RWE Renewables UK Dogger Bank South (West) Limited

RWE Renewables UK Dogger Bank South (East) Limited

Dogger Bank South Offshore Wind Farms

Environmental Statement

Volume 7

Appendix 30-2 Greenhouse Gas Assessment Methodology (Revision 2) (Clean)

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Company:	**RWE Renewables UK Dogger Bank South (West) Limited and RWE Renewables UK Dogger Bank South (East) Limited**	Asset:	**Development**
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01	June 2024	Final for DCO Application	RHDHV	RWE	RWE
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Revision Change Log			
Rev No.	**Page**	**Section**	**Description**
01	N/A	N/A	Submitted for DCO Application
02	Various	Various	**Appendix 30-2 Greenhouse Gas Assessment Methodology** [APP-224] has been updated at the request of the Examining Authority within the Rule 17 [PD-018] to accurately reflect the proposed development and contains all the updated information within the Appendix as a result of **Project Change Request 1 and Project Change Request 2** (document reference 10.49 and 10.53)
02	Various	Various	**Appendix 30-2 Greenhouse Gas Assessment Methodology** [APP-224] has been updated to incorporate the Greenhouse Gas Sensitivity Analysis of Wake Effects (document ref: 14.10) report previously issued into Examination.
02	33	Table 30-2-9	Updated errata in **Table 30-2-9** from revision 01 in relation to Cable Route Section 10B for the In-Isolation Scenario

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Glossary

Term	Definition
Array Areas	The DBS East and DBS West offshore Array Areas, where the wind turbines, offshore platforms and array cables would be located. The Array Areas do not include the Offshore Export Cable Corridor or the Inter-Platform Cable Corridor within which no wind turbines are proposed. Each area is referred to separately as an Array Area.
'Cradle to (factory) gate'	The extraction, manufacture, and production of materials to the point at which they leave the factory gate of the final processing location.
Inter-Platform Cables	Buried offshore cables which link offshore platforms.
Landfall	The point on the coastline at which the Offshore Export Cables are brought onshore, connecting to the onshore cables at the Transition Joint Bay (TJB) above mean high water.
Landfall Zone	The generic term applied to the entire landfall area between Mean Low Water Spring (MLWS) and the Transition Joint Bays (TJBs) inclusive of all construction works, including the landfall compounds, Onshore Export Cable Corridor and intertidal working area including the Offshore Export Cables.
Offshore Converter Platforms (OCPs)	The OCPs are fixed structures located within the Array Areas that collect the AC power generated by the wind turbines and convert the power to DC, before transmission through the Offshore Export Cables to the Project's Onshore Grid Connection Points.
Onshore Converter Stations	A compound containing electrical equipment required to transform HVDC and stabilise electricity generated by the Projects so that it can be connected to the electricity transmission network as HVAC. There will be one Onshore Converter Station for each Project.

Term	Definition
Onshore Export Cable Corridor	This is the area which includes cable trenches, haul roads, spoil storage areas, and limits of deviation for micro-siting. For assessment purposes, the cable corridor does not include the Onshore Converter Stations, Transition Joint Bays or temporary access routes; but includes Temporary Construction Compounds (purely for the cable route).
Onshore Export Cables	Onshore Export Cables take the electric from the Transition Joint Bay to the Onshore Converter Stations.
Onshore Substation Zone	Parcel of land within the Onshore Development Area where the Onshore Converter Station infrastructure (including the Haul Roads, Temporary Construction Compounds and associated cable routeing) would be located.
The Projects	DBS East and DBS West (collectively referred to as the Dogger Bank South Offshore Wind Farms).
The Applicant	The Applicants for the Projects are RWE Renewables UK Dogger Bank South (East) Limited and RWE Renewables UK Dogger Bank South (West) Limited. The Applicants are themselves jointly owned by the RWE Group of companies (51% stake) and Masdar (49% stake).
Wind turbine	Power generating device that is driven by the kinetic energy of the wind.
Wake effect	Shorthand referring to all effects the presence of wind turbines have on wind flow: • wake effect where extraction of energy from the wind leaves lower windspeed downwind of turbines, • blockage which causes slowing of the wind ahead of turbines and acceleration behind and to the sides.
Wake loss	The loss in energy production from a wind farm due to wake (and blockage) effects, represented as a percentage of the expected energy production.

Acronyms

Term	Definition
AUB	Autonomous Underwater Vehicles
AW	Agusta Westland
CTV	Crew Transfer Vessel
DBS	Dogger Bank South
DESNZ	Department for Energy Security and Net Zero
DfT	Department for Transport
DfT	Department for Transport
ES	Environmental Statement
GHG	Greenhouse Gas
GloMEEP	Global Maritime Energy Efficiency Partnerships
HGV	Heavy Goods Vehicle
ICE	Inventory of Carbon and Energy
IEMA	Institute of Environmental Management & Assessment
JUV	Jack-Up Vessel
NRMM	Non-Road Mobile Machinery
OCP	Offshore Converter Platforms
ROV	Remotely Operated Vehicles
SOV	Service Operations Vessel
US EPA	United States Environmental Protection Agency

30.2 Greenhouse Gas Assessment Methodology

1. This appendix of the Environmental Statement (ES) presents the greenhouse gas (GHG) assessment methodology, specifically in relation to the activity data, emission factors and assumptions used for calculating GHG emissions arising from the Projects. The GHG assessment has been carried out in accordance with the Institute of Environmental Management & Assessment (IEMA) Guide: Assessing Greenhouse Gas Emissions and Evaluating their Significance (IEMA, 2022). The GHG assessment is performed based on the realistic worst case scenario for both the In Isolation and the Sequential Scenarios, as detailed in section 30.3.2 of **Volume 7, Chapter 30 Climate Change (application ref: 7.30)**. The outcomes of the Sequential Scenario are considered to be to representative of the Concurrent Scenario, therefore a separate assessment for the Concurrent Scenario has not been undertaken, as discussed in section 30.3.2.2.1 of **Volume 7, Chapter 30 Climate Change (application ref: 7.30)**. The scope of this document includes the methodology used to calculate the following emissions source groups:

    - Embodied carbon in materials;
    - Marine vessels;
    - Helicopters;
    - Road traffic vehicles;
    - Plant and equipment; and
    - Wake effects.

2. As detailed in **Volume 7, Chapter 30 Climate Change (application ref: 7.30), Appendix 30-2 Greenhouse Gas Assessment Methodology (application ref: 7.30.30.2)** has been updated to incorporate the changes to the Projects' Design Parameters resulting from **Project Change Request 1** and **Project Change Request 2 – Onshore Substation Zone (document reference 10.49 and 10.53).** This appendix has been updated to reflect the changes to the Projects design with regard to GHG emissions. In addition, the methodology for estimating the change in emissions from potential wake effects has been added.

30.2.1 Embodied emissions in materials

3. Emissions of 'Cradle-to-factory gate', a term which includes the extraction, manufacture and production of materials to the point at which they leave the site of the final processing location, have been calculated for the Development Scenarios. GHG emissions are derived from quantities or volumes of known materials that would be used in construction, including the following infrastructure:

- The key offshore components of the Projects comprise:
  - Wind turbines (i.e., tower, nacelle, rotor, blades) and associated foundations;
  - Offshore converter platforms (OCPs) and associated foundations;
  - Other platforms and their associated foundations;
  - Scour protection around foundations and cable protection (i.e., rock); and
  - Offshore export, Inter-Platform Cables and array cables (i.e., copper or aluminium);
- The key onshore components comprise:
  - Ducts installed underground to house the electrical cables along the Onshore Export Cable Corridor;
  - Onshore Export Cables installed with duct;
  - Joint bays and link boxes installed along the Onshore Export Cable Corridor;
  - Trenchless crossing points at certain locations such as some roads, railways and sensitive habitats (e.g., rivers of conservation importance);
  - Temporary Construction Compounds and accesses;
  - Temporary bridges and culverts;
  - Onshore Converter Stations and onward HVAC connections to the proposed Birkhill Wood National Grid Substation near Creyke Beck; and
  - Permanent operational Onshore Convertor Stations and cable route access.

4. To provide a precautionary assessment, it is assumed that there will be no reduction in the emission intensity during abstraction and manufacturing of materials up until and during the construction phase of the In Isolation Scenario and Sequential and/or Concurrent Scenario. This is considered to be a conservative approach, as the earliest that construction of any of the Development Scenarios is anticipated to be 2026, where the emissions intensity of some sectors such as transport and industry are likely to have reduced. The maximum quantities of each type of construction material to be used on site are obtained, and the relevant emission factors sources from the Inventory of Carbon and Energy (ICE) database (Jones & Hammond, 2019), where possible. Alternative sources for emission factors are used for more specific components of offshore wind farms and are detailed in **Table 30-2-1**.

5. Precautionary assumptions are adopted with respect to material quantities to be used for each component of the Projects; these include contingencies allowing for the worst case scenario (e.g., maximum number of wind turbines) of the maximum design envelope to be considered. It has also been assumed that virgin materials will be used for the Projects, whereas it is likely that recycled materials will be utilised for some components.

6. There are many possible foundation types currently available to support offshore wind turbines and/or offshore platforms. The options under consideration include, monopiles and pin pile jackets, suction bucket jackets or gravity based foundations (for platforms only). It was assumed that monopiles would be adopted, as this is the worst case scenario based on the foundation footprint and material requirements for scour protection. In addition, the gravity based jackets are quantified for the offshore platforms as the worst case foundation option due the quantities of scour protection required.

7. The emission factors from the ICE database are 'Cradle-to-(factory) gate' and, therefore do not include the transportation of materials to site. Emissions associated with the movement of materials to the site are quantified from the information available at this stage in the application for the road traffic vehicle and marine vessel source groups, as highlighted in section 30.4.2.3.2 and 30.4.2.3.3 of **Volume 7, Chapter 30 Climate Change (application ref: 7.30)** respectively. The road traffic vehicle source group also included emissions associated with the removal of excavated materials from the site.

8. The Cradle-to-(factory) gate emissions factors used in the GHG assessment for embodied emissions in construction materials are presented in **Table 30-2-1**. The use of materials for the construction of the Projects are not limited to components presented in **Table 30-2-1**.

Table 30-2-1 Emission Factors for Embodied GHGs in Materials

Material	Emission factor (kg $CO_2e.kg^{-1}$, unless otherwise stated)	Source	Notes
Copper	2.71	ICE Database, v3.0 November 2019 (Jones & Hammond, 2019)	Average of embodied CO_2e virgin and recycled values provided in ICE Database
Engineering steel (42CrMo4 proxy)	1.27		N/A
Glass reinforced plastic (GRP) – Fibreglass (fibreglass and carbon fibre proxy)	8.1	ICE Database, v3.0 November 2019 (Jones & Hammond, 2019)	CO_2 only. Also used for carbon fibre as a proxy in lieu of other available embodied carbon emission factor
General polyethylene (polyester proxy)	2.54		N/A
Glass (general)	1.44		N/A
Iron (cast iron proxy)	2.03		N/A
Steel (average) (also used 100 Cr6 proxy)	2.47		Average of embodied CO_2e steel values provided in ICE Database
Rock or gravel	0.079		Stone (general)
Aluminium (general, European mix including imports)	6.67	ICE Database, v3.0 November 2019 (Jones &	N/A

Material	Emission factor (kg $CO_2e.kg^{-1}$, unless otherwise stated)	Source	Notes
Asphalt	0.05	Hammond, 2019)	Assumed mid-ranged, 5% binder content
Clay (bentonite proxy)	0.39		Assumed clay representative of bentonite as bentonite is “is an absorbent swelling clay consisting mostly of montmorillonite”
Mortar (1:6 cement: sand mix) (cement bound sand proxy)	0.12	ICE Database, v3.0 November 2019 (Jones & Hammond, 2019)	N/A
Concrete	0.1		N/A
Concrete slab	0.13		N/A
Lime	0.78		N/A
Polypropylene (duct proxy)	3.69	Cableizer (n/a)	CO_2 only.
Polypropylene (geogrid, geotextile and wind turbines converter proxy)	4.98	ICE Database, v3.0 November 2019 (Jones & Hammond, 2019)	CO_2 only
PVC pipe (perforated pipe proxy)	3.23		N/A
Sand	0.01		Estimate of market average aggregate
Soil	0.02		N/A

Material	Emission factor (kg $CO_2e.kg^{-1}$, unless otherwise stated)	Source	Notes
Water	0.177 (as kg $CO_2e.m^{-3}$)	Department for Energy Security and Net Zero (DESNZ) (2023)	N/A

30.2.2 Marine Vessels

30.2.2.1 Indicative vessel logistics and assumptions

9. Marine vessels will be used to bring materials and components to the Offshore Development Area, install infrastructure (wind turbines, OCPs, foundations and cables), provide crew accommodation and support during construction, commissioning and for operation and maintenance activities.

10. The current working assumption for offshore vessel logistics during the construction and operation and maintenance phases of the Projects are outlined in **Table 30-2-2**, **Table 30-2-3, Table 30-2-4** for construction and operation and maintenance respectively. All construction vessels are assumed to operate from a port that is a maximum of 240km from the centre of the windfarm Array Areas.

Table 30-2-2 Indicative Number of Vessels Movements During Construction

Activity	Vessel	Maximum number of return trips		Notes
		In Isolation Development Scenario	Concurrent or Sequential Development Scenario	
Site Preparation	Site Preparation Vessel	52	78	Assumes an offshore support vessel

Activity	Vessel	Maximum number of return trips		Notes
		In Isolation Development Scenario	Concurrent or Sequential Development Scenario	
Foundation Installation	Scour Layers Vessel	84	168	Assumes a fall pipe installation vessel
	Foundation Installation Spread	144	278	Assumes a Jack-Up vessel (JUV)
	Transition Piece Installation	17	33	Assumes the main vessel is a JUV and other vessels include anchor handlers
Wind Turbine Installation	Wind Turbine Installation Spread	74	148	Assumes the main vessel is a JUV and other vessels include anchor handlers, barge, and tug vessels
Installation Activities	Commissioning Vessel	78	78	Assumes a SOV
	Accommodation Vessel	2	2	Assumes a Crew Transfer Vessel (CTV)

Activity	Vessel	Maximum number of return trips		Notes
		In Isolation Development Scenario	Concurrent or Sequential Development Scenario	
Inter-array Cable Installation	Inter-array Cable Vessels	29	37	Assumes the main vessel is a cable lay vessel and other supporting vessels include cable support vessel, seabed prep vessels and tugs
	Inter-array Rock Berm Vessels	164	329	Assumes the use of a fall pipe installation vessel
Offshore Export Cable Installation	Export Cable Vessels	31	41	Assumes the main vessel is a cable laying vessel and other supporting vessel include cable support vessel, seabed prep vessels and tugs
Export Cable and Inter Platform Rock Berm Installation	Export cable and Inter Platform Cable Rock Berm Installation Vessels	417	935	Assumes the use of a fall pipe installation vessel

Activity	Vessel	Maximum number of return trips		Notes
		In Isolation Development Scenario	Concurrent or Sequential Development Scenario	
Landfall Zone Cable Installation	Landfall Zone Cable Installation Vessels	3	3	Assumes the main vessel is a cable laying vessel and other supporting vessel include cable support vessels
Offshore substation Installation	Substation Installation Vessel Topside	4	8	Assume the main vessel is an installation vessel and other supporting vessels include tugs and barges
	Substation Installation Vessel Foundation	8	16	
Other Vessels	Other Vessel	2,190	4,380	Assume the main vessel is a CTV and other supporting vessels includes guard ships and installation support vessel

11. As a conservative approach, for construction activities where the maximum number of return trips is provided as a total for all the vessels associated with a particular activity (i.e., JUV, barge, support vessel), the maximum number of return trips is attributed to the main vessel (i.e., JUV).

12. It should be noted that only indicative vessel transit details are provided by the vessel team for construction as outlined in **Table 30-2-2**. An indicative construction programme has been provided, as shown in **Volume 7, Chapter 5, Project Description (application ref: 7.5)**, for the In Isolation and Sequential Scenarios, which contains the number of months each type of vessel is predicted to be on site. This information was used to calculate the total durations on site for each vessel activity, as shown in **Table 30-2-3**.

Table 30-2-3 Approximate vessel on-site duration during construction

Activity	Vessel	In Isolation Scenario approximate duration on site (hours)	Sequential Scenario approximate duration on site (hours)	Notes
Site Preparation	Site Preparation Vessel	8,760	8,760	Assumes an offshore support vessel
Foundation Installation	Scour Layers Vessel	13,140	26,280	Assumes a fall pipe installation vessel
	Gravity Base Foundation Ballast Vessel	13,140		Assumes a transport vessel
	Foundation Installation Spread			Assumes a Jack-Up vessel (JUV)
	Transition Piece Installation			Assumes the main vessel is a JUV and other vessels include anchor handlers.
Wind Turbine Installation	Wind Turbine Installation Spread	21,900	39,420	Assumes the main vessel is a JUV and other vessels include anchor handlers, barge, and tug vessels
Installation Activities	Commissioning Vessel	21,900	39,420	Assumes a SOV
	Accommodation Vessel	21,900	39,420	Assumes a Crew Transfer Vessel (CTV)

Activity	Vessel	In Isolation Scenario approximate duration on site (hours)	Sequential Scenario approximate duration on site (hours)	Notes
Inter-array Cable Installation	Inter-array Cable Vessels	21,900	39,420	Assumes the main vessel is a cable lay vessel and other supporting vessels include cable support vessel, seabed prep vessels and tugs
	Inter-array Rock Berm Vessels	21,900	39,420	Assumes the use of a fall pipe installation vessel
Offshore Export Cable Installation	Export Cable Vessels	21,900	39,420	Assumes the main vessel is a cable laying vessel and other supporting vessel include cable support vessel, seabed prep vessels and tugs
Export Cable and Inter Platform Rock Berm Installation	Export cable and Inter Platform Cable Rock Berm Installation Vessels	21,900	39,420	Assumes the use of a fall pipe installation vessel
Landfall Cable Installation	Landfall Cable Installation Vessels	21,900	35,040	Assumes the main vessel is a cable laying vessel and other supporting vessel include cable support vessels
Offshore substation Installation	Substation Installation Vessel Topside	17,520	35,040	Assume the main vessel is an installation vessel

Activity	Vessel	In Isolation Scenario approximate duration on site (hours)	Sequential Scenario approximate duration on site (hours)	Notes
	Substation Installation Vessel Foundation	17,520	35,040	and other supporting vessels include tugs and barges
Other Vessels	Other Vessel	21,900	39,420	Assume the main vessel is a CTV, and other supporting vessels includes guard ships and installation support vessel

13. As a conservative scenario, it has been assumed that each visit in **Table 30-2-4** will require a separate vessel movement to/from the operation and maintenance base. The duration that each vessel (listed in **Table 30-2-4**) will spend on site is not known at this stage, and therefore further assumptions adopted from other projects of similar nature have also been used for this assessment. These assumptions include:

- Each JUV will be on site for two weeks per visit; and
- Cable maintenance and auxiliary vessel will be on site for four weeks per visit.

Table 30-2-4 Indicative Number of Vessels Movements (return trips to port) During Operation and Maintenance

Vessel Type	In Isolation Scenario visits per year	Sequential Scenario visits per year	Notes
JUV (to turbines and platforms)	9	16	Vessel(s) will be on site for multiple days and move between wind turbines
SOV	52	104	N/A

Vessel Type	In Isolation Scenario visits per year	Sequential Scenario visits per year	Notes
Small accommodation vessel	52	104	N/A
Small operation and maintenance vessel (CTV)	52	104	N/A
Lift vessels	9	16	N/A
Cable maintenance vessels	1	1	N/A
Auxiliary vessels	64	128	Auxiliary vessels include survey vessels, remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs), diver platforms, tug operations, cargo vessels, scour replacement vessels

14. For the vessels used during the construction phase, it anticipated that the construction port is a maximum of 240km from the centre of the DBS Array Areas and it's the distance used for the worst case scenario in this assessment as detailed in **Table 30-2-2**. For the operation and maintenance phases, vessels are assumed to travel to the Offshore Development Area from the Port of Grimsby. This may not be wholly representative of actual locations where the vessel will travel from but is deemed suitable for this assessment. Indicative maximum sailing distances from the worst case construction port (240km from the centre of the DBS Array Areas) and from the Port of Grimsby to the DBS Array Areas are input into the assessment.

30.2.2.2 Emission Calculation

15. Emission calculation methodologies adopted for all Development Scenarios are based on best practice guidance documents, including the United States Environmental Protection Agency's (US EPA) 'Port Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions' (2022) and the Global Maritime Energy Efficiency Partnerships Project's (GloMEEP) 'Port Emissions Toolkit' (GloMEEP, 2018).

16. Emissions from marine vessels associated with the Projects were quantified from an estimation of fuel consumption from activities during construction, and the operation and maintenance phases. Emission factors for marine gas oil (MGO), in kg CO_2e per kWh are obtained from DESNZ (DESNZ, 2023). The shipping sector is expected to decarbonise over the lifespan of the Projects, although projections for the speed and the extent that this will take place are difficult to predict. It is therefore assumed that marine vessels continued to use MGO during the construction and operation and maintenance phases of the Projects. This approach is precautionary and likely to result in an overestimation of emissions.

17. Construction vessels emissions have been quantified from the operation and maintenance phases over the anticipated life span of the In Isolation Scenario and Sequential and Concurrent Scenario (currently anticipated to be 30, 32 and 30 years respectively). This included the use of JUVs, CTVs, large and small operation and maintenance vessels, lift vessels, cable maintenance vessels and auxiliary vessels (e.g., survey, ROVs, tugs, etc.), as detailed in **Table 30-2-4**.

18. Vessel emissions during offshore transit (i.e., travelling to the DBS Array Areas) were calculated by dividing the total distance covered with the average transit speed to derive total transit time, which was multiplied by the propulsion and auxiliary engine power, their respective load factors and the emission factor. This calculation can be summarised as the following formula:

$$E_{transit} = \left(\left(A_{transit} * PE * LF_{prop} \right) + \left(A_{transit} * AE * LF_{aux} \right) \right) * EF$$

Where:

$A_{transit}$ – Activity (hours), defined as the product of the number of return trips and distance per return trip, divided by the vessel's average transit speed

PE – Propulsion engine size (kW)

AE – Auxiliary engine (kW)

LF_{prop} – Load Factors for propulsion engines

LF_{paux} – Load Factors, for auxiliary engines

EF – Emission factor (tonnes CO_2e/kWh)

19. Vessel emissions for offshore construction activities were calculated by multiplying the total on-site time provided with the propulsion and auxiliary engine power, their respective load factors and the emission factor. This calculation can be summarised as the following formula:

$$E_{on-site} = \left((A_{on-site} * PE * LF_{prop}) + (A_{transit} * AE * LF_{aux}) \right) * EF$$

Where:

$A_{on\text{-}site}$ – Activity (hours), defined by the total time on-site for the of vessels

The other factors are as defined in paragraph 19.

20. Vessel engine sizes were obtained from public vessel specification sheets, where available. Propulsion engine sizes were assumed to include the main engine and thrusters. However, auxiliary engine sizes tend to be undisclosed. Therefore, they were estimated based on the total installed power, less the propulsion engine size, or calculated using a ratio provided in US EPA's report on vessel emissions (US EPA, 2009). The majority of vessels included in the GHG assessment could be categorised as bulk carriers, whose auxiliary to propulsion ratio is estimated at 0.222. For vessels without total installed power specified and whose type falls outside of the US EPA's ratio table, an indicative estimate of 10% of the propulsion engine size was assumed for the auxiliary engine (US EPA, 2009).

21. Vessels have various operating modes such as cruising, manoeuvring and hotelling, which affect how much work is being done by the propulsion and auxiliary engines. In emission calculations, this is captured by the load factor, which represents the percentage of a vessel's maximum engine load while undertaking a specific activity. A vessel's engines are rarely operated at 100% or more of its maximum load due to fuel consumption costs, efficiency and engine maintenance requirements, therefore most vessel operators limit their engine load to around 83% or less (GloMEEP, 2018). During transit, load factors will be higher for propulsion than auxiliary engines, and vice versa for offshore construction activities. Load factors used in the vessel emission calculations are detailed in **Table 30-2-5**.

Table 30-2-5 Load factors assumed for the Projects

Engine Type	Activity	Load factor	Data Source	Assumptions
Propulsion engine	In transit	0.75	Assumed based on typical load factors	Vessels assumed to be in cruising mode.
	Offshore construction	0.31 (tugs) 0.38 (work boats and miscellaneous)	GloMEEP (2018)	Vessels assumed to be in manoeuvring mode as worst case scenario. All vessels assumed to be work boats and miscellaneous, with the exception of tugs.
Auxiliary engine	In transit	0.17	US EPA (2009)	Vessels assumed to be in cruising mode. All vessels assumed to be bulk carriers, tugs or miscellaneous vessels.
	Offshore construction	0.26		Vessels assumed to be in cruising mode. All vessels assumed to be bulk carriers, tugs or miscellaneous vessels.

30.2.3 Helicopters

22. Helicopter movements associated with the construction and operation and maintenance phases of all Development Scenarios will result in the release of GHG emissions. It is feasible that technicians will be transported to turbines using helicopters during the commissioning of the Projects, and unplanned maintenance tasks will be undertaken via helicopters during the operation and maintenance phase, when CTV access is not possible or deemed not to be suitable. The amount of GHG emissions from helicopters is calculated by determining the expected fuel consumption using maximum trip data. The volume of GHG emissions from helicopters use during the construction, operation and maintenance phases are calculated by determining the expected fuel consumption using trip data.

23. The anticipated number of helicopter journeys during construction/commissioning and operation and maintenance for the In Isolation and Sequential Scenarios are outlined in **Table 30-2-6**.

Table 30-2-6 Construction and Operation and Maintenance Phase Helicopter Movements

Phase	Activity	Annual maximum number of return trips per project	
		In Isolation Scenario	Sequential Scenario
Construction	Logistics	365	730
Operation and Maintenance	Routine operations	10	20
Operation and Maintenance	Emergency situations	6	12

24. The total distance travelled by helicopters is determined by multiplying the number of trips by the maximum trip distance. The possible airbases for the construction phase of the Projects are Humberside airport and Teesside International Airport / Durham Tees Valley Airport. The approximate distance from Teesside International Airport / Durham Tees Valley (MME) to the centre of the Projects Array Area is a straight line distance of approximately 203km (one-way). The approximate distance from the Humberside airport to the centre of the Projects Array Area is a straight line distance of 175km (one-way). As a worst case, it is assumed that helicopter trips originate at Teesside International Airport / Durham Tees Valley Airport during the construction phase. As the operation and maintenance base for the In Isolation and Sequential Scenarios is still not defined, it is also assumed that operation and maintenance phase helicopter trips originated at Teesside International Airport.

25. The likely types of helicopters for these activities include the Agusta Westland 139 (AW139), Agusta Westland 189 (AW189) and Airbus H175. Based on previous project experience, the AW189 helicopter type is selected to determine fuel consumption. The average cruise speed and fuel consumption data for an AW139 is obtained from manufacturers specifications to estimate fuel consumption. Emission factors for aviation turbine fuel (or jet fuel), in $CO_2e.t^{-1}$ fuel, are obtained from the DESNZ (2023).

30.2.4 Road Traffic Vehicles

26. Road traffic vehicle movements associated with the construction, operation and maintenance phases of all Development Scenarios would result in the release of GHG emissions. GHG emissions are calculated from the total km travelled by heavy goods vehicles (HGVs) and staff transport to and from the onshore construction sites, and during the operation and maintenance phase.

27. The total distance of vehicles travelled during the whole construction phase is obtained from **Volume 7, Chapter 24 Traffic and Transport (application ref: 7.24)**. To provide a conservative assessment, the fleet make up (in terms of fuel and Euro standards) for the earliest year of construction (2026) is used in the assessment for employee travel.

28. Emission factors for each vehicle type considered in the assessment are obtained from DESNZ (2023), in kg CO_2e per km travelled. To provide a conservative assessment, it is assumed that there are no fuel efficiency improvements or reduction in emissions over the temporal extent for each mode of transport in the assessment.

29. Distance travelled during the construction phase are calculated for HGVs and employee movements according to the following methodology:

- General:
  - Vehicles movements are collated by the Transport Consultants for the Projects from **Volume 7, Chapter 24 Traffic and Transport (application ref: 7.24)**.
  - The approach adopted is considered to represent a worst case, noting that no reduction in traffic movements has been applied to account for reassignment of traffic. For example, many HGVs would already be on the local network serving existing supply chains and would potentially reassign to serve the Projects without creating additional demand within the local area.
- HGV movements:
  - Bulk materials such as concrete and stone aggregate is assumed to make up the majority of the total HGV trips for the Projects and that these deliveries would be expected from the Port of Hull.
  - The distances from the Hull Port are calculated to the Onshore Development Area (this is approach is considered to represent a worst case scenario noting that deliveries from local supplies would reduce the distance travelled).
  - To calculate the total distance travelled in km, the total HGV movement per Projects infrastructure destination are multiplied by the distance from the Hull Port to the infrastructure destination.
- Light vehicle movements:
  - **Volume 7, Chapter 24 Traffic and Transport (application ref: 7.24)** adopted a conservative approach that assumes all construction employees travel by single occupancy vehicles, i.e., no reduction to light vehicle movements has been applied to account for employees using public transport, car-sharing etc.
  - The distribution of light vehicles presented in **Volume 7, Chapter 24 Traffic and Transport (application ref: 7.24)** is informed by a review of the distribution of local and in-migrant labour.
  - **Volume 7, Chapter 24 Traffic and Transport (application ref: 7.24)** outlines that origin of in-migrant labour is based upon the number of bed spaces within local hotels, whilst the distribution of local labour is informed by census data.

- The total distance covered by light vehicles for each construction section is obtained based on the two-way movement per construction section, the distribution of light vehicles per entry link and the distance from the entry link to the construction section.
- The total light vehicle movements are multiplied by calculated distances. This provides the total light vehicle distance travelled in km.

30. The construction phase movements used to calculate GHG emissions are provided **Table 30-2-7**.

Table 30-2-7 Construction Phase Traffic Movements

Vehicle	Total distance travelled (km)		
	In Isolation Development Scenario	Concurrent Development Scenario	Sequential Development Scenario
Cars or light vehicles	9,798,674	11,446,003	17,916,665
HGVs	5,438,971	7,379,013	10,068,100

31. The forecasted fleet composition for 2026 (first year of construction) (i.e., proportion of diesel, petrol, and electric cars) is obtained from the Department for Transport (DfT) WebTAG data v1.21 (DfT, 2023). The proportion of diesel, petrol, and electric cars in the UK fleet for 2026 is obtained from the DfT (2023) to determine a representative emission factor associated with employee travel. The fleet composition used in the assessment, and emission factors associated with each vehicle type are provided in **Table 30-2-8**. Emission factors for each vehicle type were obtained from DESNZ (2023).

Table 30-2-8 Calculation of Emission Factor Used for Light Vehicle in Assessment

Earliest year of construction	Fleet composition (DfT, 2023)			Vehicle emission factor (kg $CO_2e.km^{-1}$) (DESNZ, 2023)			Emission Factor Used in the Assessment (kg $CO_2e.km^{-1}$)
	Diesel	Petrol	Electric	Diesel	Petrol	Electric*	
2026	48.4%	32.9%	18.7%	0.17	0.164	0.066	0.147
* Assumed to be plug-in hybrid electric vehicle, as battery electric vehicle has 0 CO_2e emissions in the 2023 DESNZ dataset.							

32. It is assumed that all HGVs used for the Projects would be diesel powered. The emission factor for HGV movements (50% laden) is obtained from DESNZ (2023) and is 0.814kg $CO_2e.km^{-1}$. In the absence of suitable empirical data, it is assumed that the fleet composition of HGVs did not change over the temporal scope of the assessment to provide a precautionary approach.

33. During the operation and maintenance phase, road vehicle movements would be limited to those generated by routine operation and periodic maintenance activities at the Onshore Substation Zone and at link boxes along the onshore cable corridor. It is assumed that as a worst case there would be eight traffic movements (i.e., one visit assuming two personnel with separate vehicles) per week for each Onshore Converter Station during the 30-year lifespan of the operational phase of the In Isolation and Sequential Scenarios (respectively). Therefore, a total of 416 annual traffic movements is anticipated for operational and maintenance activities for each Onshore Converter Station. It is estimated that one visit per year is required for operation and maintenance activities at each cable joint pit / link boxes and it is assumed that each visit requires four movements. There is a total of 103 and 205 cable joint pit / link boxes for the In Isolation and Sequential Scenarios respectively, therefore there will be a total of 412 and 820 road vehicle movements per year. Each traffic movement is assumed to be 20km, therefore, the annual distances from the operation and maintenance activities are 16,560km and 133,040km the In Isolation and Sequential Scenarios respectively. Therefore, total distances travelled by road vehicles are 496,800km and 991,200km over the operational lifespan of the In Isolation and Sequential Scenarios respectively.

30.2.5 Plant and Equipment

34. The Onshore Development Area is split into sections for the construction phase. Plant and equipment use for the different sections vary over the duration of the construction phase.

35. Fuel consumption associated with the operation of non-road mobile machinery (NRMM) for the onshore components for the In Isolation and Sequential Scenarios were calculated based on the estimated use of each item of plant and equipment. Indicative construction plant and equipment for construction activities at the Landfall Zone and along the Onshore Export Cable Corridor and Onshore Substation Zone are provided and are specific to the In Isolation and Sequential Scenarios.

36. This information was used to calculate the anticipated fuel demand over the duration of construction, and the emission factor for gas oil consumption is obtained from DESNZ (2023) to derive GHG emissions.

37. The following assumptions were adopted in the assessment:

- Plant and equipment are assumed to operate throughout the consented working hours for the In Isolation and Sequential Scenarios, which are 0700 hours and 1900 hours Monday to Saturday, with no activity on Sundays or bank holidays (72 hours per week). On-time factors were applied for each plant and equipment, and are consistent with those used in **Volume 7, Appendix 25.3 Construction Noise Assessment (application ref: 7.25.25.3)**.
- Construction plant and equipment were all assumed to use diesel to provide a conservative assessment; and
- Engine sizes for plant and equipment were either provided by the design team for or obtained for NRMM typically required during construction activities, and from manufacturer specifications. It is assumed that engines operated at a load factor of 75%.

38. Indicative durations for plant and equipment at the Landfall Zone, along the Onshore Export Cable Corridor and at the Onshore Substation Zone were obtained.

39. Plant and equipment used during the construction of In Isolation and Sequential Scenarios is provided in **Table 30-2-9** and **Table 30-2-10.**

40. The information provided in **Table 30-2-9** and **Table 30-2-10** represents the average monthly number of plant and equipment that could be present at each section provided by the Applicants for the In Isolation and Sequential Scenarios. Plant and equipment numbers were provided for each section per month. There will be some variation in the use of plant and equipment over the construction period at the Landfall Zone, Onshore Export Cable Corridor and Onshore Substation Zone and onward cable route to the proposed Birkhill Wood National Grid Substation, therefore average numbers of each plant and equipment per month have been calculated (note: due to this approach, these average values may not be a whole number). The duration these plant and equipment would be used is dependent on the construction programme. The total number of operational plant hours during construction is calculated by multiplying the total number of plant/equipment required per month by the construction hours (72 hours per week).

41. For the purposes of the assessment, it is assumed that plant and equipment would be operated using gas oil as fuel, which has an emission factor of 0.257kg CO_2e per kWh (DESNZ, 2023).

Table 30-2-9 In Isolation Development Scenario Plant and Equipment Requirements (Total Construction) for Each Construction Section (Landfall Zone, Onshore Export Cable Corridor and Onshore Substation Zone)

Plant	kW	On-time	No. of plant (on average) operational per month																Total plant operational
			Section 1	Section 2	Section 3	Section 4	Section 5	Section 6A	Section 6B	Section 7	Section 8	Section 9	Section 10A	Section 10B	Section 16B	Section 14	Substation Z4	Section 15	
D6 Dozer	161	1	25	32	17	26	31	23	23	22	20	17	21	20	20	24	36	29	386
30T Excavator	204	1	42	45	31	40	45	36	37	39	31	27	32	38	32	44	53	44	616
20T Dumper	231	1	56	64	40	53	56	42	45	46	38	31	38	48	40	52	95	55	799
Smooth Drum vibrio road roller	142	1	18	18	10	18	19	14	14	14	13	11	15	13	12	15	35	17	256
21T excavator	128.4	1	29	33	22	30	29	23	23	26	20	18	22	28	20	29	79	30	461
5T Forward Tipping Dumper	62.5	1	29	31	22	30	29	23	23	26	20	18	22	28	20	29	51	30	431
Loading shovel	170	1	34	38	24	34	35	26	26	29	23	20	25	30	24	33	26	35	462
Trench Roller	142	1	10	11	8	11	8	6	6	8	6	5	5	10	6	10	0	10	120
Tractor & fencing kit	211	1	13	14	7	12	15	11	12	10	9	8	10	9	10	12	6	13	171
Tractor & trailer	211	0.7	27	28	17	23	22	18	18	19	15	13	18	23	17	22	65	22	367
Tractor & Fuel bowser (or self-propelled)	211	0.1	17	18	12	14	17	13	14	15	11	10	11	15	13	16	36	17	249

Plant	kW	On-time	No. of plant (on average) operational per month																Total plant operational
			Section 1	Section 2	Section 3	Section 4	Section 5	Section 6A	Section 6B	Section 7	Section 8	Section 9	Section 10A	Section 10B	Section 16B	Section 14	Substation Z4	Section 15	
Tractor & Water bowser (for dust suppression)	211	0.25	17	18	12	14	17	13	14	15	11	10	11	15	13	16	20	17	233
Tractor & cable drum trailer	211	0.5	2	4	2	3	3	2	2	2	2	1	1	2	2	2	0	3	33
Tractor & soil tiller, roller, seeder	211	0.25	3	6	3	4	5	3	3	3	3	2	3	4	2	3	3	4	54
Cement mixer	216	0.25	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Mobile crane	132	0.25	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Grader	205	1	8	10	5	8	10	8	8	7	6	6	8	6	7	8	12	9	126
Cable laying tracked crane	107	0.25	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Cable winch	19.1	0.5	2	4	2	3	3	2	2	2	2	1	1	2	2	2	0	3	33
Pre-cast concrete truck	216	0.05	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Mobile concrete pump	216	0.5	2	4	1	2	2	2	2	2	1	1	1	2	1	2	0	2	27
Telehandler	107	0.75	17	20	12	14	14	11	11	13	9	9	12	16	12	14	56	15	255

Plant	kW	On-time	No. of plant (on average) operational per month																Total plant operational
			Section 1	**Section 2**	**Section 3**	**Section 4**	**Section 5**	**Section 6A**	**Section 6B**	**Section 7**	**Section 8**	**Section 9**	**Section 10A**	**Section 10B**	**Section 16B**	**Section 14**	**Substation Z4**	**Section 15**	
Mobile self-contained welfare unit	8	0.25	17	18	12	14	17	13	14	14	11	10	11	14	13	15	45	17	255
Crawler Crane	107	0.25	5	5	3	5	3	2	2	3	2	2	2	4	2	4	0	4	48
Road surface paver & roller	142	0.25	2	2	2	3	2	2	2	2	2	2	3	3	2	2	11	2	44
Concrete batching plant	100	0.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	16	n/a	16
Dry-mix silos	150	0.25	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	32	n/a	32
Mobile crane (light for general use)	132	0.4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	34	n/a	34
Mobile crane (heavy)	205	0.25	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	10	n/a	10
Specialist heavy-lifting gantry & associated equipment	355	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	10	n/a	10
Static crane	132	0.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	17	n/a	17
3T Forward Tipping Dumper	32.4	0.25	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	16	n/a	16

Plant	kW	On-time	No. of plant (on average) operational per month																Total plant operational
			Section 1	Section 2	Section 3	Section 4	Section 5	Section 6A	Section 6B	Section 7	Section 8	Section 9	Section 10A	Section 10B	Section 16B	Section 14	Substation Z4	Section 15	
Scissor lift	18.5	50	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	70	n/a	70
Mobile powered aerial platform (boom lift / 'cherry picker')	31	50	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	70	n/a	70
Scaffolding	0	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	136	n/a	136
Formwork	0	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	184	n/a	184
JCB Wheeled excavator	81	0.25	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	18	n/a	18
Forklift	28	0.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	47	n/a	47

Table 30-2-10 Sequential Development Scenario Plant and Equipment Requirements (Total Construction) for Each Construction Section (Landfall Zone, Onshore Export Cable Corridor and Onshore Substation Zone)

Plant	kW	On-time	No. of plant (on average) operational per month																Total plant operational
			Section 1	Section 2	Section 3	Section 4	Section 5	Section 6A	Section 6B	Section 7	Section 8	Section 9	Section 10A	Section 10B	Section 16B	Section 14	Substation Z4	Section 15	
D6 Dozer	161	1	44	60	34	47	53	40	41	40	38	29	34	41	31	43	46	49	670
30T Excavator	204	1	73	97	66	80	84	61	66	67	62	46	54	68	55	72	73	86	1110
20T Dumper	231	1	98	118	83	101	106	70	80	80	74	54	61	79	68	90	135	103	1400

Plant	kW	On-time	No. of plant (on average) operational per month																Total plant operational
			Section 1	Section 2	Section 3	Section 4	Section 5	Section 6A	Section 6B	Section 7	Section 8	Section 9	Section 10A	Section 10B	Section 16B	Section 14	Substation Z4	Section 15	
Smooth Drum vibrio road roller	142	1	27	35	22	30	32	24	26	25	24	19	24	26	20	25	55	33	447
21T excavator	128.4	1	49	69	45	54	57	40	41	43	40	29	36	45	39	47	147	60	841
5T Forward Tipping Dumper	62.5	1	49	69	45	53	57	40	41	43	40	29	36	45	38	47	103	61	796
Loading shovel	170	1	53	79	49	59	61	46	48	48	46	33	39	50	44	52	46	67	820
Trench Roller	142	1	16	29	16	17	17	10	12	13	11	6	8	15	13	17	3	25	228
Tractor & fencing kit	211	1	19	27	17	22	25	16	22	19	18	13	16	20	14	19	6	26	299
Tractor & trailer	211	0.7	39	51	34	44	44	33	31	33	32	25	30	33	32	35	132	41	669
Tractor & Fuel bowser (or self-propelled)	211	0.1	29	36	28	31	34	24	28	27	25	21	23	28	22	27	60	31	474
Tractor & Water bowser (for dust suppression)	211	0.25	29	36	28	31	34	24	28	27	25	21	23	28	22	27	30	31	444
Tractor & cable drum trailer	211	0.5	4	5	2	6	6	4	2	3	3	2	2	3	2	5	0	4	53
Tractor & soil tiller, roller, seeder	211	0.25	6	12	6	8	10	6	6	6	6	4	5	7	4	6	3	8	103
Cement mixer	216	0.25	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Mobile crane	132	0.25	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Grader	205	1	12	18	12	16	17	13	16	14	13	10	13	14	12	14	22	19	235

Plant	kW	On-time	No. of plant (on average) operational per month																Total plant operational
			Section 1	Section 2	Section 3	Section 4	Section 5	Section 6A	Section 6B	Section 7	Section 8	Section 9	Section 10A	Section 10B	Section 16B	Section 14	Substation Z4	Section 15	
Cable laying tracked crane	107	0.25	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Cable winch	19.1	0.5	4	5	2	6	6	4	2	3	3	2	2	3	2	5	0	4	53
Pre-cast concrete truck	216	0.05	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Mobile concrete pump	216	0.5	6	7	4	5	5	3	3	4	3	2	2	4	3	5	0	5	61
Telehandler	107	0.75	28	40	26	31	28	22	23	23	22	16	21	25	25	26	130	31	517
Mobile self-contained welfare unit	8	0.25	28	35	26	30	33	23	27	25	24	19	21	26	21	26	78	30	472
Crawler Crane	107	0.25	7	13	7	6	6	3	5	5	4	2	3	6	6	6	3	11	92
Road surface paver & roller	142	0.25	4	4	4	6	4	4	4	4	4	4	5	5	4	4	21	4	85
Concrete batching plant	100	0.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	34	n/a	34
Dry-mix silos	150	0.25	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	70	n/a	70
Mobile crane (light for general use)	132	0.4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	86	n/a	86
Mobile crane (heavy)	205	0.25	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	20	n/a	20

Plant	kW	On-time	No. of plant (on average) operational per month																Total plant operational
			Section 1	Section 2	Section 3	Section 4	Section 5	Section 6A	Section 6B	Section 7	Section 8	Section 9	Section 10A	Section 10B	Section 16B	Section 14	Substation Z4	Section 15	
Specialist heavy-lifting gantry & associated equipment	355	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	20	n/a	20
Static crane	132	0.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	34	n/a	20
3T Forward Tipping Dumper	32.4	0.25	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	54	n/a	54
Scissor lift	18.5	50	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	140	n/a	140
Mobile powered aerial platform (boom lift / 'cherry picker')	31	50	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	140	n/a	140
Scaffolding	0	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	272	n/a	272
Formwork	0	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	384	n/a	384
JCB Wheeled excavator	81	0.25	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	62	n/a	62
Forklift	28	0.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	94	n/a	94

30.2.6 Wake Effects

42. An assessment on GHG emissions from potential of wake effects at neighbouring offshore wind farms to the Projects was undertaken to provide a comprehensive assessment following its exclusion being noted within the DCO Examination. The assessment considered wake effects at ten nearest offshore wind farms, which were selected as they are either in operation, under construction, consented or planned, and sit either partially or wholly within 100 km of the Projects. The offshore wind farms within the scope of the wake effects assessment are listed below:

- Dogger Bank A;
- Dogger Bank B;
- Dogger Bank C;
- Sofia;
- Hornsea 1;
- Hornsea 2;
- Hornsea Project Three;
- Hornsea Project Four;
- Outer Dowsing; and
- Dogger Bank D.

43. To determine the potential net effect of wake loss at the ten neighbouring offshore wind farms on GHG emissions, annual energy production within the study area was calculated for two scenarios:

- Business as usual (BaU): annual energy production from the existing neighbouring offshore wind farms, in the absence of the Projects; and
- Presence and operation of the Projects: energy production from the Projects and the existing neighbouring offshore wind farms, accounting for the potential reduction in energy production due to wake effects.

44. To provide a conservative assessment, it was assumed that the potential decommissioning date for each of the neighbouring offshore wind farms was extended to cover a 35-year operational lifetime. For both the In Isolation and Sequential Scenarios, three wake loss scenarios were considered in order to present a sensitivity analysis on GHG emissions, which assume a uniform wake effect at each of the neighbouring offshore wind farms within the scope of the assessment. These scenarios are outlined below:

- In Isolation Scenario: 0.25%, 0.5% and 1.0%

- Sequential Scenario: 0.5%, 1.0% and 2.0%.

45. The offshore wind farms within the scope of assessment are situated at different distances and locations to the Projects, therefore wake effects will not be uniform across each of the offshore wind farms. Consequently, these scenarios are hypothetical only.

46. For the purposes of the assessment, the 1.0% and 2.0% wake loss scenarios for the in Isolation and Sequential Scenarios (respectively) were considered to be highly conservative. The assessment assumes that uniform wake effects of this magnitude would occur at each of the ten identified offshore wind farms within scope. This assessment mirrors those undertaken by projects on other recent DCO Examinations. In practice, this is very unlikely to be the case and is very precautionary upon reflection of both the Applicants actual wake assessments provided in examination and that provided by an Interested Party.

47. The following methodology was adopted to determine the effects on GHG emissions associated with wake loss:

    - The annual energy production by the neighbouring offshore wind farms was calculated based on the size of each wind farm (in MW), and the capacity factor in the absence of any wake effects (BaU scenario).
    - Annual energy production of the neighbouring offshore wind farms was calculated after influence of potential wake effects associated with the Projects.
    - The reduction in energy production at the neighbouring offshore wind farms was calculated, based on assumed decommissioning dates at the time of assessment.
    - The resulting effects on emissions from the reduction in energy production was calculated using the same approach in the GHG assessment for calculating avoided emissions which is discussed in Section 30.4.3.1.4 of **Volume 7, Chapter 30 Climate Change (application ref: 7.30)**. This approach assumes that any loss energy production would be otherwise be generated by natural gas, which is the most common form of generation by fossil fuels in the UK grid.

30.2.6.1 Business-as-Usual Scenario

48. Annual electricity production for each of the neighbouring offshore wind farms was calculated based on the information provided in **Table 30-2-11**. The data sources for the decommissioning dates, installed capacities, and capacity factor for each of the offshore wind farm projects are provided in **Table 30-2-12**.

Table 30-2-11 Neighbouring Offshore Wind Farm Details

Project	(Expected) Commissioning Date	(Assumed) De-commissioning Date	Capacity (MW)	Capacity Factor (%)
Dogger Bank A	2025	2060	1200	58.40%
Dogger Bank B	2026	2061	1200	58.40%
Dogger Bank C	2027	2062	1200	58.40%
Sofia	2026	2061	1400	58.40%
Hornsea 1	2019	2054	1218	47.30%
Hornsea 2	2022	2057	1386	47.70%
Hornsea Project Three	2027	2062	2955	61.00%
Hornsea Project Four	2030	2065	2600	61.00%
Dogger Bank D	2035	2070	2000	61.00%
Outer Dowsing	2030	2065	1500	61.00%

Table 30-2-12 Data sources used in the wake effect calculations

Data source	Data contents
Renewable UK wind energy database	Capacity of neighbouring wind farms that are under construction, operational or consented Expected operational start date of neighbouring wind farms that are under construction, operational or consented

Data source	Data contents
Developer webpages	Capacity of planned neighbouring wind farms (Dogger Bank D and Outer Dowsing) Expected operational start date of planned neighbouring wind farms (Dogger Bank D and Outer Dowsing)
The Contracts for Difference (Standard Terms) Regulations 2014, Cfd Standard Terms Notice for the Sixth Allocation Round	Assumed load factor for Offshore Wind, for Hornsea Project Three, and Hornsea Project Four, as well as Dogger Bank D and Outer Dowsing, which do not yet have consent
The Contracts for Difference (Standard Terms) Regulations 2014, Cfd Standard Terms Notice for the Third Allocation Round	Assumed load factor for Offshore Wind, for Dogger Bank A, Dogger Bank B, Dogger Bank C, and Sofia
The Contracts for Difference (Standard Terms) Regulations 2014, Cfd Standard Terms Notice for the Second Allocation Round	Assumed load factor for Offshore Wind, for Hornsea 2
Energy numbers: UK offshore wind capacity factors	Assumed load factor for Offshore Wind, for Hornsea 1
DBS Offshore Wind Farms Environmental Statement Chapter 30 – Climate Change – Volume 7 [APP-222] Table 30-15 *Energy Produced by the Projects* Table 30-26 *GHG Emission Saved by the Sequential Scenario*	The Projects' anticipated electricity production and avoided emissions (Sequential Scenario)
The Contracts for Difference (Standard Terms) Regulations 2014, Cfd Standard Terms Notice for the Sixth Allocation Round	Assumed load factor for Offshore Wind, for Hornsea Project Three, and Hornsea Project Four, as well as Dogger Bank D and Outer Dowsing, which do not yet have consent

49. Annual energy production for the BaU scenario was calculated using the following equation:

$$BaU\ annual\ energy\ production\ (MWh\ per\ year) = Installed\ Capacity\ (MW) * Capacity\ Factor\ (\%) * 8760\ hours\ per\ year$$

50. Electricity production over the lifetime of the neighbouring wind farms was then calculated, assuming that each wind farm would have an operational lifetime of 35-years. This is five years more than the assumed lifetime of the Projects, which in the GHG assessment (**Volume 7, Chapter 30 Climate Change (application ref: 7.30)**) was assumed to be operational for 30 years.

51. It was assumed that the Projects would commence operations in 2031, which aligns with the Sequential Scenario considered in the GHG assessment in **Volume 7, Chapter 30 Climate Change (application ref: 7.30)**.

30.2.6.2 Wake Effect Scenarios

52. The reduction in annual electricity production at the neighbouring wind farms as a result of wake effects was calculated using the following equation for each wake loss scenario:

$$Annual\ electricity\ loss\ (MWh\ per\ year) = BaU\ electricity\ production\ (MWh\ per\ year) * wake\ loss\ percentage\ (\%)$$

53. The reduction in electricity production across the lifecycle of each of the neighbouring offshore wind farms as a result of wake effects was calculated using the following equation:

$$Total\ electricity\ reduction\ (MWh) = Annual\ electricty\ loss\ (MWh\ per\ year) * lifetime\ (years)$$

54. The potential effects of wake loss under the three hypothetical wake loss scenarios to annual energy production at each of the neighbouring offshore wind farms are presented in **Table 30-2-13** for the In Isolation Scenario and **Table 30-2-14** for the Sequential Scenario.

Table 30-2-13 Potential Electricity Loss due to Wake Effects on Neighbouring Wind Farms – In Isolation Scenario

Existing Project	0.25% Wake Loss		0.5% Wake Loss		1.0% Wake Loss	
	Annual Electricity Loss (MWh)	Total Electricity Loss (MWh)	Annual Electricity Loss (MWh)	Total Electricity Loss (MWh)	Annual Electricity Loss (MWh)	Total Electricity Loss (MWh)

Existing Project	0.25% Wake Loss		0.5% Wake Loss		1.0% Wake Loss	
Dogger Bank A	15,348	445,078	30,695	890,156	61,390	1,780,312
Dogger Bank B	15,348	460,426	30,695	920,851	61,390	1,841,702
Dogger Bank C	15,348	475,773	30,695	951,546	61,390	1,903,092
Sofia	17,905	537,163	35,811	1,074,326	71,622	2,148,653
Hornsea 1	12,617	290,189	25,234	580,377	50,468	1,160,754
Hornsea 2	14,479	376,443	28,957	752,886	57,914	1,505,771
Hornsea Project Three	39,476	1,223,751	78,952	2,447,502	157,903	4,895,005
Hornsea Project Four	34,733	1,180,936	69,467	2,361,871	138,934	4,723,742
Dogger Bank D	26,718	935,130	53,436	1,870,260	106,872	3,740,520
Outer Dowsing	20,039	681,309	40,077	1,362,618	80,154	2,725,236
Total	**212,009**	**6,606,197**	**424,018**	**13,212,395**	**848,037**	**26,424,789**

Table 30-2-14 Potential Electricity Loss due to Wake Effects on Neighbouring Wind Farms – Sequential Scenario

Existing Project	**0.5% Wake Loss**		**1.0% Wake Loss**		**2.0% Wake Loss**	
	Annual Electricity Loss (MWh)	**Total Electricity Loss (MWh)**	**Annual Electricity Loss (MWh)**	**Total Electricity Loss (MWh)**	**Annual Electricity Loss (MWh)**	**Total Electricity Loss (MWh)**
Dogger Bank A	30,695	890,156	61,390	1,780,312	122,780	3,560,625
Dogger Bank B	30,695	920,851	61,390	1,841,702	122,780	3,683,405
Dogger Bank C	30,695	951,546	61,390	1,903,092	122,780	3,806,185
Sofia	35,811	1,074,326	71,622	2,148,653	143,244	4,297,306
Hornsea 1	25,234	580,377	50,468	1,160,754	100,935	2,321,509
Hornsea 2	28,957	752,886	57,914	1,505,771	115,829	3,011,543
Hornsea Project Three	78,952	2,447,502	157,903	4,895,005	315,807	9,790,010
Hornsea Project Four	69,467	2,361,871	138,934	4,723,742	277,867	9,447,485
Dogger Bank D	53,436	1,870,260	106,872	3,740,520	213,744	7,481,040
Outer Dowsing	40,077	1,362,618	80,154	2,725,236	160,308	5,450,472
Total	**424,018**	**13,212,395**	**848,037**	**26,424,789**	**1,696,074**	**52,849,578**

55. To evaluate the impacts on GHG emissions, the total reduction in electricity generation across all of the neighbouring offshore wind farms was multiplied by the same emission factor for generation by natural gas, which is consistent with the approach outlined in section 30.4.3.1.4 of **Volume 7, Chapter 30 Climate Change (application ref: 7.30)**.

56. The change in avoided emissions for all neighbouring offshore wind farms (tonnes CO_2e) was compared to the avoided emissions as a result of the Projects, as reported **Volume 7, Chapter 30 Climate Change (application ref: 7.30)**.

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