Rampion 2 Wind Farm

Category 6: Environmental Statement

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1. Introduction

1.1 Overview

1.1.1 The greenhouse gas (GHG) assessment within **Chapter 29: Climate change, Volume 2** of the ES (Document Reference: 6.2.29) has been based on design assumptions described in **Chapter 4: The Proposed Development, Volume 2** of the ES (Document Reference: 6.2.4). Where further information has been obtained from the project designers or literature sources this is described in this Appendix.

1.2 Embodied carbon

1.2.1 GHG emission factors have been sourced primarily from the Inventory of Carbon and Energy (ICE) Database (ICE, 2019) and supplemented by literature studies where required.

1.2.2 GHG emission factors for the principal materials required for the Proposed Development are noted below. These are sourced from the ICE Database unless otherwise stated:

- steel, global seamless tube – 2.13kgCO_2e/kg;
- steel, cold-rolled coil – 2.73kgCO_2e/kg;
- fibreglass – 8.1kgCO_2/kg;
- iron (used for cast iron) – 2.03kgCO_2e/kg;
- copper – 2.71kgCO_2e/kg;
- SF_6 (production) – 9.00kgCO_2/kg (Harrison et al., 2010)
- stone (used for rock armour protection) – 0.079kgCO_2e/kg;
- gravel (used for scour protection gravel bed) – 0.007kgCO_2e/kg;
- aluminium – 6.67kgCO_2e/kg; and
- concrete – 0.103kgCO_2e/kg.

1.2.3 Embodied carbon represents the amount of GHG emissions produced during the process to create a product including its extraction, refinement, process, transport and fabrication. The exact location of the manufacture of equipment and plant will not be known until detailed design which will likely occur post consent and therefore, assumptions based on professional judgement have been made to estimate the distance from suppliers to the Proposed Development. European or worldwide embodied carbon factors from the ICE database have been used where possible to represent potential variations in transport requirements.

1.3 Wind turbine generator (WTG) and foundations

1.3.1 At present, best-in-class WTG design has a maximum generating capacity of 14MW. Based on results of a literature review, a linear relationship is found between WTG total material balance and key parameters of WTGs, including generating capacity, rotor blade diameter and tower height. This scaling has been used to estimate approximate material quantities for turbines considered in the GHG assessment based on available data from Siemens Gamesa SG222 14 megawatts (MW) WTG. Materials required for the construction of the blades, blade bearings, hub, generator, main bearing, transformer, convertor, nacelle cover, nacelle main frame, pitch cylinder, yaw and bedframe, cooling, tower and switchgear have been provided.

1.3.2 Total material quantities for the smaller WTG and individual WTG components have been determined based on linear interpolation using rotor blade diameter and tower height assumptions described in **Chapter 4: The Proposed Development, Volume 2** of the ES (Document Reference: 6.2.4) and giving consideration to potential future capacity based on technological development. The greatest material quantities have been taken in all cases.

1.3.3 To ensure a proportionate approach, GHG emissions have only been calculated for the main materials associated with the WTG which includes fibreglass, steel alloy, cast iron, steel and copper. These materials contribute 98.28% of the total weight of the WTG and therefore represents a proportionate approach. Quantities are given in **Table 1-1**.

Table 1-1 Material quantities and GHG emissions for the key materials within WTG

Material	Estimated weight for one smaller turbine (tonnes)	GHG emission factor ($kgCO_2e/kg$)	Total GHG emissions for 90 smaller WTG ($ktCO_2e$)
Fibreglass (expoxy)	167.9	8.10	122.4
42CrMo4 (steel alloy)	41.0	2.13	7.9
Cast iron	122.9	2.03	22.4
Steel	1,259.6	2.13	241.5
Copper	83.5	2.71	20.4
Other	22.4	N/A	N/A
TOTAL	1,704.1	-	**414.6**

1.3.4 To provide a worst-case assessment, it has been assumed that all foundations will be multileg jacket foundations since these are associated with a greater quantity of steel and therefore embodied carbon emissions. The weight of one jacket foundation is taken as 2,160 tonnes and is assumed to be composed entirely of steel. No other materials have been assessed within the GHG assessment as these are assumed to compose <1% of the material weight. The Institute of Environmental Management and Assessment (IEMA) Guidance (IEMA, 2022) states that activities that do not significantly change the result of the quantification can be excluded.

1.3.5 For the scour protection, it has been assumed that the rock armour has a density of 2,650kg/m^3 while the gravel bed has a density of 1,346kg/m^3. Volumes of scour protection are consistent with the worst-case information provided for the smaller WTG type in **Chapter 4: The Proposed Development, Volume 2** of the ES (Document Reference: 6.2.4).

1.4 Cables

1.4.1 GHG emission factors for the inter-array cables and offshore export cable have been based on literature studies of similar projects. The array cables are estimated to have an embodied carbon of 39,387kgCO_2e/km, which has been based on the results of four studies with values ranging from 20,486 – 63,653kgCO_2e/km (Birekland, 2011; Chapman, 2015; Xodus Group, 2012 and Arvesen et al., 2014).

1.4.2 Literature studies have been bench-marked against the Proposed Development specific data to confirm accuracy where GHG emissions have been calculated based on the anticipated weight of copper core material within the export cables (400mm^2 cores, total weight of 2,688 tonnes). Both methods for calculation of GHG emissions from the inter-array cables were found to be in the same order of magnitude. The calculation method based on literature study has been used in the GHG assessment as it provides a representation of other materials within the cables (i.e. insulation and armour) and can therefore be considered worse-case.

1.4.3 The export cables have been estimated to have an embodied carbon of 97,902kgCO_2e/km, which has been based on the results of three studies with values ranging from 58,394 – 119,652kgCO_2e/km (Birkeland, 2011; Chapman, 2015; and Xodus Group, 2012).

1.4.4 Literature studies have been bench-marked against Proposed Development specific data to confirm accuracy where GHG emissions have been calculated based on the anticipated weight of aluminium core material within the export cables (1,600mm^2 cores, total weight of 2,293 tonnes). Both methods for calculation of GHG emissions from the export cables were found to be in the same order of magnitude. The calculation method based on literature study has been used in the GHG assessment as it provides a representation of other materials within the cables (i.e. insulation and armour) and can therefore be considered worse-case.

1.4.5 The onshore cable has been based on the aluminium core weight only, assuming that 1,400 mm^2 aluminium cable cores will require 1,832 tonnes of aluminium.

1.5 Substations

1.5.1 It has been assumed that three offshore substations will be required, each comprising a topside structure (2,000 tonnes of steel per topside) situated on a jacket foundation (1,500 tonnes of steel per jacket). Although the substations will require quantities of other materials, including oil and SF_6 gas, these materials have not been included in the assessment as these have been assumed to compose <1% of the material weight. Institute of Environmental Assessment and Management (IEMA) Guidance (IEMA, 2022) states that activities can be excluded where they do not significantly change the result of the quantification.

1.5.2 The onshore substation at Oakendene is expected to comprise electrical equipment and buildings. The quantities of materials required for each component are shown in **Table 1-2**. Materials required for foundations of the electrical equipment have not been included at this stage as detailed design is unknown.

Table 1-2 Material quantities for components of the onshore substation at Oakendene

Component	No. required	Silicon steel (kg)	Copper (kg)	Steel (kg)	Oil (tonnes)	SF_6 Gas (kg)
650MVA 400kV/275kV Main Transformer	3	134,200	19,867	70,800	165	-
275kV Reactor	6	47,300	7,000	25,000	34	-
Auxiliary Transformer	3	96	15	71	0	-
STATCOM Transformers	6	22,500	3,060	10,900	8	-
275kV Gas Insulated Switchgear (GIS) Switchgear	14	-	-	27,000	-	2,000
400kV GIS Switchgear	7	-	-	40,000	-	3,000

1.5.3 Oil within the onshore substation has been assumed to be naphtha liquid fuel with a GHG emission factor of 3,142.37kgCO_2e/tonnes (Department for Business, Energy & Industrial Strategy (BEIS), 2023).

1.5.4 The onshore substation at Oakendene includes a control building (floor area of 784m^2), a 275kV GIS building (floor area of 875m^2) and a 400kV GIS building (floor area 700m2). The existing National Grid Bolney substation extension will include the construction of a GIS building (floor area $700m^2$). These buildings have been assumed to be steel framed industrial buildings with an estimated embodied carbon per square metre of 234kgCO_2e (Building Design, 2021).

1.6 Joint Bays

1.6.1 Joint bays (JB) have been assumed to be 14m x 4m. It has also been assumed that these will be constructed from concrete. The number of joint bays is consistent with details provided in **Chapter 4: The Proposed Development, Volume 2** of the ES (Document Reference: 6.2.4).

1.7 Transport of materials and labour to site

1.7.1 It has been assumed that all workers will commute a one-way distance of 13.2km to the onshore site by light goods vehicle (LGV), based on 2022 data from the Department for Transport on average commuting distances.

1.7.2 All materials for the onshore works have been assumed to be transported to the site by heavy goods vehicles (HGV). The vast bulk of HGV movements relate to transport of sand and gravel / crushed stone. In the absence of firm procurement decisions, which will be made at detailed design post-DCO Application, the assumed distance travelled by HGV (71km) has been based on an average distance from potential outlets for such materials in the geographical vicinity of the Proposed Development.

1.7.3 All materials for the offshore works are assumed to be transported to the site by marine vessel. The location of the Marshalling Yard/Pre-Assembly Harbour has been assumed as the base for installation vessels, transport vessels and cable laying vessels. It is assumed to be based in Northern Europe (UK, Netherlands or Germany).

1.8 Construction and installation processes

1.8.1 Energy use from onshore construction processes has been estimated as 0.12% of the GHG emissions from embodied carbon associated with the Proposed Development. This value is based on recent lifecycle carbon assessments for offshore wind farms similar to the Proposed Development (Xodus Group, 2012; Norfolk Boreas Offshore Wind Farm, 2020) which ranged from 0.04 – 0.28% of embodied carbon emissions. This is in lieu of more detailed information for construction processes on site which will not be available until later in the design process.

1.8.2 GHG emissions for the marine vessels have been calculated using the following approach:

- $GHG\ emissions\ (kgCO_2e) = C\ (kgCO2e/l) \times SFC\ (l/kWh) \times P\ (kW) \times t\ (h)$

1.8.3 This is based on:

- GHG emission factors ©: BEIS 2023 GHG emission factors for marine fuel oil of 3.10kgCO_2e/l or marine gas oil of 2.77kgCO_2e/l (BEIS, 2023);

- specific fuel consumption (SFC): of 0.226l/kWh;
- effective power of the vessel's engines (P), based on broad assumptions of the use of similar vessels to those used for the existing Rampion 1 project; and
- time (t) in hours that the power is required.

1.8.4 A range of marine vessels are required for construction and installation. For each broad category, example vessels based on those used for the existing Rampion 1 project have been used to inform the effective power (effective power including all efficiency losses) of vessel engines. This is set out in **Table 1-3**. Technological advances in marine vessels mean that this is considered a worse-case scenario approach.

1.8.5 The quantity of time spent on each activity has been generated from a literature review and is set out in **Table 1-3** for each broad category of marine vessel. Time spent in transit is assumed to use 100% total installed power (worse-case scenario), while based on a literature review, time spent within the array is assumed to use 28% of total installed power.

1.8.6 Offshore cable laying is assumed to be laid at rate of 5km/day.

Table 1-3 Categories of marine vessel and total installed power (kW)

Category of marine vessel	Total installed power (kW)	Estimate of (non-transit) activity (hours) per marine vessel movement
Installation vessels – WTG / foundations	15,586	24
Support vessels	6,500	12
Transport vessels	16,200	24
Crew transfer vessels	1,104	8
Main laying vessels	14,740	112
Main jointing vessels	10,200	100
Main burial vessels	10,200	168
Spoil barges	803	5

1.8.7 Other vessels, notably smaller craft and crew transfer vessels are assumed to be locally sourced, with an assumed average distance of 34.5km from port to the centre of the array.

1.9 Operation and maintenance GHG emissions

1.9.1 Operation and maintenance phase activities of the onshore elements of the Proposed Development are described in **Chapter 4: The Proposed**

Development, Volume 2 of the ES (Document Reference: 6.2.4) and are anticipated to be minimal. This is because maintenance of the onshore cable will be undertaken by light vehicle access only, while monitoring of the onshore substation will be undertaken remotely and is only expected to require minimal scheduled maintenance and operation activities. The GHG emissions associated with this activity is therefore negligible and has been scoped out of the GHG assessment.

1.9.2 Operation and maintenance phase activities occurring offshore are anticipated to include:

- array and export cable repairs;
- replenishment of array and export cables rock protection;
- J-tube replacements on WTG and offshore substations;
- anode replacement on the WTG and offshore substation;
- ladder replacements on the WTG and offshore substation;
- WTG exchange events associated with failures of major WTG components; and
- offshore substation exchange events associated with major failures.

1.9.3 GHG emissions associated with the materials required for these operation and maintenance phase activities are detailed in **Table 1-4**.

1.9.4 For the purposes of the GHG emissions assessment, it has been assumed that no onshore cables require replacement and materials required for painting and cleaning events of WTGs are scoped out.

1.9.5 J-tubes are assumed to weigh 184.19kg/m and be 10m in length based on literature searches (Flamco, 2013).

1.9.6 Anodes consists of 45kg of aluminium based on literature studies (Cathwell, 2021).

1.9.7 Ladder replacements are assumed to be associated with the replacement of the external ladder from the boat landing to the work platform. Expert knowledge from the existing Rampion 1 project suggests that the total weight of the boat landing, rest platforms and external access ladder is 14,393kg. It is assumed that this is all composed of steel. It is unknown what proportion of this weight is associated with the external access ladder and therefore the total weight has been used as a worse case in the GHG emissions assessment.

1.9.8 Exchange events are associated with failures of major WTG components. This cannot be quantified since it will depend on the reliability of the various components and the nature of failures and therefore an estimate has been provided.

1.9.9 The average weight of the components of the 14MW WTG described in **Table 1-4** is 119 tonnes which is equivalent to 7% of the total weight of the 14MW WTG, although it is recognised that the components will all have varying embodied carbon associated with their replacement. Lifecycle carbon assessments for offshore wind farms have suggested that spare parts account for 10% of production costs (Chapman, 2015) and 16% of GHG emissions associated with WTGs (embodied carbon and installation). For the Proposed Development, exchange events in the WTG have therefore been estimated as 10% of the embodied carbon of WTG.

1.9.10 This approach has also been applied to exchange events associated with the offshore substations which are estimated as 10% of the embodied carbon of the offshore substation.

1.9.11 A worse-case scenario approach has been taken with regard to vessel movements associated with operation and maintenance activities, including the following:

- Vessel movements are assumed to originate in Newhaven;
- numbers of Jack up vessels required is based on a worse-case per year scenario (rather than an average); unlike other operational and vessel movements, these will originate from Northern Europe and be utilised for 14 days per occurrence; and
- each operation and maintenance activity will require a separate vessel movement.

1.9.12 Assumed 'work' hours for different operation and maintenance activities have been taken from literature reviews including: crew transfer vessels (8 hours work); minor repairs (average of 8 hours); major repairs (average of 34 hours); substation major repair (average of 48 hours); and cable replacement (average 32 hours).

1.9.13 Offshore operation and maintenance activities are assumed to require some road journeys associated with workers commuting. It has been assumed that 50 staff vehicles per day will be required in line with **Chapter 23: Transport, Volume 2** of the ES (Document Reference: 6.2.23). Consistent with previous assumptions, a one-way distance of 15km by light goods vehicle (LGV) is used, based on 2022 data from the Department for Transport (DfT, 2022) on average commuting distances. Calculations are based on 265 working days per year for 30 years.

Table 1-4 Breakdown of embodied carbon associated with materials required for the operation and maintenance phase

Component	Activity data	GHG emissions ($ktCO_2e$)
Array cable repairs	3.6km of cable (68 lifetime events, 600m per event)	1.6
Export cable repairs	2.4km of cable (4 lifetime events, 600m per event)	0.2
Rock replacement for cables (array and export)	311,375,000 kg of stone (25% of original rock protection volume)	33.8

Component	Activity data	GHG emissions ($ktCO_2e$)
J-tube replacements (WTG and offshore substation)	44,206kg of steel (240 events)	0.1
Anode replacement (WTG and offshore substation)	22,950kg of aluminium (510 events)	0.3
Ladder replacement (WTG and offshore substation)	6, 908,640kg of steel (480 events)	14.7
WTG exchange events	10% of embodied carbon associated with WTG	41.5
Offshore substation exchange events	10% of embodied carbon associated with offshore substation	2.2
TOTAL		**94.4**

1.10 Glossary of terms and abbreviations

Table 1-5 Glossary of terms and abbreviations

Term	Description
Carbon	'Carbon' is used as shorthand to refer to the basket of six greenhouse gases (GHGs) recognised by the Kyoto Protocol (UFCCC, 2015). GHGs are converted to carbon dioxide equivalents (CO_2e) based on their global warming potential per unit as compared to one unit of CO_2.
Carbon dioxide equivalent (CO_2e)	Carbon dioxide equivalent (CO_2e) is a term for describing different GHGs in a common unit. For any quantity and type of GHG, CO_2e represents the amount of carbon dioxide (CO_2) which would have the equivalent global warming impact.
Carbon payback period	The period of time required before displaced GHG emissions equal the life cycle GHG emissions for the Proposed Development.
Climate change	The United Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: *'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'* (UNFCCC, 1992). While climate change can be attributable to natural causes, the UNFCCC distinguish climate change as related to human activities altering the atmospheric composition and climate variability.
Climate Change Resilience (CCR)	The ability to successfully withstand the impacts of climate change.
Climate Change Risk Assessment (CCRA)	An assessment considering UK-wide climate risks and opportunities across multiple sectors of the economy (Defra, 2022).
CO_2	Carbon dioxide
Department for Business, Energy & Industrial Strategy (BEIS)	The Government department formerly responsible for business; industrial strategy; science; research and innovation; energy and clean growth; and climate change.
Development Consent Order (DCO)	This is the means of obtaining permission for developments categorised as Nationally Significant Infrastructure Projects, under the Planning Act 2008.

Term	Description
Environmental Impact Assessment (EIA)	The process of evaluating the likely significant environmental effects of a proposed project or development over and above the existing circumstances (or 'baseline').
Embodied carbon	The embodied carbon describes the carbon footprint of a material, allowing for the sum of the energy required in resource extraction, and any processing required, as well as the transport and supply logistics to the factory gate (prior to transport to the Proposed Development for use), to be accounted for within the overall GHG estimation.
Environmental Statement (ES)	The written output presenting the full findings of the Environmental Impact Assessment.
GHG intensity	Measures the GHG emissions of different types of electricity generation relative to the intensity of the electricity generation. It is measured in emissions of CO_2e or CO_2 (e.g. gCO_2e, tCO_2 etc.), relative to an energy unit e.g. kWh, GWh, etc.
GIS	Gas Insulated Switchgear
Greenhouse Gas (GHG) emissions	GHG emissions are determined by the Kyoto Protocol (1997) to include six categories of gases: carbon dioxide, methane, nitrous oxide, F-gases (hydrofluorocarbons and perfluorocarbons), sulphur hexafluoride and nitrogen trifluoride. To provide consistent reporting of these gases, each is weighted by its global warming potential and converted to a carbon dioxide equivalent (CO_2e).
$GtCO_2e$	Giga-tonnes (Gt) of carbon dioxide equivalent (CO_2e).
GW	Gigawatts
HGV	Heavy Goods Vehicle
ICE	Inventory of Carbon and Energy
Institute of Environmental Management and Assessment (IEMA)	International membership organisation for environment and sustainability professionals.
Joint Bay (JB)	Terminology used to describe the structure in which cables are joined.
$ktCO_2e$	Kilo-tonnes (kt) of carbon dioxide equivalent (CO_2e).
LGV	Light Goods Vehicle

Term	Description
Low carbon activity	Low carbon activities are those that generate products or services which themselves deliver low carbon outputs.
Marine Intergovernmental Panel on Climate Change (IPCC)	The United Nations body for assessing the science relating to marine climate change.
$MtCO_2e$	Mega-tonnes (Mt) of carbon dioxide equivalent (CO_2e).
MW	Megawatts
N_2O	Nitrous oxide
Net zero GHG emissions	Net-zero GHG emissions are achieved when GHG emissions to the atmosphere are balanced by anthropogenic removals.
NPPF	National Planning Policy Framework
NPS	National Policy Statement
Planning Inspectorate	The Planning Inspectorate deals with planning appeals, national infrastructure planning applications, examinations of local plans and other planning-related and specialist casework in England and Wales.
Proposed Development	The development that is subject to the application for development consent, as described in **Chapter 4: The Proposed Development, Volume 2** of the ES (Document Reference: 6.2.4).
Receptor	These are as defined in Regulation 5(2) of The Infrastructure Planning 'Environmental Impact Assessment' Regulations 2017 and include population and human health, biodiversity, land, soil, water, air, climate, material assets, cultural heritage and landscape that may be at risk from exposure to direct and indirect impacts as a result of the Proposed Development.
RED	Rampion Extension Development Limited (the Applicant)
Scoping Opinion	A Scoping Opinion is adopted by the Secretary of State for a Proposed Development.
Scoping Report	A report that presents the findings of an initial stage in the Environmental Impact Assessment process.
Secretary of State	The Minister for Department for Energy Security and Net Zero (DESNZ).

Term	Description
United Nations Framework Convention on Climate Change (UNFCCC)	A United Nations framework ultimately aiming to prevent dangerous human interference with the climate system.
WRI	World Resources Institute
WTG	Wind Turbine Generator

1.11 References

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