# Outer Dowsing Offshore Wind

# Preliminary Environmental Information Report

# Volume 1, Chapter 31: Climate Change

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OUTER DOWSING OFFSHORE WIND

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# Table of Contents



# List of Tables

## List of Figures

## Abbreviations

| Acronym | Expanded name |
|---|---|
| AR4 | Fourth Assessment Report of the UN IPCC |
| BEIS | Department for Business, Energy & Industrial Strategy (now the Department for Energy Security and Net Zero (DESNZ)) |
| CCC | Climate Change Committee |
| CCGT | Combined Cycle Gas Turbine |
| $CO_2eq$ | Carbon Dioxide equivalents (measurement unit for GHG emissions) |
| DCO | Development Consent Order |
| DECC | Department of Energy & Climate Change, now the Department for Energy Security and Net Zero (DESNZ) |
| DESNZ | Department for Energy Security and Net Zero, formerly Department of Business, Energy and Industrial Strategy (BEIS), which was previously Department of Energy & Climate Change (DECC) |
| ECC | Export Cable Corridor (offshore ECC or indicative onshore ECC) |
| EIA | Environmental Impact Assessment |
| EPP | Evidence Plan Process |
| ES | Environmental Statement |
| ETG | Expert Topic Group |
| GHG | Greenhouse Gas |
| GT R4 Limited | The Applicant. The special project vehicle created in partnership between Corio Generation (a wholly owned Green Investment Group portfolio company), Gulf Energy Development and TotalEnergies. |
| GWP | Global Warming Potential |
| hr | Hour |
| ICE | Inventory of Carbon and Energy |
| IPCC | Intergovernmental Panel on Climate Change |
| ISO | International Organisation for Standardisation |
| LCA | Life Cycle Assessment |
| NPS | National Policy Statement |
| NSIP | Nationally Significant Infrastructure Project |
| ODOW | Outer Dowsing Offshore Wind, trading name of GT R4 Limited |
| OnSS | Onshore Substation |
| OSS | Offshore Substation Platform |
| ORCP | Offshore Reactive Compensation Platform |
| PEIR | Preliminary Environmental Information Report |
| SoS | Secretary of State |
| WTG | Wind Turbine Generator |
| t | Tonne |
| tkm | Tonne-kilometre (freight effort moving one t a distance of one km) |

# Terminology

| Term | Definition |
|---|---|
| Baseline | The status of the environment at the time of assessment without the development in place. |
| Cumulative impact | Impacts that result from changes caused by other past, present or reasonably foreseeable actions together with the Project. |
| Development Consent Order (DCO) | An order made under the Planning Act 2008 granting development consent for a Nationally Significant Infrastructure Project (NSIP) from the Secretary of State (SoS) for Business, Energy and Industrial Strategy (BEIS), now the Department for Energy Security and Net Zero (DESNZ). |
| Effect | Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of an impact with the sensitivity of a receptor, in accordance with defined significance criteria. |
| Environmental Impact Assessment (EIA) | A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the Environmental Impact Assessment (EIA) Regulations, including the publication of an Environmental Statement (ES). |
| Environmental Statement (ES) | The suite of documents that detail the processes and results of the EIA. |
| Impact | An impact to the receiving environment is defined as any change to its baseline condition, either adverse or beneficial. |
| Inter-array cables | Cable which connects the wind turbines to each other and to the offshore substation(s). |
| Landfall | The location at the land-sea interface where the offshore export cables will come ashore. |
| Mitigation | Mitigation measures, or commitments, are commitments made by the Project to reduce and/or eliminate the potential for significant effects to arise as a result of the Project. Mitigation measures can be embedded (part of the project design) or secondarily added to reduce impacts in the case of potentially significant effects. |
| National Policy Statement (NPS) | A document setting out national policy against which proposals for Nationally Significant Infrastructure Projects (NSIPs) will be assessed and decided upon. |
| Outer Dowsing Offshore Wind (ODOW) | The Project. |
| Onshore Export Cable Corridor | The Onshore Export Cable Corridor is the area within the PEIR Boundary within which the export cable running from the landfall to the onshore substation will be situated. |

| Term | Definition |
|---|---|
| Onshore substation (OnSS) | The Project's onshore substation, containing electrical equipment to enable connection to the National Grid. |
| Onshore substation (OnSS) | The Project's onshore substation, containing electrical equipment to enable connection to the National Grid. |
| Onshore Infrastructure | The combined name for all onshore infrastructure associated with the Project from landfall to grid connection. |
| Preliminary Environmental Information Report (PEIR) | The PEIR is written in the style of a draft Environmental Statement (ES) and provides information to support and inform the statutory consultation process in the pre-application phase. Following that consultation, the PEIR documentation will be updated to produce the Project's ES that will accompany the application for the Development Consent Order (DCO). |
| Project design envelope | A description of the range of possible elements that make up the Project's design options under consideration, as set out in detail in the project description. This envelope is used to define the Project for Environmental Impact Assessment (EIA) purposes when the exact engineering parameters are not yet known. This is also often referred to as the "Rochdale Envelope" approach. |
| The Applicant | GT R4 Ltd. The Applicant making the application for a DCO.<br>The Applicant is GT R4 Limited (a joint venture between Corio Generation, TotalEnergies and Gulf Energy Development (GULF)), trading as Outer Dowsing Offshore Wind. The project is being developed by Corio Generation (a wholly owned Green Investment Group portfolio company), TotalEnergies and GULF. |
| The Planning Inspectorate | The agency responsible for operating the planning process for Nationally Significant Infrastructure Projects (NSIPs). |
| The Project | Outer Dowsing Offshore Wind (ODOW) including proposed onshore and offshore infrastructure |
| Wind turbine generator (WTG) | All the components of a wind turbine, including the tower, nacelle, and rotor. |

# 31 Climate Change

## 31.1 Introduction

31.1.1 This chapter of the Preliminary Environmental Information Report (PEIR) presents the results to date of the Environmental Impact Assessment (EIA) process for the potential impacts of Outer Dowsing Offshore Wind (the Project) on Climate Change. Specifically, this chapter considers the potential impact of the Project from the Wind Turbine Generators (WTGs) via the Offshore Substation Platform (OSS) to Landfall, along the Onshore Export Cable Corridor (ECC), and incorporating the Onshore substation (OnSS) during the construction, operation and maintenance, and decommissioning phases.

31.1.2 GT R4 Limited ("the Applicant") is proposing to develop the Project. The Project will be located approximately 54km from the Lincolnshire coastline in the southern North Sea. The Project will include both offshore and onshore infrastructure including an offshore generating station (windfarm), export cables to landfall, onshore cables, and connection to the electricity transmission network, and ancillary and associated development (see Volume 1, Chapter 3: Project Description for full details).

31.1.3 This chapter should be read alongside the following chapters:

- Volume 1, Chapter 2: Need, Policy and Legislative Context;
- Volume 1, Chapter 3: Project Description;
- Volume 1, Chapter 4: Site Selection and Consideration of Alternatives;
- Volume 1, Chapter 5: EIA Methodology;
- Volume 2, Appendix 5.1: Offshore Cumulative Effects Assessment;
- Volume 2, Appendix 5.2: Onshore Cumulative Effects Assessment;
- Volume 1, Chapter 24: Hydrology, Hydrogeology and Flood Risk; and
- Volume 1, Chapter 27: Traffic and Transport.

## 31.2 Statutory and Policy Context

31.2.1 The need for the Project arises from the United Kingdom's (UK) Government's ambition to deliver 50GW of renewable energy from offshore wind by 2030.

31.2.2 The commitment to offshore wind targets was originally set out in the Offshore Wind Sector Deal agreed between the Government and the offshore wind industry in 2019. Originally targeting 30GW of operating capacity by 2030, this figure was increased to 40GW in the Energy White Paper published in 2020, as part of the plan for the green industrial revolution. In its Sixth Carbon Budget, published in 2020, the Climate Change Committee (CCC) recommended that offshore wind should become the backbone of the whole UK energy system, growing from 40GW of capacity in 2030 to 100GW or more by 2050. In October 2021, the UK Government has committed to decarbonise the UK's electricity system by 2035.

31.2.3 Most recently, the UK Government has outlined an even greater level of ambition in the British Energy Security Strategy (HM Government, 2022), which sets out an ambition to reach 50GW of offshore wind by 2030. As part of this strategy, investing in offshore wind generation has been listed as one of the key points of the UK Government's '10 Point Plan', contributing to a carbon net zero by 2050. The British Energy Security Strategy is anticipated to support 90,000 jobs in offshore wind by 2028, with a goal of accelerating offshore wind deployment, ensuring energy security and stabilising consumer prices in the longer term.

31.2.4 Details regarding the relevant international obligations on climate change and national climate change and energy legislation are set out in Volume 1 Chapter 2: Need, Policy and Legislative Context of the PEIR. This Chapter identifies legislation guidance, national and local policy of relevance to the potential impact of and on climate change associated with construction, operation and decommissioning of the Project.

31.2.5 The Planning Act 2008 (as amended) is the primary legislation that established the legal framework for applying for, examining, and determining applications for Nationally Significant Infrastructure Projects (NSIPs). National Policy Statements (NPS) set the framework for decisions by the Secretary of State (SoS) for Energy Security and Net Zero.

## National Policy Statements

31.2.6 The Overarching National Policy Statement for Energy EN1 (DECC, 2011a), makes references to predictions that a continuation of global emission trends, including emissions of greenhouse gases such as carbon dioxide could lead average global temperatures to rise by up to 6°C by the end of this century. The potential impacts associated with such a global temperature rise include (DECC, 2014):

- Increased frequency of extreme weather events such as floods and drought;
- Reduced food supplies;
- Impacts on human health;
- Increased poverty; and
- Ecosystem impacts, including species extinction.

31.2.7 The NPSs are currently being revised and draft versions were published for consultation in 2023 including the Draft Overarching NPS EN-1 (DESNZ, 2023).

31.2.8 The draft NPS EN-1 (DESNZ, 2023) also notes the change in target and focus since the original iteration of EN-1 which had a target of 80% reduction in greenhouse gases by 2050, by highlighting the more ambitious target to reach Net Zero by 2050.

31.2.9 Part 2 of the Overarching National Policy Statement for Energy (NPS EN-1) sets out the government policy context for major energy infrastructure. This includes the need to meet legally binding targets to cut greenhouse gas emissions, transition to a low carbon economy and decarbonise the power sector.

31.2.10 Paragraph 1.1.1 of the National Policy Statement for Renewable Energy Infrastructure (NPS EN-3) underlines the importance of the generation of electricity from renewable sources by stating that electricity generation from renewable sources of energy is an important element in the Government's development of a low-carbon economy. It stresses that there are ambitious renewable energy targets in place and that a significant increase in generation from large-scale renewable energy infrastructure is necessary.

31.2.11 The Draft National Policy Statement for Renewable Energy Infrastructure (NPS EN-3) including paragraph 1.1.1, states that electricity generation from renewable sources of energy is an essential element of the transition to net zero.

31.2.12 Section 5.3.4 of the draft NPS EN-1 also includes the following requirement in relation to Greenhouse Gas (GHG) assessment:

- All proposals for energy infrastructure projects should include a GHG assessment as part of their ES. This should include:
  - A whole life carbon assessment showing construction, operational and decommissioning carbon impacts;
  - An explanation of the steps that have been taken to drive down the climate change impacts at each of those stages; and
  - Measurement of embodied GHG impact from the construction stage.
  - How reduction in energy demand and consumption during operation has been prioritised in comparison with other measures.
  - How operational emissions have been reduced as much as possible through the application of best available technology for that type of technology.
  - Calculation of operational energy consumption and associated carbon emissions.
  - Whether and how any residual carbon emissions will be (voluntarily) offset or removed using a recognised framework.
  - Where there are residual emissions, the level of emissions and the impact of those on national and international efforts to limit climate change, both alone and where relevant in combination with other developments at a regional or national level, or sector level, if sectoral targets are developed.

31.2.13 The draft NPS EN-1 outlines several methods of mitigation the Project should consider:

- 5.3.5 states that "A GHG assessment should be used to drive down GHG emissions at every stage of the proposed development and ensure that emissions are minimised as far as possible for the type of technology, taking into account the overall objectives of ensuring our supply of energy always remains secure, reliable and affordable, as we transition to net zero;
- 5.3.6 states that "Applicants should look for opportunities within the proposed development to embed nature-based or technological solutions to mitigate or offset the emissions of construction and decommissioning", and

- 5.3.7 "Steps taken to minimise and offset emissions should be set out in a GHG Reduction Strategy, secured under the development consent order. The GHG Reduction Strategy should consider the creation and preservation of carbon stores and sinks including through woodland creation, peatland restoration and through other natural habitats.".

31.2.14 Paragraph 152 of the National Planning Policy Framework (NPPF) applies a number of core planning principles that are to underpin planning decision making, including to support the transition to a low carbon future in a changing climate. Planning should help to shape places in ways that contribute to radial reductions in greenhouse gas emissions and support renewable and low carbon energy and associated infrastructure.

31.2.15 The Climate Change Act 2008 sets legally binding targets for reducing emissions of greenhouse gases by 2050. The net UK carbon account for 2050 must be at least 100% lower than the 1990 baseline.

31.2.16 The UK Carbon Budgets: to support continuous efforts to achieve Net Zero by 2050 under the UK Climate Change Act 2008, a series of sequential carbon budgets have been developed. Each budget provides a five-year statutory cap on total GHG emissions, which should not be exceeded to meet the UK's emission reduction commitments. These legally binding targets are currently available to the 6th carbon budget period (2033-2037) which became legislation under the Carbon Budget Order 2021, and which came into force on 24 June 2021.

31.2.17 The UK's Net Zero Strategy: The 2021 Report to Parliament: Progress in Reducing Emissions highlighted that whilst the UK Government has made historic climate promises, it has been too slow to follow these with delivery. Therefore, sustained reductions in emissions will require a strong Net Zero Strategy. The Strategy includes policies and proposals for decarbonising all sectors of the UK economy to meet net zero by 2050.

## 31.3 Consultation

31.3.1 Consultation is a key part of the Development Consent Order (DCO) application process. Consultation regarding Climate Change has been conducted through the EIA scoping process (ODOW, 2022). An overview of the Project consultation process is presented within Volume 1, Chapter 6: Consultation.

31.3.2 A summary of the key issues raised during consultation to date, specific to Climate Change, is outlined in Table 31.1 below, together with how these issues have been considered in the production of this PEIR.

Table 31.1: Summary of consultation relating to Climate Change

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| Scoping Opinion (the Inspectorate, 9 September 2022)<br>Comment ID: 3.23.1<br>Paragraphs 9.2.15 and 9.2.27 | Impacts on climate resilience during construction<br><br>The Inspectorate disagrees that within a 10-year period of construction the impacts from climate change would not lead to a significant effect as impacts to infrastructure would be | The effects of climate change during construction are likely to be limited to the consequences of flooding as a result of extreme weather |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | limited, particularly at coastal locations. This does not take into account extreme weather events both onshore and offshore or impacts to human receptors (e.g., construction workers). It is not clear whether this will be accounted for in the assessment of major accidents and disasters (Scoping Report paragraphs 9.1.46 to 9.1.59).<br>The ES should assess impacts from climate change over the construction period where significant effects are likely to occur and describe and secure any relevant mitigation measures. | events. The effects of such flooding events are assessed in the Volume 1, Chapter 24: Hydrology, Hydrogeology and Flood Risk. |
| Scoping Opinion (the Inspectorate, 9 September 2022)<br>Comment ID: 3.23.2<br>Paragraphs 9.2.19 to 9.2.20 | Impacts on climate resilience during decommissioning<br><br>The Scoping Report proposed to scope out climate resilience issues during decommissioning on the basis of the 'short period' over which of decommissioning is expected to occur. The Scoping Report contains no information regarding the length of time decommissioning activities would take place; therefore, the Inspectorate does not agree to scope this matter out of the assessment at this stage. The ES should include an assessment of climate resilience during decommissioning, where likely significant effects could occur, and include appropriate cross reference to the assessment of climate resilience matters in other relevant aspect chapters, such as Hydrology, Hydrogeology and Flood Risk, and also the proposed major accidents and disasters assessment matrix (Scoping Report paragraphs 9.1.46 to 9.1.59), as appropriate. | The effects of climate change during decommissioning are considered to be no worse than those for construction, and are addressed in Volume 1, Chapter 24: Hydrology, Hydrogeology and Flood Risk. |
| Scoping Opinion (the Inspectorate, 9 September 2022)<br>Comment ID: 3.23.3<br>Paragraph 9.2.21 | Cumulative impacts from emissions<br><br>The Inspectorate agrees that the assessment of GHG emissions against the carbon budgets are inherently cumulative and therefore this will be assessed in the Climate Change aspect chapter rather than as a separate element of the cumulative chapter. | This is addressed within Section 31.3.3 to 31.7. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| Scoping Opinion (the Inspectorate, 9 September 2022)<br>Comment ID: 3.23.4 Paragraph 9.2.24 | Transboundary climate change Effects<br><br>The Inspectorate agrees that although climate change is a global issue, the assessment will focus on the UK context and relevant targets and budgets. Therefore, the Inspectorate is content to scope out transboundary effects in relation to climate change. | N/A |

31.3.3 As identified in Volume 1, Chapter 4: Site Selection and Alternatives and Volume 1, Chapter 3: Project Description, the Project design envelope has been refined and will be refined further prior to DCO application. The refinement of the Project design envelope takes consideration of stakeholder consultation feedback.

## 31.4 Introduction to GHG Assessment

31.4.1 Since the industrial revolution, humans have accelerated the release of previously stored carbon (in the form of carbon dioxide) and other gases into the atmosphere, where they act to trap heat and cause global warming. Climate change is the term for this long-term rise in average temperatures, which is also associated with changes to global weather patterns.

31.4.2 The climate change impacts of a product, process, service or installation can be determined using a technique known as Life Cycle Assessment (LCA). The International Standards Organisation (ISO), in its series ISO 14040-44, defines LCA to be the "compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle", and outlines the four-step method adopted for this analysis. The sections that follow cover each of these steps in turn, explaining:

- Setting the system boundary to define the scope of work;
- Collecting the necessary data for the modelling;
- Bringing together the flow data and characterisation factors; and
- Interpreting and reporting the results.

31.4.3 The relative contributions that different so-called greenhouse gases (GHGs) make towards climate change are denoted by the global warming potential (GWP) of each gas, relative to the chosen reference gas, carbon dioxide. Because the gases dissipate at different rates in the atmosphere, the GWP of gases varies according to the timeframe of the analysis. Whilst datasets exist for GWP over 20-year and 500-year timeframes, the usual basis for international analysis and reporting is 100-years (GWP100).

31.4.4 Even within this timeframe, the United Nations Intergovernmental Panel on Climate Change has published a series of Assessment Reports to provide the latest scientific opinion on the GWP factors that should be used. Although the sixth report (AR6) has recently been published (UN IPCC, 2023), the UK government's carbon reporting factors are still based on AR4 (UN IPCC, 2007), and so the GWP factors used in this report are based on that report and are presented below. The table lists all of the gases that make a contribution to the total reported, and no significant emissions are thought to be excluded from the calculations.

Table 31.2: GWP100 factors (from AR4) used in this analysis

| Greenhouse gas | GWP100 factor (in kg $CO_2$eq per kg) |
|---|---|
| Carbon dioxide ($CO_2$) | 1 |
| Methane ($CH_4$) | 25 |
| Nitrous Oxide ($N_2O$) | 298 |
| Sulphur Hexafluoride ($SF_6$) | 22,800 |

## 31.5 Setting the Goal and Scope for Analysis

31.5.1 The first step was to agree the goal and scope for the analysis, defining what would be within the scope of study and what would not. The topics and the decisions agreed are summarised in Table 31.3.

Table 31.3: Scope of Analysis

| Topic | Decision |
|---|---|
| Study goal: | To identify the life cycle climate change impacts of the Project, in comparison with how its electricity might otherwise be generated. |
| Scenarios: | One scenario was considered, involving the construction, operation and decommissioning of the Project. |
| Time: | The Project is expected to operate for at least 35 years. This means that impacts arising from its decommissioning, as well as those from the later years of its operation, are subject to some level of uncertainty. The approach taken to deal with this uncertainty has generally been to assume the worst case. This is explained in more detail in the relevant sections below. |
| Geography: | The Project will be located off the coast of East England. Accordingly, the study was founded on operations in the UK, and included freight impacts to get materials and components to that region from their points of origin, around the globe. As The Project has not concluded any procurement of major components, it is unable to confirm origins of main suppliers at this stage. |
| Functional unit: | This is the basis for the reporting of the results. Initial calculations sought to estimate the lifetime impacts of the Project. For the purposes of comparing these to the alternative means of electricity generation, impacts are reduced to an average carbon intensity of generation, in g $CO_2$eq/kWh. |
| Impact criteria: | A full LCA would examine a wide range of environmental impacts. However, for this Climate Change assessment, it is sufficient to focus solely on global warming potential (GWP) impacts, over a 100-year period (GWP100). |

| Topic | Decision |
|---|---|
| Data sources: | The data sources used in this study are discussed in the next section. |
| Life-cycle stages: | An **attributional approach** was deemed appropriate for this study, looking at the Project's complete impacts across its lifetime.<br>A **systems expansion** approach was adopted to account for the benefits of the electricity generated over its lifetime. This was expected to displace UK marginal electricity, expected to continue to be generated by Gas for years to come. A sensitivity was also performed against the Government's "all non-renewables" technology mix.<br>The **"cut-off" approach** was adopted to account for the benefits of recycled content and recyclability at the end of life. Simply put, this means that the Project could be credited with the benefits of using secondary rather than virgin raw materials in its inputs but could not take credit for sending materials to be recycled at end of life (to avoid double-counting). |
| Platform: | Calculations were performed in MS Excel®. |
| GHG absorption: | ODOW will result in the permanent loss of ~18ha of above ground vegetation as a result of the permanent onshore infrastructure. Although there would also be temporary loss of vegetation as a result of construction activity (estimated to be 160Ha), this combined with the permanent loss of 18Ha represents a negligible loss of absorption capacity in comparison to climate change impact (in t $CO_2$eq) contributions from each of the projects life cycle stages. Therefore, in line with similar assessments undertaken for other DCO schemes including Hornsea Project Four, Awel-y-Mor and Norfolk Vanguard offshore windfarms, GHG emissions associated with the loss of GHG absorption capacity are not considered in the assessment. |

## 31.6 Data Collection

31.6.1 Data collection is the most challenging aspect of an LCA study. Looking to model the entire burdens of an offshore windfarm before, during and after an assumed 35-years of operation is a challenge, and involves collecting data from the across six key stages of the life cycle:

- Raw Materials;
- Manufacturing;
- Installation;
- Operation;
- Freight; and
- End of Life.

31.6.2 The rest of this section provides more detail on the data collected for each of the six stages. The primary source of data for the Project was information regarding the planning design and construction of the windfarm that has also been used to inform the EIA process to date for the Project.

## Raw Materials

31.6.3 'Raw Materials' refers to the environmental impacts embedded in the materials of construction of the windfarm (but not their fabrication or installation, which are covered in later stages). The Project provided details of the materials that are expected to be needed for, for example, the wind turbine generators (WTGs). This information was supported with data provided in a bespoke template, on the amounts of materials expected to be used in the construction. The main components and weights are listed in Table 31.. For the purposes of undertaking a robust, worst case analysis, it was assumed that none of these materials would contain recycled content, instead being from newly extracted materials.

Table 31.4: Main materials in Project components, and their amounts (indicative values)

| Description | Detail | Value | Units |
|---|---|---|---|
| WTG Foundation | Steel | 251,736 | t |
| | Cement | 45,804 | t |
| OSS Foundation | Steel | 8,831 | t |
| | Cement | 300 | t |
| OSS Topside | Steel | 8,636 | t |
| ORCP Foundation | Steel | 8,831 | t |
| | Cement | 300 | t |
| ORCP Topside | Steel | 8,636 | t |
| WTG Tower | Steel | 37,558 | t |
| | Aluminium | 1,162 | t |
| WTG Blades | Carbon fibre | 8,730 | t |
| | Wood | 69,840 | $m^3$ |
| WTG Nacelle | Copper | 4,029 | t |
| | Other | 76,551 | t |
| | Oil & Grease | 1 | t |
| Inter-array cables | Aluminium (*) | 12,476 | t |
| Interconnector cables | Aluminium (*) | 5,638 | t |
| Offshore export cables | Aluminium (*) | 22,584 | t |
| | Lead | 16,705 | t |
| | Steel | 31,495 | t |
| Landfall cables | Aluminium (*) | 67 | t |
| | Lead | 33 | t |
| | Steel | 109 | t |
| Onshore export cables | Aluminium (*) | 30,413 | t |
| | Lead | 22,493 | t |
| | Steel | 42,413 | t |
| Onshore Substation | Concrete | 16,000 | $m^3$ |
| | Fill | 538,440 | t |
| | Fencing | 9 | t |
| | Reinforcement | 1,900 | t |
| | Chippings | 18,816 | t |
| | Drainage | 6 | t |
| | Structural Steel | 3,800 | t |

| Description | Detail | Value | Units |
| --- | --- | --- | --- |
| | Cladding | 19,200 | $m^2$ |
| | Asphalt | 20,800 | $m^3$ |
| Offshore Substation Platform Fluids & Gases | Oil & Grease | 4,262 | t |
| | Diesel | 213 | t |
| | SF6 | 64 | t |
| | Battery | 4,487 | t |

(*) The cables may be made from aluminium or copper. As the former has about three times the GWP, only aluminium was assumed as the worst case scenario.

## Manufacturing

Some of the values in the above section simply cover the production of, for example, a tonne of steel. Further emissions are embedded during the manufacturing of the windfarm components from those materials. From experience, it is not practical to gather actual manufacturing data for all components, and many would make a negligible contribution to the final impacts, but it was deemed appropriate to estimate the manufacturing burdens for some of the materials, as detailed in Table 31.4. The quoted weights were deduced from all of the data described above.

Table 31.4: Materials weights separately assigned manufacturing burdens

| Description | Detail | Value | Units |
| --- | --- | --- | --- |
| Metal working | Aluminium | 19,276 | t |
| Metal working | Copper | 133,644 | t |
| Metal working | Lead | 39,231 | t |
| Metal working | Steel | 403,953 | t |
| Plastic pipe production | Polyethylene | 6 | t |

## Installation

31.6.4 Installation covers the extensive effort associated with constructing the Project. For the different aspects of the installation, the typical assumed single-trip distances are presented in Table 31.5.

Table 31.5: Installation travel distances in km

| Vessel | Distance (km) |
| --- | --- |
| Helicopters | 75 |
| Foundations | 534 |
| WTGs | 158 |
| Cables | 845 |
| OPs | 280 |

31.6.5 Estimations were provided of the anticipated numbers of journeys that will be required by a range of vessels, as shown in Table 31.6. Combining these data led to the deduction of the total activities also presented in the table.

Table 31.6: Vessel activities during installation

| Vessel | Total Movements | Total Activity | Units |
|---|---|---|---|
| Helicopter | 375 | 101 | hr |
| Cable-burial | 32 | 54,080,000 | tkm |
| Cable-jointing | 16 | 27,040,000 | tkm |
| Cable-laying | 42 | 70,980,000 | tkm |
| Installation | 127 | 107,315,000 | tkm |
| Support | 3,662 | 1,547,195,000 | tkm |
| Transport | 964 | 407,290,000 | tkm |

31.6.6 An estimate of the piling work (energy per blow, strikes per pile, piles per turbine and total number of turbines) that would be necessary to construct the windfarm, lead to an estimation of 2,300TJ of energy. This is assumed to be delivered by diesel (with a NCV of 43GJ/t).

## Operation

31.6.7 During the operation of the Project, many trips will again be needed to keep the installation in good working order. The anticipated numbers of annual journeys are presented in Table 31.7.

Table 31.7: Vessel activities during operation and maintenance (per year)

| Vessel | Total Movements | Total Activity | Units |
|---|---|---|---|
| Helicopter | 2,216 | 598 | hr |
| Transport vessel | 2,216 | 936,429,000 | tkm |

31.6.8 The maintenance work will include regular replacement of various materials, listed in Table 31.8.

Table 31.8: Anticipated materials needed (per infrastructure item per year) during operation

| Material | Turbine | Substation | Units |
|---|---|---|---|
| Grease | 3,200 | 0 | l |
| Hydraulic oil | 6,400 | 0 | l |
| Gear oil | 12,800 | 0 | l |
| Nitrogen | 400,600 | 0 | l |
| Transformer silicon/ester oil | 48,100 | 0 | l |
| Diesel fuel | 3,200 | 64,100 | l |
| SF6 | 600 | 16,000 | kg |
| Glycol/Coolants | 96,100 | 0 | l |

31.6.9 It is also anticipated that the Project will consume a relatively low level of grid electricity itself, in order to enable its efficient operation. There is some uncertainty about the level involved, however the estimate used in these calculations is 5,446 MWh/year.

## Freight

31.6.10 In addition to the vessel movements already described, the calculations consider the freight that will bring the construction and maintenance materials to the local area, and (at end of life) remove the materials for recycling or disposal. The estimated total additional amounts of freight movements required, in thousands of tonne-kilometres (ktkm) by road and by sea, are presented in Table 31.9.

Table 31.9: Additional anticipated freight requirements

| Stage | Road ktkm | Rail ktkm | Ship ktkm | Air ktkm |
|---|---|---|---|---|
| Raw Materials | 87,894 | 0 | 10,370,352 | 0 |
| Manufacturing | 0 | 0 | 0 | 0 |
| Construction | 0 | 0 | 0 | 0 |
| Operation | 2,033 | 0 | 0 | 0 |
| End of Life | 127,770 | 0 | 0 | 0 |
| Total | 217,697 | 0 | 10,370,352 | 0 |

## Decommissioning (End of Life)

31.6.11 It is difficult to be certain what will happen to the Project's materials at end of life, simply because this will not occur for at least another 35 years, by which time, the state of available technology may be very different. To a large extent, however, the choice of the "cut-off" approach to accounting for recycled content and recycling means this is less critical.

31.6.12 In that accounting framework, the Project could be given credit for any recycled materials used in its lifetime, as these (typically) contain less embedded carbon than the virgin materials they replace. In reality, as described in the Materials section above, it has been assumed that all materials are virgin. At end of life, the materials are charged with the further burdens of their management, until they reach their final resting place, or are ready to become new materials.

31.6.13 For wind turbine infrastructure, this means that the transport elements at end of life must be included, but once the materials reach the point where they are ready to be recycled, they exit the analysis boundary and are not further considered. Moreover, for the materials that are landfilled, associated emissions should be included, however it is anticipated that there should be little if anything emissions of the materials whilst in a landfill, so the burden is reduced to the freight impacts also ready mentioned above.

## 31.7 Life Cycle Impact Assessment

31.7.1 By bringing all the above information, and applying appropriate characterisation factors, a first estimation was determined.

### Characterisation factors

31.7.2 Three sources were used to estimate the unit impacts of the different flows required across the lifetime model of the windfarm, as follows:

- For two factors (as well as some energy unit conversions), it was necessary to use the UK Government's "conversion factors for company reporting of greenhouse gas emissions". These are themselves based on the Fourth Assessment Report (AR4) from the International Panel on Climate Change (IPCC);
- For one factor, the University of Bath's Inventory of Carbon and Energy (2019) dataset was used; and
- All the remaining characterisation factors were taken from the Ecoinvent database (2023). To ensure consistency with the UK Government's data, the method used was the same IPCC2007 data from the AR4 report.

31.7.3 This selection of sources for the characterisation factors means that all impacts are reported as emissions of greenhouse gases that contribute to climate change, considered over a 100-year period, relative to the impact of carbon dioxide, so in units of weight of carbon dioxide equivalents.

### Climate Change Results

31.7.4 Applying the chosen characterisation to the inventory of flows generated during the data collection, and summing by life cycle stage, led to the compilation of the initial results presented in Table 31.10 below.

Table 31.10: Climate change impact (in t $CO_2$eq) contributions from each life cycle stage

| Life Cycle Stage | GWP100a (t $CO_2$eq) |
|---|---|
| Raw Materials | 3,561,000 |
| Manufacture | 1,397,000 |

| Life Cycle Stage | GWP100a (t $CO_2$eq) |
|---|---|
| Transport | 126,000 |
| Installation | 21,000 |
| Operation and Freight | 427,000 |
| End Of Life | 0 |
| **Total** | **5,532,000** |

31.7.5 The results show that the Project's materials (and their manufacture) make the largest contribution to the overall impacts. In contrast, despite the large number of vessel movements throughout the lifetime, the impacts from transport are relatively insignificant. Equally, the uncertainty around the levels of electricity consumed by the Project is unlikely to be material, as the use phase impacts are of the order of a thousand times smaller than materials and manufacturing.

## Carbon Intensity Calculation

31.7.6 5.5Mt $CO_2$eq is a significant amount of carbon emissions for the Project over its lifetime, but this should be assessed in the context of the electricity it will generate. There are uncertainties about how much electricity will be generated (these are explored later), however it is estimated that its annual production levels might be of the order of 7,227GWh/yr. Running at this rate for 35 years, the Project will generate 253,000GWh of electricity over its lifetime. Dividing the aforementioned 5.5Mt $CO_2$eq of carbon emissions across this electricity generated yields the average carbon intensity of the electricity over the Project's lifetime:

- Project carbon intensity $= \frac{\text{Lifetime carbon emissions}}{\text{Lifetime electricity generated}} = \frac{5{,}532{,}000}{253{,}000} =$ 21.4t/GWh (or g/kWh)

## Pay Back Period

31.7.7 It is common practice to determine the Project's "pay-back" period – that is, how long into the lifetime of the windfarm before the carbon emissions associated with its construction are counter-acted by the lower carbon emissions of the electricity it generates. In order to perform this calculation, it is necessary to determine how the electricity would otherwise be generated. It is accepted that, when the windfarm comes online, its additional electricity will not replace nuclear or other renewable generating technologies. Rather, it will displace whatever generation technology would have been "the last to be turned on" – not the grid mix, therefore, but the so-called "marginal mix". In the UK, for the foreseeable future, the marginal mix technology is gas, which has a carbon intensity of about 372g/kWh[1]. Alternatively, RenewableUK recommends[2] using the DUKES "all non-renewable fuels" emission factor of 432g/kWh[1].

[1] Taken from DUKES 2022 data, Table 5.14.

[2] See https://www.renewableuk.com/page/UKWEDExplained

31.7.8 Multiplying these intensities by the 7,227GWh of electricity generated each year reveals that the counterfactual-sourced electricity would be responsible for 2.7Mt $CO_2$eq (gas) or 3.1Mt $CO_2$eq (all non-renewables) each year. The cumulative impact of this over the first three-years of operation is compared in Figure 31.1 with the total lifetime impact for the Project. As the annotation shows, under the assumptions outlined above, the Project would be expected to achieve payback in about two-years (and then deliver annual savings for each of the following 33-years of operation).

31.7.9 Another way of looking at this is to determine the cumulative impacts of 35-years of the alternative electricity sources. These turn out to be 94 (gas) or 109Mt $CO_2$eq (all non-renewables), respectively 17 and 20 times the lifetime carbon impacts of the Project.

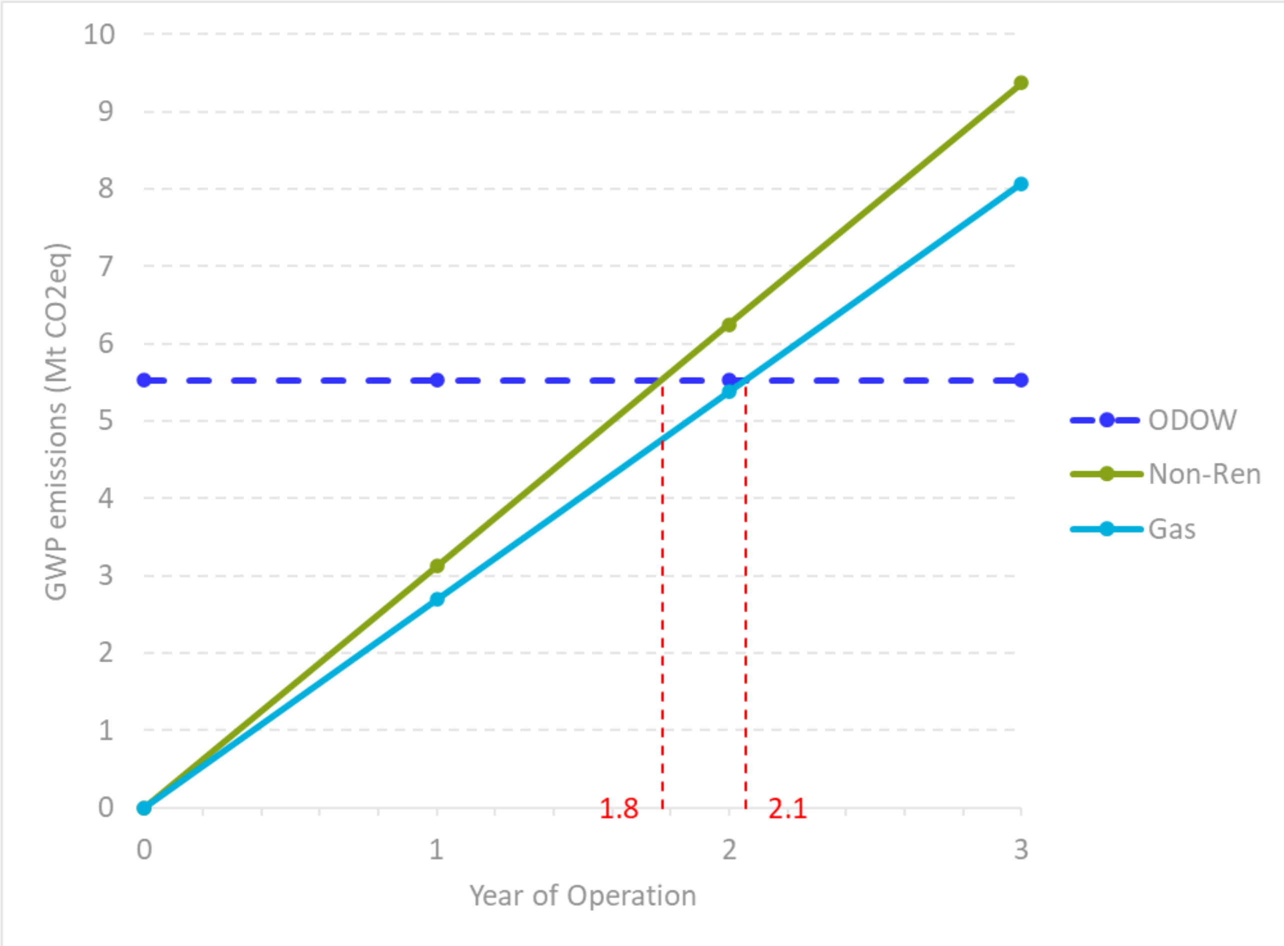


Figure 31.1: Cumulative GWP emissions from Project versus counterfactuals

## Sensitivity Testing

31.7.10 As demonstrated in Figure 31.1 above, it is good practice to explore how the results might depend on important uncertainties or assumptions in the underlying data. In this instance, the results are quite conclusive that the Project is (17-20 times) better than the likely counterfactual electricity alternatives. However, it is still instructive to explore how much the values might change, based on changes in the underlying data. In this section, two further checks are performed below.

### Annual Electricity Production

31.7.11 It was stated above that there is some uncertainty about the amount of electricity that the Project might annually produce, with the initial value used being 7,227GWh. Underpinning this value is an inherent assumption about the possible load factor of the Project; what if that were unduly optimistic?

31.7.12 To explore this, two scenarios were proposed, in which the electricity generated might be lower than the initial assumption. Reducing the electricity by 10% increases the payback time to 2.0-2.3 years, so has little effect on the results. To explore a much more extreme possibility, the annual electricity production was halved, to 3,614GWh/yr. Even under these circumstances, the Project still achieved carbon payback after 3.5-4.1-years of operation. The Project conclude from these results that the GHG results are relatively robust to uncertainties around the exact amount of electricity that will be generated.

### Construction Burdens

31.7.13 As there are some uncertainties about the exact details surrounding the materials to be used for the Project, it was decided to explore how the results would change if the material burdens were double the originally estimated values. In this scenario, the Project would take 2.9-3.4-years to payback its carbon burden, once again demonstrating the strong carbon benefit of the Project.

## 31.8 Summary

31.8.1 This study has performed a LCA of the Project. The scope considered impacts across the whole life cycle, from the production of the raw materials used to construct the facility, all the way through to the recycling or disposal of those same materials after decommissioning at the end of its lifetime.

31.8.2 The greenhouse gas emissions across an assumed 35-year lifetime operation are estimated to be 5.5Mt $CO_2$eq. The Project is expected to produce 7,227GWh of electricity each year, meaning the carbon intensity of the electricity generated will be about 21.4g $CO_2$eq/kWh.

31.8.3 When compared with the alternative of generating the electricity by gas CCGT (with a carbon intensity of 372g $CO_2$eq/kWh) or “all non-renewables” (432g $CO_2$eq/kWh), the Project will pay-back the embedded emissions in its construction in about two years.

## 31.9 References


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