrastructure, detailed in **Section 19.6.2.1,** by the estimated GHG emissions that would be released from gas supplied electricity. This emission factor was derived from the Net Zero Teesside project, as this reflects the emissions intensity of a recently consented gas-fired power plant (20.7 tonnes CO_2e per GWh electricity) (Net Zero Teesside Power Limited, 2021). This is a precautionary approach, which assumes a 95% carbon capture efficiency rate for all operating gas-fired power plants in the UK over the O&M phase of the WDA infrastructure.

64. This emission factor represents the operational use of gas at source and is not representative of lifecycle emissions, which include the extraction, processing and transportation of gas to a power station. Therefore, it is not directly comparable with the level of lifecycle emissions arising from the WDA infrastructure.

65. As a result, the GHG assessment has only estimated avoided emissions during the O&M phase of the WDA infrastructure, as detailed in **Section 19.7.2.2.2**.

Table 19.12 'Do nothing' predicted future baseline - GHG emissions

Timeframe	Anticipated Energy Produced by the Project (GWh)	GHG Emissions from Electricity Generated from Natural Gas with CCS (tonnes CO_2e)
Per year	6,565	135,892
Lifetime of the Project (35 years)	229,770	4,756,234

19.7 ASSESSMENT OF EFFECT SIGNIFICANCE

66. The potential significance of effects on GHG emissions that may occur during construction (including pre-construction activities), O&M and decommissioning of the WDA infrastructure is assessed in the following sections. The assessment follows the methodology set out in **Section 19.5.2** and is based on the realistic worst-case scenarios defined in **Section 19.4.2**. This assessment has been undertaken on the basis of all embedded mitigation measures outlined in **Table 19.7**. The embedded mitigation measures relevant for each impact are listed in the summary **Table 19.22**.

19.7.1 Sensitivity

67. As detailed in **Section 19.5.2.3**, all GHG emissions will affect the same receptor, the global atmosphere, as opposed to directly affecting any specific local receptor and is therefore considered to be of **high sensitivity** to additional emissions.

19.7.2 Magnitude of Impact

68. This section presents the GHG emissions associated with the construction (including pre-construction activities), O&M, and decommissioning phases of the WDA infrastructure. The carbon benefits of the Project are presented, including the quantity of the GHG emissions saved (or avoided) and the GHG intensity of the electricity produced by the Project.

19.7.2.1 Construction (including pre-construction activities)

69. The emission sources considered for the construction (including pre-construction activities) phase of the WDA infrastructure were categorised into lifecycle modules A0, A1, A2, A3, A4, and A5. GHG emissions were quantified in accordance with the methodology outlined in Section 1.2 of the **Appendix 19.1 Greenhouse Gas Assessment Methodology**.

70. Based on the worst-case scenario outlined in **Section 19.4.2**, the GHG emissions predicted to be released during the construction (including pre-construction activities) phase are estimated to be approximately 4,759,276 tonnes CO_2e. Full details are presented in **Table 19.13** and are listed by lifecycle module and source group. Embodied carbon in material is expected to be the largest emission source during construction (including pre-construction activities), contributing approximately 88% of emissions during this phase. The next largest emission source is marine vessels in transit, comprising approximately 9% of total construction emissions.

Table 19.13 Construction (including pre-construction activities) GHG emissions

Lifecycle Module	Emission Source Group	GHG Emissions (tonnes CO_2e)	Percentage of Construction (including pre-construction activities) Phase Emissions (%)*
A0 (Pre-construction)	Marine vessels (transit and onsite)	24,755	1%
A1 to A3 (Embodied Carbon)	Embodied carbon in materials and components	4,166,050	88%
A4 (Transportation)	Marine vessels (transit)	432,298	9%
A5 (Construction)	Marine vessels (on site)	136,173	3%
Total (over construction phase)		**4,759,276**	
*The total percentages may not sum to 100% due to rounding.			

71. The GHG emissions total for the construction (including pre-construction activities) phase presented in **Table 19.13** is representative of activities under the worst-case scenario and following the adoption of a number of conservative assumptions. The Applicant will seek to reduce emissions during the construction (including pre-construction activities) phase through identifying and implementing GHG emissions reduction measures, subject to detailed feasibility to confirm viability.

19.7.2.1.1 Comparison to the UK and Scotland's recommended Carbon Budgets

72. The construction of the WDA infrastructure is due to commence in the second half of 2030 and last for a duration of five years. It would therefore fall within the UK's fifth and sixth Carbon Budget periods and Scotland's recommended second Carbon Budget period, which are presented in **Table 19.2** and **Table 19.3**. Estimated emissions during construction of the WDA infrastructure would constitute approximately 0.14% and 0.25% of the UK's fifth and sixth Carbon Budgets, respectively. Similarly, the estimated emissions would consist of approximately 0.2% and 2.7% of Scotland's recommended first and second Carbon Budgets, respectively. This forms a small proportion overall, considering that the emissions occur over a short, defined period. In addition, construction of the WDA infrastructure will facilitate its long-term contribution in supporting Scotland and the UK's decarbonisation targets through the provision of renewable energy to the UK's NETS.

19.7.2.1.2 Significance of Effect

73. As GHG emissions released during the construction phase form a relatively small contribution towards the UK and Scottish Carbon Budgets, and with reference to the criteria outlined in **Table 19.11,** is considered to be fully consistent with policy requirements and good practice design standards. In addition, the Applicant will seek to identify GHG emission reduction measures during the construction phase. Measures that are technically feasible and commercially viable will be considered and implemented where appropriate. Construction of the WDA infrastructure is therefore considered to be unlikely to adversely affect the UK's and Scotland's ability to meet their future Carbon Budgets.

74. In accordance with the criteria outlined in **Table 19.11,** construction phase GHG emissions are considered to have a **minor adverse** effect, which is **not significant** in EIA terms.

19.7.2.2 Operation & Maintenance

75. The emission sources considered for the O&M phase of the WDA infrastructure include the lifecycle modules B1, B2, B3 and B4 as detailed in **Table 19.10**. GHG emissions were quantified in accordance with the methodology outlined in Section 1.2 of the **Appendix 19.1 Greenhouse Gas Assessment Methodology**.

76. Based on the worst-case scenario outlined in **Section 19.4.2**, the GHG emissions predicted to be released during the O&M phase are estimated to be approximately 1,904,549 tonnes CO_2e. Full details are presented in **Table 19.14** and are listed by lifecycle module and source group.

Table 19.14 O&M GHG emissions

Lifecycle Module	Emission Source Group	GHG Emissions (tonnes CO_2e)	Percentage of O&M Phase Emissions (%)*
B1 (Use) B2 (Maintenance) B3 (Repair) B4 (Replacement)	Fugitive emissions (SF_6)	65,142	3%
	Marine vessels (transit)	137,786	7%
	Marine vessels (on site)	1,429,857	75%
	Helicopter (transit)	25,212	1%
	Embodied carbon – spare parts	246,552	13%
Total (over the O&M phase)		**1,904,549**	
*The total percentages may not sum to 100% due to rounding.			

77. The GHG emissions total presented in **Table 19.4** are representative of activities under the worst-case scenario and following the adoption of a number of conservative assumptions. The Applicant will seek to reduce emissions during the O&M phase through identifying and implementing GHG emissions reduction measures, subject to detailed feasibility to confirm viability.

19.7.2.2.1 Comparison to the UK and Scotland's recommended Carbon Budgets

78. The O&M phase is expected to commence in 2035, and therefore the first eight years of operation would fall within the sixth and seventh UK carbon budget periods, and Scotland's recommended second, third and fourth Carbon Budget periods, which are presented in **Table 19.2** and **Table 19.3**.

79. For the UK's sixth and seventh Carbon Budget periods, the estimated O&M emissions would account for 0.008% and 0.051% of the respective Carbon Budgets. For Scotland's recommended second, third and fourth Carbon Budget periods, the estimated O&M emissions would account for 0.004%, 0.33% and 1.11% of the respective Carbon Budgets. As the subsequent UK and Scotland's Carbon Budgets are currently unknown, further consideration of the contribution of the O&M emissions cannot be undertaken. However, the magnitude of emissions over the WDA infrastructure lifetime is anticipated to be a negligible contribution to the future UK and Scotland's Carbon Budgets.

80. Furthermore, a number of conservative assumptions were adopted in the assessment, including the use of emission factors representative of present day activities to calculate emissions across the full O&M phase, therefore the emission estimates in **Table 19.14** are likely to be an overestimation.

19.7.2.2.2 Avoided Emissions

81. The avoided emissions from the WDA infrastructure are detailed in this section and include lifecycle module D2, which considers the benefits of supplying renewable energy to the UK's NETS beyond the lifecycle stages.

82. **Table 19.15** presents the quantity of GHG emissions which would have otherwise been produced under the 'Do Nothing' scenario (**Section 19.6.2.2**). This figure is used to determine the avoided emissions as a result of the WDA infrastructure operations, accounting for GHG emissions released during the O&M phase.

Table 19.15 Avoided GHG emissions

Lifecycle Module	Lifetime O&M GHG Emissions (tonnes CO_2e)	Lifetime GHG Emissions Produced under the 'Do Nothing' Scenario (tonnes CO_2e)	Avoided Emissions during the O&M Phase (tonnes CO_2e)
D2 (displacement of non-renewable electricity)	1,904,549	4,756,234	2,851,685

83. Assuming electricity generated by the WDA infrastructure displaces electricity that would have been generated from a gas-fired power station equipped with CCS, approximately 2,851,685 tonnes CO_2e would be avoided during the O&M phase.

84. The comparison is based on the precautionary assumption that all gas-fired power stations operating in the UK over the O&M phase of the WDA infrastructure would have a 95% carbon capture rate.

19.7.2.2.3 GHG Intensity of Electricity Generation

85. Based on the anticipated electricity output and the level of GHG emissions over the O&M phase, the GHG intensity per unit of electricity generated by the Project during its O&M phase is estimated to be 8.29 g CO_2e/kWh. This is lower than other forms of equivalent generation, as discussed in **Section 19.7.2.4.1**.

19.7.2.2.4 Significance of Effect

86. The WDA infrastructure would contribute to the UK meeting the projected increase in electricity demand resulting from population and economic growth (BEIS, 2022) and support the UK's decarbonisation aims through the provision of renewable energy. In addition, the Applicant will seek to identify GHG emissions reduction measures during the O&M phase. Measures that are technically feasible and commercially viable will be considered and implemented where appropriate.

87. Based on the criteria set out in

88. **Table 19.11**, given the low operational GHG intensity of electricity generation and the level of predicted avoided emissions, the WDA infrastructure would 'substantially exceed net zero requirements' and provide 'a positive climate impact', therefore, the O&M phase of the WDA infrastructure is considered to have a **beneficial** effect on GHG emissions, which is **significant** in EIA terms.

19.7.2.3 Decommissioning

89. **Chapter 3 Project Description** presents a general approach to decommissioning of the WDA infrastructure. A Decommissioning Programme will be prepared for approval by the Scottish Ministers prior to the construction of the WDA infrastructure.

90. In line with the worst-case scenario outlined in **Section 19.4.2** and the methodology outlined in Section 1.2.5 of **Appendix 19.1 Greenhouse Gas Assessment Methodology**, emissions arising from marine vessels during decommissioning are assumed to be equivalent to those released during the construction phase. In addition, emissions from the disposal of the portion of the WTGs, OSP and cables that are not reused, repurposed, or recycled have been calculated, based on current limitations.

91. It is acknowledged that regulatory requirements and industry best practice related to decommissioning of offshore windfarm developments change over time. It is anticipated that a large proportion of windfarm components would be recycled, repurposed or incinerated for energy recovery at the end-of-life stage, as opposed to being sent to landfill, with current estimates for wind turbine recyclability ranging from 85% to 90% (Schmid et al., 2020). There are developing approaches and technologies for decommissioning offshore windfarms, which could result in a lower GHG footprint than currently anticipated (Spyroudi et al., 2021), such as repowering and life extension strategies, that could be explored as part of determining the final decommissioning strategy for the WDA infrastructure. In addition, it is likely that a number of sectors will experience decarbonisation over the lifecycle of the WDA infrastructure to achieve the legally binding emission reduction targets set under the UK Climate Change Act 2008 (as amended by the 2050 Target Amended Order 2019) and the Climate Change (Emissions Reduction Targets) (Scotland) Act 2019, which require the UK and Scotland to achieve net zero by 2050 and 2045 respectively.

92. Therefore, predicted GHG emissions, presented in **Table 19.16**, from the decommissioning of the WDA infrastructure at this stage, are likely to be an overestimation.

93. As detailed in Section 1.2.5 of **Appendix 19.1 Greenhouse Gas Assessment Methodology**, the GHG emissions sources during decommissioning include lifecycle module C1, C2, C3 and C4, as set out in **Table 19.10**. Emissions from C1, C2 and C3 are assumed to be equivalent to the construction (including pre-construction activities) lifecycle modules, A4 and A5. Emissions from C4 are based on the assumption of 10% of recovered above-ground components and 5% of recovered cables being sent to landfill. The total decommissioning emissions are estimated to be 571,250 tonnes CO_2e, as shown in **Table 19.16**.

Table 19.16 Decommissioning GHG emissions

Lifecycle Module	Emission Source Group	GHG emissions (tonnes CO_2e)	Percentage of Decommissioning Phase Emissions (%)*
C1 (Deconstruction and demolition) C2 (Transport to and from site) C3 (Waste processing or recovery)	Transportation of the recovered components and materials, which is assumed to be equivalent to the emissions associated with the A4 (Transportation) lifecycle module.	432,298	76%
	Deconstruction and demolition of WTGs, OSPs, and cables, which is assumed to be equivalent to the emissions associated with the A5 (Construction) lifecycle module.	136,173	24%
C4 (Disposal)	Emissions associated with the recovered components and	2,779	0.5%

Lifecycle Module	Emission Source Group	GHG emissions (tonnes CO_2e)	Percentage of Decommissioning Phase Emissions (%)*
	materials that are sent to the landfill.		
Total (Decommissioning)		571,250	
*The total percentages may not sum to 100% due to rounding.			

19.7.2.3.1 Significance of Effect

94. Decommissioning would result in a single occurrence of GHG emissions and is an inherent process in the lifecycle of offshore wind projects. As noted previously, it is anticipated that the decommissioning of the WDA infrastructure is unlikely to adversely affect the UK's or Scotland's net zero position. In addition, the Applicant will seek to identify GHG emissions reduction measures during the decommissioning phase. Measures that are technically feasible and commercially viable will be considered and implemented where appropriate. Therefore, the emissions total estimated in **Table 19.16** are highly likely to be an overestimation. Decommissioning emissions from the WDA infrastructure are therefore considered to have **minor adverse** effect, which is **not significant** in EIA terms.

19.7.2.4 Potential Effects during the Whole Project Lifecycle

95. Indicative GHG emissions associated with the whole Project (including the WDA, Offshore ECC and OnTDA) are presented in **Table 19.17**.

Table 19.17 Whole Project GHG emissions

Project phase	Lifecycle phase	GHG emissions (tonnes CO_2e)	Percentage of WDA lifecycle emissions (%)	Percentage of Phase Emissions (%)
WDA Total	Construction (including pre-construction activities)	4,759,276	66%	-
	O&M	1,904,549	26%	-
	Decommissioning	571,250	8%	-
	Sub-Total	**7,235,075**	-	96%
Offshore ECC (indicative)	N/A	327,380	N/A	4%
OnTDA (indicative)	N/A	563	N/A	<0.01%
Whole Project Total		**7,563,018**		

96. The anticipated total GHG emissions from the construction (including the pre-construction activities), O&M, and decommissioning of the WDA infrastructure only were estimated to be 7,235,075 tonnes CO_2e. GHG emissions from the construction (including pre-construction activities) phase of the WDA infrastructure are anticipated to contribute the largest proportion of lifecycle emissions, accounting for 66% of the total emissions footprint. The emission calculations were undertaken on a worst case

scenario basis, as decommissioning emissions were estimated using conservative assumptions. As noted in **Section 19.7.2.3**, this approach is likely an overestimation of emissions during the decommissioning phase.

97. The indicative GHG emissions from the OnTDA are estimated to be 563 tonnes CO_2e. As outlined in **Table 19.8** and Section 1.3 of **Appendix 19.1 Greenhouse Gas Assessment Methodology**, these emissions were calculated with the limited information available at this stage of the OnTDA design. As the OnTDA design progresses and detailed information is available, the whole Project GHG emissions can be updated as part of the separate OnTDA EIA application.

98. GHG emissions predicted from the whole Project are estimated to be 7,563,018 tonnes CO_2e. The WDA infrastructure is expected to contribute the largest proportion to the overall emission of the Project, with 96% of the total Project GHG emissions. While updated information on the Offshore ECC and OnTDA may reduce uncertainty around their respective GHG emissions, the conclusion that the WDA infrastructure is the largest contributor to the whole Project GHG emissions is unlikely to change.

19.7.2.4.1 Whole Project GHG intensity

99. The overall GHG intensity of the electricity generated by the whole Project, including the construction (including pre-construction activities, O&M and decommissioning) is estimated to be 32.9 g CO_2e per kWh. This compares favourably with other forms of fossil fuel electricity generation (CCC, 2013; Net Zero Teeside Power Limited, 2021) as listed below:

- Unabated Combined Cycle Gas Turbine: 380 to 500 kg CO_2e per MWh; and
- Gas with CCS: 20 to 245 kg CO_2e per MWh.

100. It should be noted that the figures reported above are for the whole Project and exclude upstream emissions from the extraction and processing of natural gas prior to combustion at the generation facility. Therefore, a comparison of whole Project emissions to these figures is a conservative approach.

19.7.2.4.2 Overall Significance of Effect

101. Overall, as the whole Project would enable the provision of renewable energy to the UK's NETS and contribute positively to the UK and Scotland's progress towards meeting their net zero targets. The overall significance of effect is therefore considered to be **beneficial**, which is **significant** in EIA terms.

19.8 CUMULATIVE EFFECTS ASSESSMENT

102. As noted in **Section 19.5.3**, the incorporation of the whole Project assessment means cumulative emissions from the Project are accounted for, and no additional consideration of specific cumulative effects with other plans or projects is required with respect to GHG emissions.

19.9 TRANSBOUNDARY EFFECTS

103. As stated in **Section 19.5.4**, the receptor for the GHG assessment is the global atmosphere, and therefore GHG emissions have an indirect transboundary effect on climate change. GHG emissions released and avoided by the WDA infrastructure have been assessed in the context of the UK's and Scotland's recommended Carbon Budgets, which have been set in accordance with international climate agreements. Therefore, transboundary effects are not considered to require specific consideration for the GHG assessment.

19.10 INTER-RELATED AND INTERACTING IMPACTS

19.10.1 Inter-relationships

104. The receptor for the GHG assessment is the global atmosphere. As there are no other topics that have a direct effect on this receptor, there are no inter-relationships with this topic.

19.10.2 Interactions

105. The impacts identified and assessed in this chapter have the potential to interact with each other. Areas of potential interaction between impacts are presented in **Table 19.18**, **Table 19.19**, and **Table 19.20** below. The impacts are assessed relative to each development phase (i.e. construction, O&M or decommissioning) to see if (for example) multiple construction impacts affecting the same receptor could increase the magnitude of impact upon that receptor.

106. The receptors for the Blue Carbon Assessment in **Appendix 19.2 Blue Carbon Assessment** are blue carbon habitats and the global atmosphere. Emissions from the release of blue carbon have the potential to add to the GHG emissions profile from the WDA but are accounted for separately in **Appendix 19.2 Blue Carbon Assessment** due to uncertainties in the pathways and data related to the release of blue carbon. This approach was consulted on with MD-LOT and NatureScot. Any comments received as part of this consultation and any changes that resulted from this consultation are detailed in **Appendix 19.2 Blue Carbon Assessment**.

107. A subsequent lifetime assessment has been undertaken which considers the impact interactions identified and the potential for impacts to affect receptors relevant to this chapter across all development phases (**Table 19.21**).

Table 19.18 Potential interaction between impacts – construction

Potential Interactions Between Construction Impacts			
	Impact 1: GHG emissions	Impact 2: Disturbance to blue carbon habitats	Impact 3: Loss of blue carbon
Impact 1: GHG emissions	N/A	Yes	Yes
Impact 2: Disturbance to blue carbon	Yes	N/A	Yes
Impact 3: Loss of blue carbon	Yes	Yes	N/A

Table 19.19 Potential interactions between impacts – O&M

Potential Interactions Between O&M Impacts			
	Impact 1: GHG emissions	Impact 2: Disturbance to blue carbon habitats	Impact 3: Loss of blue carbon
Impact 1: GHG emissions	N/A	Yes	Yes
Impact 2: Disturbance to blue carbon	Yes	N/A	Yes
Impact 3: Loss of blue carbon	Yes	Yes	N/A

Table 19.20 Potential interaction between impacts – decommissioning

Potential Interactions Between Decommissioning Impacts			
	Impact 1: GHG emissions	Impact 2: Disturbance to blue carbon habitats	Impact 3: Loss of blue carbon
Impact 1: GHG emissions	N/A	Yes	Yes
Impact 2: Disturbance to blue carbon	Yes	N/A	Yes
Impact 3: Loss of blue carbon	Yes	Yes	N/A

Table 19.21 Potential interactions between impacts – phase and lifetime assessment

Highest Significance of Effect Level					
Receptor	**Construction**	**O&M**	**Decommissioning**	**Phase Assessment**	**Lifetime Assessment**
GHG Assessment					
Global atmosphere	Minor adverse	Beneficial	Minor adverse	**No greater than individually assessed impact for each phase.** The impacts are considered to have an overall beneficial effect on the receptor. It is considered that effects would not, when considered together, result in appreciably greater impact than assessed individually.	**No greater than individually assessed impact.** As with the phase assessment, all potential adverse impacts are non-significant and localised in nature, limiting the potential for different impacts to interact across the different phases
Blue Carbon Assessment					
Blue carbon habitats	Minor	Minor	Negligible	**No greater than individually assessed impact for each phase.** The impacts are considered to have a minor to negligible effect on the receptor. Given that each impact is localised, it is considered that effects would not, when considered together, result in appreciably greater impact than assessed individually.	**No greater than individually assessed impact for each phase.** As with the phase assessment, all potential impacts are non-significant and localised in nature, limiting the potential for different impacts to interact across the different phases.
Global atmosphere	Negligible	Negligible	Negligible	**No greater than individually assessed impact for each phase.** The impacts are considered to have a negligible adverse effect on the receptor. It is considered that effects would not, when considered together, result in appreciably greater than assessed individually.	**No greater than individually assessed impact for each phase.** As with the phase assessment, all potential impacts are non-significant, limiting the potential for different impacts to interact across different phases

19.11 POTENTIAL MONITORING REQUIREMENTS

108. The WDA is not anticipated to require any specific monitoring requirements with respect to GHG emissions.

19.12 SUMMARY

109. **Table 19.22** presents a summary of the assessment of potential effects on climate change during the construction, O&M and decommissioning phases of the WDA infrastructure.

110. The GHG assessment evaluated the GHG emissions associated with the WDA infrastructure and the potential for avoided emissions by replacing electricity that would otherwise have been generated from gas-fired power stations with CCS. The estimated avoided emissions due to the WDA infrastructure are 2,851,685 tonnes CO_2e, resulting in a **beneficial** effect, which is considered to be significant in EIA terms. The GHG assessment also considered emissions associated with the whole Project and compared these outcomes to the relevant UK and Scotland's recommended carbon budgets. The methodology for the GHG assessment is detailed in **Appendix 19.1 Greenhouse Gas Assessment Methodology.**

111. The Blue Carbon Assessment presented in **Appendix 19.2 Blue Carbon Assessment**, outlines that the WDA infrastructure would result in **minor to negligible** effects during the construction, O&M and decommissioning phases, which is **not significant** in EIA terms.

112. **Table 19.22** presents the summary of likely significant environmental effects, mitigation, monitoring and residual effects for climate change related to GHG emissions.

Table 19.22 Summary of potential effects for climate change

Potential Impact	Receptor(s)	Relevant Embedded Mitigation Measures	Sensitivity	Magnitude of Impact	Significance of Effect	Additional Mitigation	Residual Significance of Effect	Proposed Monitoring	Whole Project	Cumulative Residual Significance of Effect
Construction										
GHG emissions	Global atmosphere	M-51	High	N/A	Minor adverse (Not Significant)	N/A	Minor adverse (Not Significant)	N/A	Not significant	N/A
Disturbance to blue carbon habitats	Blue carbon habitats	N/A	High	Negligible	Minor (Not significant)	N/A	Minor (Not significant)	N/A	Not significant	N/A
Blue carbon loss	Global atmosphere	N/A	High	N/A	Negligible (Not Significant)	N/A	Negligible (Not Significant)	N/A	Not significant	N/A
O&M										
GHG emissions	Global atmosphere	N/A	High	N/A	Beneficial (Significant)	N/A	Beneficial (Significant)	N/A	Not significant	N/A
Disturbance to blue carbon habitats	Blue carbon habitats	N/A	High	Negligible	Minor (Not significant)	N/A	Minor (Not significant)	N/A	Not significant	N/A
Blue carbon loss	Global atmosphere	N/A	High	N/A	Negligible (Not Significant)	N/A	Negligible (Not Significant)	N/A	Not significant	N/A
Decommissioning										
GHG emissions	Global atmosphere	N/A	High	N/A	Minor adverse (Not Significant)	N/A	Minor adverse (Not Significant)	N/A	Not significant	N/A
Disturbance to blue carbon habitats	Blue carbon habitats	N/A	High	Negligible	Minor (Not significant)	N/A	Minor (Not significant)	N/A	Not significant	N/A
Blue carbon loss	Global atmosphere	N/A	High	N/A	Negligible (Not Significant)	N/A	Negligible (Not Significant)	N/A	Not significant	N/A

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