MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

Environmental Statement

Volume 4, Annex 1.1: Greenhouse gas assessment

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Glossary

Term	Meaning
Generation Assets	The generation assets associated with the Morgan Offshore Wind Project and the Morecambe Offshore Windfarm include the offshore wind turbines, inter-array cables, offshore substation platforms and platform link (interconnector) cables to connect offshore substations.
Maximum design scenario	The realistic worst case scenario, selected on a topic-specific and impact specific basis, from a range of potential parameters for the Transmission Assets.
Morecambe Offshore Windfarm: Transmission Assets	The offshore export cables, landfall and onshore infrastructure required to connect the Morecambe Offshore Windfarm to the National Grid.
Morgan and Morecambe Offshore Wind Farms: Transmission Assets	The offshore export cables, landfall and onshore infrastructure for the Morgan Offshore Wind Project and the Morecambe Offshore Windfarm. This includes the offshore export cables, landfall site, onshore export cables, onshore substations, 400 kV grid connection cables and associated grid connection infrastructure such as circuit breaker compounds. Also referred to in this report as the Transmission Assets, for ease of reading.
Morgan Offshore Wind Project: Transmission Assets	The offshore export cables, landfall and onshore infrastructure required to connect the Morgan Offshore Wind Project to the National Grid.
Offshore export cables	The cables which would bring electricity from the Generation Assets to the landfall.
Onshore export cables	The cables which would bring electricity from the landfall to the onshore substations.
Onshore Infrastructure Area	The area within the Transmission Assets Order Limits landward of Mean High Water Springs. Comprising the offshore export cables from Mean High Water Springs to the transition joint bays, onshore export cables, onshore substations and 400 kV grid connection cables and associated temporary and permanent infrastructure including temporary and permanent compound areas and accesses. Those parts of the Transmission Assets Order Limits proposed only for ecological mitigation/biodiversity benefit are excluded from this area.
Onshore substations	The onshore substations will include a substation for the Morgan Offshore Wind Project: Transmission Assets and a substation for the Morecambe Offshore Windfarm: Transmission Assets. These will each comprise a compound containing the electrical components for transforming the power supplied from the generation assets to 400 kV and to adjust the power quality and power factor, as required to meet the UK Grid Code for supply to the National Grid.
Substation	Part of an electrical transmission and distribution system. Substations transform voltage from high to low, or the reverse by means of electrical transformers.

Term	Meaning
Transmission Assets	See Morgan and Morecambe Offshore Wind Farms: Transmission Assets (above).

Acronyms

Acronym	Meaning
GHG	Greenhouse Gas
GWP	Global Warming Potential
HGV	Heavy Goods Vehicle
IPCC	Intergovernmental Panel on Climate Change
LCA	Life Cycle Assessment
UK	United Kingdom
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute

Units

Unit	Description
CO_2e	Carbon dioxide equivalent
GW	Gigawatts
kg	Kilograms
km	Kilometres
m	Metre
m^2	Square Metre
MVA	Megavolt amperes
MW	Megawatt
t	Tonnes

1 Greenhouse gas assessment

1.1 Introduction

1.1.1.1 This document forms Annex 1.1 of Volume 4 of the Environmental Statement (ES) prepared for the Morgan and Morecambe Offshore Wind Farms: Transmission Assets (hereafter referred to as the Transmission Assets).

1.1.1.2 This greenhouse gas (GHG) technical report sets out the methodology and calculations of the GHG emissions for the Transmission Assets. These calculations inform the assessment of the climate change impacts in Volume 4, Chapter 1: Climate change of the ES. This annex should be read in conjunction with the chapter as supporting information.

1.1.1.3 GHG emissions have been estimated by applying published emissions factors to activities in the baseline and to those required for the Transmission Assets. The emissions factors relate to a given level of activity, or amount of fuel, energy or materials used, to the mass of GHGs released as a consequence. This annex presents the technical calculations which form the basis of the potential magnitude of impact as assessed within the climate change chapter (Volume 4, Chapter 1: Climate change) of the ES.

1.1.1.4 The purpose of the Transmission Assets is to connect the Morgan Offshore Wind Project and the Morecambe Offshore Windfarm to the National Grid, contributing to:

- the United Kingdom (UK) Government's ambition to deliver 50 GW of offshore wind by 2030;
- delivering much needed investment and securing construction and operations jobs in the UK;
- securing our energy supply; and
- the UK's response to the climate change crisis.

1.1.1.5 The Morgan Offshore Wind Project: Generation Assets and the Morecambe Offshore Windfarm: Generation Assets (collectively known as the 'Generation Assets') will be consented separately (see Volume 1, Chapter 1: Introduction of the ES for further details). Therefore, the focus of this annex is on the impacts of the Transmission Assets.

1.1.1.6 However, given their purpose, the Transmission Assets would never operate in isolation. As such, the cumulative impacts of the Transmission Assets with the Generation Assets on the global atmospheric mass of CO_2 have been assessed. The findings of this cumulative assessment are set out in section 1.11 of Volume 4, Chapter 1: Climate change of the ES.

1.2 Scope

1.2.1.1 The GHGs considered in this assessment are those in the 'Kyoto basket' of global warming gases expressed as their CO_2-equivalent (CO_2e) global warming potential (GWP). This is denoted by CO_2e units in emissions factors and calculation results. GWPs used are typically the 100-year factors in the

Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (IPCC, 2013) or as otherwise defined for national reporting under the United Nations Framework Convention on Climate Change.

1.2.1.2 The annex scope considers the Transmission Assets during the construction, operation and maintenance, and decommissioning phases. Key emissions sources included in the assessment are:

- onshore and offshore land use change;
- embodied carbon emissions in materials; and
- transport emissions both onshore and offshore.

1.3 Methodology

1.3.1 Introduction

1.3.1.1 GHG emissions caused by an activity are often categorised into 'scope 1', 'scope 2' or 'scope 3' emissions, following the guidance of the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) Greenhouse Gas Protocol suite of guidance documents (WRI and WBCSD, 2004).

- Scope 1 emissions: direct GHG emissions from sources owned or controlled by the company, e.g. from combustion of fuel at an installation.
- Scope 2 emissions: caused indirectly by consumption of purchased energy, e.g. from generating electricity supplied through the national grid to an installation.
- Scope 3 emissions: all other indirect emissions occurring as a consequence of the activities of the company, e.g. in the upstream extraction, processing and transport of materials consumed or the use of sold products or services.

1.3.1.2 This assessment has sought to include emissions from all three scopes, where this is material and reasonably possible from the information and emissions factors available, to capture the impacts attributable most completely to the Transmission Assets. These emissions are not separated out by defined scopes (scopes 1, 2 or 3) in the assessment.

1.3.1.3 Due to the nature of the Transmission Assets, i.e. onshore and offshore infrastructure constructed to transport generated electricity from the Generation Assets to the grid, the gross GHG emissions total is dominated by embodied carbon emissions. As set out in **section 1.1**, details of the total emissions of the Transmission Assets with the Generation Assets are set out in Volume 4, Chapter 1: Climate change of the ES.

1.3.1.4 The Transmission Assets emissions include those resulting from the manufacturing and construction of the onshore substations, offshore and onshore cabling, cable protection, onshore cable crossings (i.e. where the onshore export cable corridor will cross existing infrastructure and obstacles), joint bays, transition joint bays and link boxes, in addition to fuel use by vehicle movements. They have been calculated via a range of methodologies, including published benchmark carbon intensities and life cycle analysis (LCA) literature, and the application of material or fuel emission intensities to material or fuel quantities. Detailed information regarding the design parameters assessed is set out in Volume 4, Chapter 1: Climate Change of the ES, within Table 1.11.

1.3.1.5 Key sources relied upon for the assessment are as follows.

- Environmental Product Declaration Power transformer TrafoStar 500 MVA (ABB, 2003).
- RICS Professional Information, UK Methodology to calculate embodied carbon of materials RICS (2012).
- Inventory of Carbon & Energy (ICE) database (Jones and Hammond, 2019).
- Life Cycle Environmental Impacts of Offshore Wind Power Generation and Power Transmission (Birkeland, 2011).

1.3.2 Embodied carbon

1.3.2.1 An LCA comprises an evaluation of the inputs, outputs and potential environmental impacts that occur throughout the lifecycle of a particular project, in this case electricity transmission infrastructure associated with offshore wind farms, encompassing either a cradle-to-gate (project site) or a cradle-to-grave (accounting for in use and decommissioning) approach. This can be further broken down into the following LCA phases of development:

- materials and construction (LCA stages A1-A5);
- operation and maintenance (LCA stages B1-B5); and
- decommissioning (LCA stages C1-C4).

1.3.2.2 As the Transmission Assets are currently in the relatively early stages of design, data relating to specific metrics for site-specific design details, including two substations and cable designs etc. are currently unavailable. Therefore, data has been extracted from peer reviewed reports or estimated based on approximate material quantities and associated materials carbon intensity figures, to provide estimate figures for each stage of this LCA. Methodology specific to each item assessed is summarised within **sections 1.5**, **1.7**, and **1.8**.

1.3.3 Land use change

1.3.3.1 The calculation of climate change effects as a result of land use change considers the potential impact of the Transmission Assets on carbon sinks that may be required for temporary and permanent land take. The development of biodiversity benefit and mitigation areas are excluded from this assessment as they are not considered to result in a material increase in GHG emissions during the construction, operation and maintenance, and decommissioning phases.

1.4 Assumptions and limitations

1.4.1.1 The majority of the construction phase GHG emissions associated with the manufacturing of components is likely to occur outside the territorial boundary of the UK and hence outside the scope of the UK's national carbon budget, policy and governance. However, in recognition of the climate change effect of GHG emissions (wherever occurring), and the need to avoid 'carbon leakage' overseas when reducing UK emissions, emissions associated with the construction stage have been presented within the assessment and quantification of GHG emissions as part of the Transmission Assets.

1.4.1.2 Due to the relatively early stage in the development design, there is a degree of uncertainty regarding the construction stage GHG emissions resulting from the manufacturing and construction of the Transmission Assets. The assessment has sought to limit the impact this may have by assessing a maximum design scenario (which will result in a conservative or worst case assessment). The maximum design scenario considers the scenario resulting in the greatest potential for GHG emissions (i.e. the greatest number and size of structures, resulting in the greatest consumption of fuel and materials). Detailed information regarding the maximum design scenario assessed is set out in **Table 1.1**, below.

1.4.1.3 Detailed LCA information is not yet available for all items specific to electricity transmission infrastructure. As such, where not available, a conservative estimate of construction materials or fuels has been scaled by relevant emissions factors. These emissions factors do not account for emissions associated with the manufacture of products, and as such may underestimate embodied carbon emissions. However, it is unlikely that this would significantly impact the assessment of effects.

1.4.1.4 Currently, there is very little literature surrounding electricity transmission infrastructure only. Many offshore wind farm LCAs account for such infrastructure within their calculations, but largely do not provide a detailed breakdown of information for each item. As such, applications for offshore wind generation(considering generation infrastructure only) may include emissions associated with transmission infrastructure, despite lying outside of the scope of their assessment, as intensity factors reported may be difficult to separate out into individual wind farm elements. This assessment considers only electricity transmission infrastructure.

1.5 Key parameters for assessment

1.5.1 Maximum design scenario

1.5.1.1 The maximum design scenarios identified in **Table 1.1** have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. These scenarios have been selected from the Project Design Envelope provided in Volume 1, Chapter 3: Project description of the ES. Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the Project Design Envelope (e.g., different infrastructure layout), to that assessed here be taken forward in the final design.

Table 1.1: Maximum design scenario considered for the assessment of impacts

Impact	Phase[a]			Maximum Design Scenario
	C	O	D	
The impact of GHG emissions arising from the manufacturing and installation of the Transmission Assets.	✓	×	×	**Construction phase** • The greatest number of transport vehicles and vessels for the installation of the Transmission Assets (total 12 no. tug/anchor handlers, 46 no. cable lay installation and support vessels, 30 no. guard vessels, 6 no. survey vessels, 20 no. seabed preparation vessels, 148 no. crew transfer vessels, 22 no. cable protection Installation vessels, 20 no. helicopters, 356,408 no. heavy goods vehicles (HGVs), 898,127 no. light vehicles (LVs)). • The greatest area of onshore substations – 223,500 m^2 total permanent footprint (including landscaping, planting and drainage), this includes up to 28 buildings. Largest building up to 80 m in width, 140 m in length. • The maximum area of cable route (484 km x 350 mm offshore export cables (6 no.), 306 km x 300 mm onshore export cables (18 no.), 156 km x 300 mm 400 kV grid connection cable (12 no.)). • The maximum volume of cable protection (596,540 m^3). • The maximum area of joint bays and link boxes (25 m x 10 m x 4 m (170 no.), and 2 m x 5 m x 2 m (170 no.), respectively). • The maximum number of transition joint bays (6 no.). • The maximum area of direct pipe at landfall (1,500 m x 1.27 m maximum pipe diameter x 35 mm x 6 no. pipelines). • The maximum area of direct pipe for the crossing under Blackpool Airport (1,400 m x 1.5 m maximum pipe diameter x 35 mm x 6 no. pipelines). • The maximum area of direct pipe for the Ribble crossing (650 m x 1.57 m maximum pipe diameter x 35 mm x 4 no. pipelines). • The maximum area of Horizontal Directional Drilling (HDD) for the crossing under existing infrastructure and obstacles such as roads, railways and rivers (6,225 m x 0.315 m maximum duct diameter x 29 mm x 2 to 6 no. pipelines).
The impact of GHG emissions arising from the consumption of materials and activities required to facilitate the operation and maintenance of the	×	✓	×	**Operation and maintenance phase** • The greatest number of maintenance vehicles and machinery across the lifetime of the Transmission Assets (42 no. per year crew transfer vessels, 3 no. jack-up vessels, 4 no. per year cable repair vessels, 20 no. per year other vessels, 8 no. excavators, 16 no. helicopters, 12 no. per year inspection drones).

Impact	Phase[a]			Maximum Design Scenario
	C	O	D	
Transmission Assets.				
The impact of GHG emissions arising from land use change during the construction, operation and maintenance and decommissioning phases.	✓	✓	✓	**Construction, operation and maintenance and decommissioning phases** • The greatest permanent footprint of the onshore substations is 223,500 m^2 (including landscaping, planting and drainage). This includes up to 28 buildings. Largest building up to 80 m in width, 140 m in length. • The maximum area of cable route (484 km x 350 mm offshore export cables (6 no.), 306 km x 300 mm onshore export cables (18 no.), 156 km x 300 mm 400 kV grid connection cable (12 no.)). • The maximum volume of cable protection (596,540 m^3). • The maximum area of joint bays and link boxes (25 m x 10 m x 4 m (170 no.), and 2 m x 5 m x 2 m (170 no.), respectively). • The maximum number of transition joint bays (6 no.). • The maximum area of direct pipe at landfall (1,500 m x 1.27 m maximum pipe diameter x 35 mm x 6 no. pipelines). • The maximum area of direct pipe for the crossing under Blackpool Airport (1,400 m x 1.5 m maximum pipe diameter x 35 mm x 6 no. pipelines). • The maximum area of direct pipe for the Ribble crossing (650 m x 1.57 m maximum pipe diameter x 35 mm x 4 no. pipelines). • The maximum area of HDD for the crossing under existing infrastructure and obstacles such as roads, railways and rivers (6,225 m x 0.315 m maximum duct diameter x 29 mm x 2 to 6 no. pipelines).
The impact of GHG emissions arising from decommissioning works (e.g., plant, fuel and vessel use) and the recovery (or disposal) of materials.	×	×	✓	**Decommissioning phase** • Greatest number of transport vehicles and vessels for the installation of the Transmission Assets – the decommissioning sequence will generally be the reverse of the construction sequence and will involve similar types and numbers of vessels and equipment (total 12 no. tug/anchor handlers, 46 no. cable lay installation and support vessels, 30 no. guard vessels, 6 no. survey vessels, 20 no. seabed preparation vessels, 148 no. crew transfer vessels, 22 no. cable protection Installation vessels, 20 no. helicopters, 356,408 no. HGVs, 898,127 no. LVs). • The greatest area of onshore substations is 219,000 m^2 (including landscaping, planting and drainage). This includes up to 28 buildings. Largest building up to 80 m in width, 140 m in length. • The maximum area of cable route (484 km x 350 mm offshore export cables (6 no.), 306 km x 300 mm onshore export cables (18 no.), 156 km x 300 mm 400 kV grid connection cable (12 no.)).

Impact	Phase[a]			Maximum Design Scenario
	C	O	D	
				• The maximum volume of cable protection (596,540 m^3). • The maximum area of joint bays and link boxes (25 m x 10 m x 4 m (170 no.), and 2 m x 5 m x 2 m (170 no.), respectively). • The maximum number of transition joint bays (6 no.). • The maximum area of direct pipe at landfall (1,500 m x 1.27 m maximum pipe diameter x 35 mm x 6 no. pipelines). • The maximum area of direct pipe for the crossing under Blackpool Airport (1,400 m x 1.5 m maximum pipe diameter x 35 mm x 6 no. pipelines). • The maximum area of direct pipe for the Ribble crossing (650 m x 1.57 m maximum pipe diameter x 35 mm x 4 no. pipelines). • The maximum area of HDD for the crossing under existing infrastructure and obstacles such as roads, railways and rivers (6,225 m x 0.315 m maximum duct diameter x 29 mm x 2 to 6 no. pipelines).

[a] C=construction, O=operation and maintenance, D=decommissioning

1.6 Assessment of construction effects

1.6.1 Land use change

1.6.1.1 The infrastructure components of the Transmission Assets that will alter the onshore and offshore land/sea bed use comprise:

- onshore substations and associated infrastructure, including permanent access roads not located on existing tracks;
- landfall infrastructure (including transition joint bays);
- onshore export cables;
- 400 kV grid connection cables; and
- offshore export cables.

1.6.1.2 Land use change onshore and offshore is detailed below, with temporary and permanent change identified as relevant.

Onshore

1.6.1.3 Volume 3, Chapter 6: Land use and recreation and Volume 3, Annex 6.1: Published agricultural land classification and soils data of the ES outline the baseline conditions for the onshore components in terms of land use and any effects of the Transmission Assets on land use.

1.6.1.4 The current land use for the onshore elements of the Transmission Assets primarily comprises agricultural land. This land has been broadly categorised as Agricultural Land Grades 2, 3, and 4 with the likely presence of peat or peaty soils, based on available land classification mapping (see Volume 3, Annex 6.1: Published agricultural land classification and soils data of the ES, and Volume 3, Chapter 6: Land use and Recreation). With regards to the assessment of GHG emissions, land with high carbon stock such as woodland and peat is of most relevance. As is detailed within the Baseline section (Section 6.7) of Volume 3, Chapter 6: Land use and Recreation, there was potential for peat to the east and west of Huck Lane, however, surveys conducted in 2024 conclude that the potential peat land is categorised as organic carbon and not peat. Furthermore, the Desk Based Assessment (Volume 3, Annex 5.4: Geoarchaeological desk based assessment report of the ES) for the Historic Environment chapter has stipulated that any buried peat would be below 2 m and as such not disturbed by any construction activity.

1.6.1.5 Therefore, it is not anticipated that the Transmission Assets will directly affect any significant carbon stores (i.e. peat), and the change concerning the carbon storage value of the land use would be minimal. This is applicable for both temporary land use change, where the habitat is anticipated to return back to its pre-development habitat after decommissioning, and permanent land use change where the habitat may not be restored. Temporary and permanent land use change associated with the Onshore Infrastructure Area is detailed below.

1.6.1.6 Given the following processes following construction and during decommissioning, it is anticipated that land use change associated with the onshore export cables and 400 kV grid connection cables is temporary and the existing baseline environment would be restored:

- Once the onshore export cable and 400 kV grid connection cable installation work is completed the ground will be reinstated using stored subsoil and topsoil, the land will be restored to its original condition. Hedgerows will be replanted using locally sourced native species, where practicable.
- Joint bays will be completely buried, with the land above reinstated.
- The onshore export cables and 400 kV grid connection cables may be recovered and removed by pulling the cables through the ducts. Otherwise, they will be left in place in the ground with the cable ends cut, sealed and securely buried as a precautionary measure;
- Joint bays and link boxes will be removed only if it is feasible with minimal environmental disturbance or if their removal is required to return the land to its current agricultural use;

1.6.1.7 Given the following decommissioning process, land use change associated with the onshore substations may be permanent or temporary, depending on the outcome of the Onshore Decommissioning Plan (CoT36).

- The case for decommissioning the onshore substations in the event of the Generation Assets being decommissioned will be reviewed in discussion with the transmission system operator and any relevant regulators in the light of any other existing or proposed future use of the onshore substations. The onshore substations may result in permanent land use change should it remain in operation following discussion with the transmission system operator and the regulator at the decommissioning phase.
- If complete decommissioning takes place, then all the electrical infrastructure will be removed. Foundations will be broken up and the site reinstated, or alternatively repurposed for another use (may be subject to additional relevant consents and licences at the time).

Offshore

1.6.1.8 Volume 2, Chapter 2: Benthic subtidal and intertidal ecology of the ES outlines the baseline conditions for the offshore export cable corridor and any subsequent effects of the Transmission Assets on the sea bed.

1.6.1.9 The offshore environment consists of various subtidal habitats of mixed sediments comprising sand, mud and gravels, and intertidal mudflats. These habitats support diverse benthic sediment-based communities. Such environments are detailed within Volume 2, Chapter 2: Benthic subtidal and intertidal ecology of the ES.

1.6.1.10 The change in any sea bed use would be constrained to the Transmission Assets Order Limits: Offshore, with no direct impact on any carbon stores. The sea bed would be temporarily affected throughout the construction and operation and maintenance phases of the development. However, through the decommissioning process it is anticipated that the existing baseline environment would be restored, as the current preferred approach is to leave all offshore cables and any offshore cable protection may be left *in situ*, to minimise environmental impacts associated with their removal. However, a future scenario could exist where they may be retrieved and recycled, in line with latest relevant legislation and guidance at that time.

1.6.1.11 As no carbon stores are directly affected by the Transmission Assets and the benthic habitats are anticipated to return back to its pre-development habitat after decommissioning, the change concerning the carbon storage value would be minimal.

1.6.2 Embodied carbon

1.6.2.1 The following sections detail the methodology used to calculate the construction stage emissions associated with the Transmission Assets.

1.6.2.2 The construction stage emissions cover the LCA stages A1-A5, materials and construction, i.e., emissions associated with the extraction, processing and manufacturing of materials. In addition, emissions associated with the transport of materials and technology to site (within the UK) has been analysed.

Onshore Substations

1.6.2.3 The potential impact of the proposed onshore substations has been estimated using an intensity for the manufacturing GWP of 2,190 $kgCO_2e$ per MW (ABB, 2003). This was scaled by the total combined capacity of the Generation Assets, totalling 1,980 MW, to give an estimated embodied carbon value of 4,336 tCO_2e.

1.6.2.4 The onshore substation elements are to be housed within a number of main and secondary buildings. At this stage of design, material estimates have some uncertainty in terms of their quantities and specific products to be used in the final, detailed design. As such, a published benchmark (RICS, 2012) has therefore also been used to estimate possible emissions from the substation buildings. A carbon intensity of 545 $kgCO_2e/m^2$ was scaled by the total maximum area of proposed buildings (30,700 m^2), to give an embodied carbon value of 16,732 tCO_2e.

Export cables (onshore and offshore)

1.6.2.5 Construction stage emissions associated with the offshore export cables, onshore export cables and 400 kV grid connection cables have been calculated using approximate material quantities of copper and lead, and scaled by the length of each cable and relevant materials emissions factors (2.71 $kgCO_2e/kg$ for copper, 1.67 $kgCO_2e/kg$ for lead, Jones and Hammond, 2019). Material quantities applied to this calculation and resultant emissions are summarised within **Table 1.2**, below. Construction stage emissions associated with the offshore export cables, onshore export cables and 400 kV grid connection cables total 60,012 tCO_2e.

Table 1.2: Export cables material quantities

Cable Type	Cable length (km)	Cable weight factor (kg/m)		Material weight (kg)		Total embodied carbon (tCO_2e)	
		Copper	Lead	Copper	Lead	Copper	Lead
220 kV onshore export cables	306	17.0	10.4	5,202,000	3,182,400	14,097	5,315
220 kV or 275 kV offshore export cables	484			8,228,000	5,033,600	22,298	8,406
400 kV grid connection cables	156			2,652,000	3,182,400	7,187	2,709

1.6.2.6 Onshore export cables and 400 kV grid connection cables will be installed within cable ducts. Emissions associated with such ducts were estimated based on duct dimensions and material (349.95 km in length, 0.250 m maximum diameter, 7 mm wall thickness, construction from unplasticized polyvinyl chloride (UPVC)) and UPVC to weight ratio of 1,500 kg/m^3. Material quantities total 2,805,120 kg of UPVC, when scaled by the relevant material intensity factor (3.23 $kgCO_2e$/kg, Jones and Hammond, 2019) associated emissions total 9,061 tCO_2e.

Onshore cable crossings

1.6.2.7 The onshore export cable corridor and 400 kV grid connection cables will cross existing infrastructure and obstacles such as roads, railways and rivers. Methodologies for the calculation of emissions associated with the construction of such crossings are detailed below.

- Landfall: material quantities associated with the construction of the direct pipe between the transition joint bay working area and the beach were estimated based on the pipeline dimensions (1,500 m in length, 1.27 m maximum diameter, 35 mm wall thickness, 6 no. bores) and steel volume to weight ratio of 7,800 kg/m^3 (Jones and Hammond, 2019). Material quantities total 9,532,833 kg of steel pipe, when scaled by the relevant material intensity factor (2.78 $kgCO_2e$/kg, Jones and Hammond, 2019) associated emissions total 26,501 tCO_2e.
- Blackpool Airport crossing: material quantities associated with the construction of the direct pipe Blackpool Airport crossing technique were estimated based on the pipeline dimensions (1,400 m in length, 1.5 m maximum diameter, 35 mm wall thickness, 6 no. bores) and steel volume to weight ratio of 7,800 kg/m^3 (Jones and Hammond, 2019). Material quantities total 10,554,300 kg of steel pipe, when scaled by the relevant material intensity factor (2.78 $kgCO_2e$/kg, Jones and Hammond, 2019) associated emissions total 29,341 tCO_2e.
- Ribble Crossing: material quantities associated with the construction of the direct pipe crossing under the River Ribble were estimated based on the pipeline dimensions (650 m in length, 1.57 m maximum diameter, 35 mm wall thickness, 4 no. bores) and steel volume to weight ratio of 7,800 kg/m^3 (Jones and Hammond, 2019). Material quantities total

3,422,900 kg of steel pipe, when scaled by the relevant material intensity factor (2.78 $kgCO_2e/kg$, Jones and Hammond, 2019) associated emissions total 9,516 tCO_2e.

- Additional onshore cable crossings: the onshore export cable corridor will cross existing infrastructure and obstacles such as roads, railways and rivers. Material quantities associated with the construction of the HDD crossing technique (using high density polyethylene (HDPE)) were estimated based on the duct dimensions (6,225 m in length, 0.315 m maximum diameter, 29 mm wall thickness, 2 to 6 no. bores) and HDPE to weight ratio of 970 kg/m3. Material quantities total 2,832,028 kg of HDPE, when scaled by the relevant material intensity factor (2.52 $kgCO_2e/kg$, Jones and Hammond, 2019) associated emissions total 7,137 tCO_2e.

Cable Protection

1.6.2.8 Construction stage emissions associated with offshore cable protection were calculated by scaling the volume of cable protection (768,740 m^3) by an approximate material density to estimate the total weight of material, totalling 1,580,831 kg. This value was then scaled by the relevant material emission factor (0.007 $kgCO_2e/kg$, Jones and Hammond, 2019). Resultant emissions total 11,808 tCO_2e.

Joint bays, transition joint bays and link boxes

1.6.2.9 Material quantities associated with the construction of joint bays, transition joint bays and link boxes were estimated based on their dimensions (25 m x 10 m x 4 m, 80 m x 40 m x 4 m, and 2 m x 5 m x 2 m, respectively, assuming material thickness of 0.2 m). Material quantities total 40,632,000 kg of concrete, and scaled by the relevant material intensity factor (0.103 $kgCO_2e/kg$, Jones and Hammond, 2019). Total emissions were estimated at 4,185 tCO_2e.

Vehicle movements

1.6.2.10 Indicative vessel, helicopter, and onshore traffic movements were used to calculate emissions associated with their movements during the construction phase.

1.6.2.11 Emissions associated with vessel movements were calculated by estimating their total main engine energy requirement through multiplying the engine size of the vessels by anticipated activity hours informed by vessel speed and distance from port (vessel information was sourced from specifications of likely vessel types). This value was then scaled by the emission factor for marine gas oil (0.258 $kgCO_2e/kWh$) (DESNZ and Defra, 2024), totalling 6,006 tCO_2e.

1.6.2.12 Helicopter movements and their associated emissions were calculated by determining the anticipated fuel consumption, informed by their predicted movements. An indicative number of return trips and assumed distance from a potential helicopter base, alongside average fuel consumption (430 kg/hr) and fuel economy data (145 knots/hr) (obtained from manufacturers specifications) were used to estimate fuel consumption. Emission factors for aviation turbine fuel (2.54 $kgCO_2e/l$) (DESNZ, 2024) were then scaled by the fuel consumption to give associated emissions, totalling 16 tCO_2e.

1.6.2.13 HGV movements and personnel vehicle movements associated with the construction of the onshore export cables, 400 kV grid connection cables and onshore substations were scaled by an assumed average distance of travel (120 km for HGVs, in line with RICS whole life carbon guidance (2023), and 50 km for personnel) and an emissions factor for fully laden diesel HGVs (0.98496 $kgCO_2e/km$) and medium petrol car (0.17819 kgCO2e/km) (DESNZ and Defra, 2024). Resultant emissions associated with the onshore vehicle movements total 45,296 tCO_2e.

1.7 Assessment of operational effects

1.7.1 Fuel and energy consumption operation and maintenance activities

1.7.1.1 Emissions during the operational phase of the Transmission Assets refer to activities contributing to the high level management of the asset. Maintenance can be divided into preventative maintenance and corrective maintenance.

- Preventative maintenance: proactive repair to, or replacement of, known wear components based on routine inspections or monitoring systems.
- Corrective maintenance includes the reactive repair or replacement of failed or damaged components.

1.7.1.2 The Transmission Assets' maintenance activities largely involve inspection, remote monitoring, repainting, removal of marine growth, reburial of cables, and geophysical surveys. Emissions associated with such activities are largely captured within vessel or helicopter movements. Where materials are used (i.e., new paint and coatings), associated emissions are negligible and immaterial and as such have not been assessed further.

1.7.1.3 Emissions associated with the proposed maintenance vessel and helicopter movements follow the methodology detailed at **paragraphs 1.6.2.10 to 1.6.2.13.** Such emissions total 69,573 tCO_2e.

1.7.1.4 It is anticipated that the subtidal (i.e. below MLWS) offshore export cables may have up to 21 cable repair events over the Transmission Assets' 35 year lifetime, each up to 4 km of cable repair per event. The intertidal offshore export cables may have up to 8 repair events over the Transmission Assets' 35 year lifetime, with up to 1 km of repair per event for the for the Morgan Offshore Wind Project: Transmission Assets, and up to 2.4 km of cable repair per event for the Morecambe Offshore Windfarm: Transmission Assets. To present a maximum design scenario, it has been assumed that the repair event will involve replacing the respective cable lengths described above. Emissions associated with the replacement of such cables were calculated using the methodology detailed at **paragraph 1.6.2.5**. Total emissions from cable replacement over the project lifetime were calculated to be 7,283 tCO_2e.

1.8 Assessment of decommissioning effects

1.8.1.1 The majority of emissions during this phase relate to the use of plant for decommissioning, disassembly, transportation to a waste site, and ultimate disposal and/or recycling of the equipment and other site materials.

1.8.1.2 In the absence of detailed information regarding onshore and offshore transport movements during the decommissioning phase, it has been assumed that such emissions equal or are less than those associated with the construction phase, totalling 51,318 tCO_2e. Given carbon emissions associated with use of plant and fuel is expected to have achieved good levels of decarbonisation at the decommissioning phase of the Transmission Assets, this is likely to present a conservative worst-case scenario.

1.8.1.3 It is anticipated that the onshore export cables and 400kV grid connection cables will be left *in situ* or removed via joint bays. Joint bays and link boxes will be removed only if it is feasible with minimal environmental disturbance or if their removal is required to return the land to its current agricultural use. All offshore cables and any offshore cable protection may be left *in situ*, to minimise environmental impacts associated with their removal. Any elements dismantled and removed will be directed to recycling and disposal, in line with the latest relevant guidance at the time (see CoT55 within Volume 1, Annex 5.3: Commitments register of the ES). The components of the onshore substations are considered to be highly recyclable. When disposing of such elements, recycling is the preferred solution. This not only prevents the materials from being sent to landfills, but also reduces the need for the extraction of primary materials. Material which cannot be recycled might be used for incineration or energy from waste. As such, emissions associated with the disposal of materials at the end of their lifetime is considered to be immaterial and may even result in future avoided emissions. This impact is not assessed further.

1.9 Summary

1.9.1.1 The lifetime GHG emissions arising from the consumption of materials and activities required to facilitate the construction, operation and maintenance and decommissioning of the Transmission Assets, as detailed within this Annex, are presented in **Table 1.3**, below.

Table 1.3: Net whole life GHG emissions.

LCA Stage	Transmission Assets emissions (tCO_2e)
Construction (A1-A5)	229,947
Operation and Maintenance (B1-B5)	76,856
Decommissioning (C1-C4)	51,318
Total	358,121

1.10 References

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