NORTH FALLS

Offshore Wind Farm

PRELIMINARY ENVIRONMENTAL INFORMATION REPORT

Appendix 33.1 Greenhouse Gas Assessment Methodology

Document Reference No: 004646206-03
Date: May 2023
Revision: 03

PRELIMINARY ENVIRONMENTAL INFORMATION REPORT

May 2023

Project	North Falls Offshore Wind Farm
Sub-Project or Package	Environmental Impact Assessment
Document Title	Preliminary Environmental Information Report Appendix 33.1 Greenhouse Gas Assessment Methodology
Document Reference	004646206-03
Revision	03 (Draft A)
Supplier Reference No	PB9244-RHD-ZZ-ON-RP-CC-0163

Revision	Date	Status/Reason for Issue	Originator	Checked	Approved
01 (Draft B)	29/11/22	1st draft for NFOW review	IOM	JP	-
02 (Draft B)	27/02/23	2nd draft for NFOW review	IOM	JP	
03 (Draft A)	29/03/23	Final	IOM/JP	GC	JP/DH/AP

Contents

Tables

Glossary of Acronyms

AUV	Autonomous Underwater Vehicles
BEIS	Department for Business, Energy & Industrial Strategy
CBS	Cement Bound Sand
CO_2e	Carbon dioxide equivalent
CTV	Crew Transfer Vessel
DfT	Department for Transport
ES	Environmental Statement
GHG	Greenhouse Gas
GRP	Glass Reinforced Plastic
HDD	Horizontal Directional Drilling
HGV	Heavy Goods Vehicle
ICE	Inventory of Carbon and Energy
JUV	Jack-up vessel
MGO	Marine Gas Oil
NdFeB	Neodymium proxy
NRMM	Non-Road Mobile Machinery
O&M	Operation and Maintenance
PVC	Polyvinyl chloride
ROV	Remotely Operated Vehicles
SOV	Serviced Operation Vessel
TP	Transition Pieces
WTG	Wind Turbine Generator

Glossary of Terminology

Array/interconnecting cables	Cables which link the wind turbine generators with each other and the offshore substation platform(s).
Cable construction compound	Area set aside to facilitate construction of the onshore cable route. Will be located adjacent to the onshore cable route, with access to the highway.
‘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
Haul road	The track along the onshore cable route used by construction traffic to access different sections of the onshore cable route.
Horizontal directional drill (HDD)	Trenchless technique to bring the offshore cables ashore at the landfall. The technique will also be used for installation of the onshore export cables at sensitive areas of the onshore cable route.
Interconnector cable corridor	The corridor of the seabed between the northern and southern array areas
Jointing bay	Underground structures constructed at regular intervals along the onshore cable route to join sections of cable and facilitate installation of the cables into the buried ducts.
Landfall	The location where the offshore cables come ashore.
Link boxes	Underground chambers or above ground cabinets next to the onshore export cables housing low voltage electrical earthing links.
Offshore cable corridor	The corridor of seabed from array areas to the landfall within which the offshore export cables will be located.
Offshore export cables	The cables which bring electricity from the array areas to the landfall.
Offshore project area	The overall area of the array areas and the offshore cable corridor.
Offshore substation platform(s)	Fixed structure(s) located within the array areas, containing electrical equipment to aggregate the power from the wind turbine generators and convert it into a more suitable voltage for export to shore via offshore export cables.
Onshore cable corridor(s)	Onshore corridor(s) within which the onshore export cables and associated infrastructure will be located. A final onshore cable route for which consent will be sought will be selected from within these corridor(s).
Onshore cable route	Onshore route within which the onshore export cables and associated infrastructure would be located.
Onshore export cables	The cables which take the electricity from landfall to the onshore substation. These comprise High Voltage Alternative Current (HVAC) cables, buried underground.
Onshore project area	The boundary in which all onshore infrastructure required for the Project will be located (i.e. landfall; onshore cable route, accesses, construction compounds; onshore substation and National Grid substation extension), as considered within the PEIR.
Onshore substation	A compound containing electrical equipment required to transform and stabilise electricity generated by the Project so that it can be connected to the National Grid.
Onshore substation zone	Area within which the onshore substation will be located.
Scour protection	Protective materials to avoid sediment being eroded away from the base of the wind turbine generator foundations and offshore substation platform foundations as a result of the flow of water.
The Applicant	North Falls Offshore Wind Farm Limited (NFOW).
The Project or ‘North Falls’	North Falls Offshore Wind Farm, including all onshore and offshore infrastructure.

Transition joint bay	Underground structures that house the joints between the offshore export cables and the onshore export cables
Trenchless crossing compound	Areas within the cable corridor which will house trenchless crossing (e.g. HDD) entry or exit points.
Wind turbine generator (WTG)	Power generating device that is driven by the kinetic energy of the wind

1 Greenhouse Gas Assessment Methodology

1.1 Introduction

1. This appendix of the Preliminary Environmental Information Report (PEIR) presents the greenhouse gas (GHG) assessment methodology, associated assumptions and emissions factors used for calculating GHG emissions arising from the North Falls offshore wind farm (hereafter 'North Falls' or 'the Project'), specifically for:

- Embodied emissions in construction materials (Section 1.2);
- Emissions arising from marine vessels in transit and at the wind farm site (Section 1.3);
- Emissions arising from helicopter movements (Section 1.4);
- Emissions arising from road traffic vehicle movements (Section 1.5); and
- Emissions arising from plant and equipment (Section 1.6).

2. A number of assumptions were made in the GHG assessment, and these are presented in Table 33.11 of Chapter 33 Climate Change (Volume I) and outlined in this technical appendix.

1.2 Embodied emissions in materials

3. Emissions of 'cradle to (factory) gate', a term which includes the extraction, manufacture and production of materials (required for the construction of the Project) to the point at which they leave the factory gate of the final processing location, were calculated for the Project. GHG emissions were derived from quantities or volumes of likely materials that will be used in construction. These assumptions will be further refined for the Environmental Statement (ES) stage, where possible.

4. These include the following infrastructure:

- The key offshore components (and their main material components) of the Project comprise:
    - Wind turbine generators (WTGs), including the tower, nacelle, rotor, blades (materials: steel, copper, iron, fiberglass, etc.);
    - Offshore substation platforms and structures (material: steel);
    - WTG and offshore substation foundations (e.g. monopiles, jackets, gravity based, etc.) (material: steel);
    - Scour protection (material: rock); and
    - Offshore export (main material is likely to be aluminum) and interconnecting cables (main material is likely to be copper).
- The key onshore components (and their main material components) of the Project comprise:
    - Imported material for construction at landfall and along the onshore cable route, such as stone, asphalt, kerbs, concrete, pipe, cement

bound sand (CBS), ducting, geogrid/geotextile, bentonite, water and steel reinforcement;

- Onshore export cables (main material is likely to be aluminum) installed underground from the landfall to the onshore substation; and
- Onshore substation (main materials are likely to be steel and copper).

5. Quantities for all materials to be used during construction were not available at the time of the assessment, therefore estimated quantities of the most common and GHG intensive materials were included. To provide a precautionary assessment, it was assumed that there will be no reduction in the emissions intensity during abstraction and manufacturing of materials up until and during the construction phase of the Project. This is likely to be a conservative approach as the emissions intensity of some sectors such as transport and industry is likely to decrease over time and the earliest date of construction would be 2026.

6. The estimated quantities (based on current working assumptions) of each type of the main construction materials to be used on site were obtained from the Project's design team, and the relevant emission factors sourced from the Inventory of Carbon and Energy (ICE) database (Jones & Hammond, 2019) where possible, were then applied to the estimated quantities to calculate total tonnes of carbon dioxide equivalent (CO_2e), which is the term for describing different GHGs in a common unit. Alternative sources for emission factors were used for more specific components to wind farms, and are detailed in Table 1.

7. Precautionary assumptions were adopted with respect to material quantities to be used for each component of the Project, which include contingency allowing for the worst-case scenario (e.g. maximum number of WTGs) of the maximum design envelope to be accounted for. These are outlined in Section 33.3.2 of Chapter 33 Climate Change (Volume I). It has also been assumed that virgin materials will be used, whereas the Project will seek to use recycled sources for some of the components.

8. There are many possible foundation types currently available to support offshore WTGs and/or offshore platforms. Based on the current best estimates of foundations to be used for the Project, emissions were quantified for monopiles or jackets in the greenhouse gas (GHG) footprint assessment, depending on the worst case for each material type. The worst case maximum scour protection volumes for each foundation type have been used, these are gravity based for both the WTG and offshore substations.

9. The emission factors used in the GHG assessment for embodied emissions associated with the main construction materials are presented in Table 1. Total embodied carbon emissions (in tonnes CO_2e) were calculated by applying the emission factors in Table 1 to the current working estimates of construction material quantities.

Table 1 Emission factors for embodied GHGs in materials

Component(s)	Material	Emission factor (kg $CO_2e.kg^{-1}$, unless otherwise stated)	Source	Notes
Offshore export and onshore cables	Aluminium (general, European mix including imports)	6.67	ICE database, v3.0 November 2019 (Jones & Hammond, 2019)	N/A
Onshore landfall/cable route	Asphalt	0.05		Assumed mid-ranged, 5% binder content
Onshore landfall/cable route	Clay (bentonite proxy)	0.39		Assumed clay representative of bentonite as bentonite *"is an absorbent swelling clay consisting mostly of montmorillonite"*
Onshore landfall/cable route	Mortar (1:6 cement: sand mix) (cement bound sand proxy)	0.12		N/A
Onshore landfall/cable route	Concrete	0.10		N/A
Onshore landfall/cable route	Concrete slab	0.13		N/A
WTG generator/ transformer/ switchgear, offshore array/interconnecting cables, onshore substation transformers and reactor	Copper	2.71		Average of embodied CO_2e steel values provided in ICE database
WTG main and blade bearing	Engineering steel (42CrMo4 proxy)	1.27		N/A
WTG blades, nacelle cover	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
WTG switchgear	General polyethylene (polyester proxy)	2.54		N/A
WTG transformer	Glass (general)	1.44		N/A
WTG hub	Iron (cast iron proxy)	2.03		N/A
WTG generator	NdFeB magnets (Neodymium proxy)	27.6	Jin *et al*. (2016)	N/A
Onshore landfall/cable route	Polypropylene (duct proxy)	3.69	Cableizer (n/a)	CO_2 only.
Onshore landfall/cable route	Polypropylene (geogrid, geotextile	4.98	ICE database, v3.0 November	CO_2 only.

Component(s)	Material	Emission factor (kg $CO_2e.kg^{-1}$, unless otherwise stated)	Source	Notes
	and WTG converter proxy)		2019 (Jones & Hammond, 2019)	
Onshore landfall/cable route	PVC (polyvinyl chloride) pipe (perforated pipe proxy)	3.23		N/A
Onshore landfall/cable route	Sand	0.01		Estimate of market average aggregate
WTG components, monopile/jacket foundation, offshore substation topside and foundation, onshore substation components	Steel (average) (also used 100 Cr6 proxy)	2.47		Average of embodied CO_2e steel values provided in ICE database
WTG and offshore substation foundation scour protection, onshore landfall/cable route	Rock or gravel	0.079		Stone (general)
Landfall/ osnhore cable route	Water	0.149 (as kg $CO_2e.m^{-3}$)	Department for Business, Energy & Industrial Strategy (BEIS) (2022)	N/A

10. The emission factors from the ICE database are 'cradle-to-factory' and, therefore do not include the transportation of materials to site.

11. Emissions associated with the movement of materials to the site were quantified from the information available at this stage in the Project for the marine vessel and road traffic vehicle source groups, as highlighted in Sections 33.4.3.3.2 and 33.4.3.3.4 of Chapter 33 Climate Change (Volume I) and detailed in Section 1.3 and 1.5, respectively.

1.3 Marine vessels

12. Marine vessels will be used to bring materials and components to the wind farm site, install infrastructure (WTGs, offshore substation platforms, substructure and cables), provide crew accommodation and support during construction, commissioning and for Operation and Maintenance (O&M) activities.

1.3.1 Indicative vessels logistics – current working assumptions

13. The current working assumptions for offshore vessel logistics during have been supplied by the project design team and have been taken from an indicative example project of a similar size to North Falls. Transit movements are outlined in Table 2 and Table 3 for construction and O&M respectively. Assumptions for

vessel movements will be further refined before the ES and GHG emissions will be updated where relevant.

Table 2 Indicative number of vessels movements during construction

Activity	Indicative vessel type	Maximum number of return trips	*Notes*
Foundation installation	Scour Layer Vessels	241	*Based on fallpipe vessel with capacity of 20,000t* *Assumption that scour layer vessels originate from Norway (only included one-way transit in calculations as Project has no control over where scour layer vessels go after visiting site)*
	Gravity Base Foundation Vessels	454	*Based on vessel with capacity of 1,650t*
	Jack-up installation vessels (JUVs)	40	*Assumes the installation vessel is moving between the wind farm site and marshalling harbour (in either the Netherlands or Germany) with two foundations per trip. Assumed Port of Rotterdam for the PEIR calculations**
	Support vessels	72	*Such as multicast, serviced operation vessels (SOVs), tugs, etc. operating out of local harbours (e.g. Harwich or Lowestoft**)* *7 other vessels in foundation spread to go to port every 14 days. Campaign duration # of WTGs * 2 days*
	Transport vessels	40	*Assumed Port of Rotterdam for the calculations**
	Crew transfer vessels (CTVs)	300	*Assuming four visits per foundation, from local harbour (e.g. Harwich or Lowestoft**)*
WTG installation	TP Installation Vessels	36	*Based on 6 TPs per loadout, 3 vessels in the spread*
	WTG Installation vessels	24	*Assuming 3x installation spreads, with main vessels shuttling between the site and pre-assembly harbour with three WTGs sets per trip (one set = tower, nacelle, rotor and blades). Assumed Port of Rotterdam for calculations**
	Support vessels	42	*Such as multicast, SOVs, tugs, etc. operating out of local harbours (e.g. Harwich or Lowestoft**)* *4 other vessels in WTG spread to go to port every 14 days. Campaign duration # of WTGs * 2 days*
	CTVs	750	*Assuming 10 visits per turbine, from local harbour (e.g. Harwich or Lowestoft**)*
Offshore substation installation	Installation vessels	12	*Assuming topside, jackets and pin piles transported and installed separately from marshalling harbour (in either UK, the Netherlands or Denmark). Assumed Port of Rotterdam for the calculations**

Activity	Indicative vessel type	Maximum number of return trips	*Notes*
	Support vessels	12	*Such as multicast, SOVs, tugs, etc. operating out of local harbours (e.g. Harwich or Lowestoft**)*
	Transport vessels	12	*Assumed Port of Rotterdam for calculations**
	CTVs	60	*During commissioning of the substations. Assuming local harbour (e.g. Harwich or Lowestoft**)*
Array/interconnecting cable installation	Main laying vessels	25	*Assuming cable manufacturers in north east UK**
	Main burial vessels	Assumed same vessel as laying	*Assumed Port of Rotterdam for the calculations* as port of mobilisation in Europe*
	Support vessels	300	*Such as multicast, CTVs, dive spreads, etc. operating out of local harbours (e.g. Harwich or Lowestoft**)*
Export cable installation	Main laying vessels	9	*Assuming cable manufacturers in Southern Europe **
	Main burial vessels	592	*To and from port of mobilisation in Europe. Assumed Port of Rotterdam for the calculations** *Fallpipe vessel with capacity of 4000t*
	Main jointing vessels	9	*Joints are not planned. If required, vessels would operate from local construction port (e.g. Harwich or Lowestoft**), so these have been included to provide a worst case scenario*
	Support vessels	60	*Such as multicast, CTVs, dive spreads, etc. operating out of local harbours (e.g. Harwich or Lowestoft**)*
*At this stage, assumptions were made regarding the originating location of vessels, and, where possible, have been based on the reasonable worst case option for each originating location. If further details are known about these locations at the ES stage, GHG emission calculations will be updated. **Lowestoft was used as a worst case scenario			

14. It should be noted that only indicative vessel transit details have been provided by the project team for construction, as outlined in Table 2. An indicative construction programme has also been provided by the project design team, and these indicative durations (detailed below) have been used in the calculation of GHG emissions from vessel activity during construction. These assumptions will be further refined for the ES:

- WTG installation vessels – approximately nine months;
- Foundation installation vessels – approximately 12 months;
- Offshore substation installation vessels – approximately five months (assumed based on indicative information provided for WTG installation); and

- Array/interconnecting cables and export cable installation vessels – 12 months and six months respectively.

Table 3 Indicative number of vessels movements during O&M

Vessel type	Visits per year	*Notes*
JUV (to turbines and platforms)	7	*Vessel(s) will be on site for multiple days and move between WTGs*
SOV	52	*N/A*
Small O&M vessel (CTV)	1,460	*N/A*
Lift vessels	7	*N/A*
Cable maintenance vessels	1	*N/A*
Auxiliary vessels	60	*Auxiliary vessels include: survey vessels, remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs), diver platforms, tug operations, cargo vessels, scour replacement vessels.*

15. As a conservative scenario, it has been assumed that each visit in Table 3 will require a separate vessel movement to/from the O&M base. The duration that each vessel listed in Table 3 will spend on site is not known at this stage, and therefore further assumptions adopted from other projects of a similar nature have also been used for the assessment. These assumptions include:

- Each JUV and CTV will be on site for four days per visit; and
- O&M, lift, cable maintenance and auxiliary vessels will be on site for two weeks per visit.

16. Vessels used during construction and O&M phases were assumed to travel to the windfarm site from a range of locations, including the marshalling, manufacturer and mobilisation ports (current assumptions on these locations are provided in Table 2) and a local construction and O&M port (such as Harwich or Lowestoft).

17. Emissions from dredging activities during the construction of the Project have not been included in the assessment, as a breakdown of information regarding dredging activities is not known at this stage of the Project.

1.3.2 Emission calculations

18. Marine vessel activities were estimated for the Project to derive estimated fuel consumption during construction and O&M.

19. Indicative vessel types (that will be used during construction and O&M activities) were provided by the project team and representative vessel specifications for these vessel types have been estimated from projects of a similar nature to North Falls. Therefore, fuel consumption figures were calculated by multiplying the engine size of the vessels by activity hours in transit or active on the wind farm site (accounting for average engine load factors).

20. Emission factors for Marine Gas Oil (MGO), in kg $CO_2e.kWh^{-1}$ were obtained from the BEIS (now the Department for Energy Security and Net Zero (DESNZ)) (BEIS, 2022). The shipping sector is expected to decarbonise over the lifespan

of the Project, although projections for the speed and the extent that this will take place are difficult to predict. It was therefore assumed that marine vessels continued to use MGO during the construction and O&M phases of North Falls. This approach is considered to be conservative and may result in an overestimation of emissions, particularly with respect to the O&M phase.

21. GHG emissions from marine vessels were calculated using the following equation:

$$E = P * A * EF$$

Where:

E = GHG emissions (CO_2e)

P = engine power, as a function of total engine power multiplied by the engine load factor (kW)

A = activity hours (hours)

EF = emission factor (tonnes CO_2e per kWh)

22. The required engine power for each vessel to be used for the Project was determined by obtaining the total engine power specific to each type of vessel to be used multiplied by a load factor. Engine load factors were adapted from previous project experience, and were assumed to be typically 0.75 whilst in transit, and 0.50 during construction and installation activities.

23. Activity hours during transit were determined by dividing the total distance travelled for each vessel by typical average vessel speeds in transit, and activity hours at the windfarm site were estimated for the total hours at the windfarm site.

24. Emissions were quantified from the O&M phase over the anticipated life span of the Project (currently anticipated to be 30 years). This included the use of JUVs, CTVs, large and small O&M vessels, lift vessels, cable maintenance vessels and auxiliary vessels (e.g. survey, Remotely Operated Vehicles (ROVs), tugs, etc.), as detailed in Table 3.

25. Some elements of the data used to calculate GHG emissions from marine vessels are confidential at this stage due to commercial sensitivities, therefore a detailed breakdown of information used to derive GHG emissions from this source is unavailable.

1.4 Helicopters

26. Helicopter movements associated with the commissioning and O&M phases of the Project 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 Project and unplanned maintenance tasks will be

undertaken via helicopters during the O&M phase, when CTV access is not possible. The amount of GHG emissions from helicopters was calculated by determining the expected fuel consumption using trip data provided by the project team.

27. The project design team provided indicative, anticipated number of helicopter journeys during construction/commissioning and O&M, based on a similar offshore wind farm project, and these are outlined in Table 4.

Table 4 Helicopter movements

Phase	Activity	Maximum number of return trips
Construction or commissioning	WTG installation	300
	Offshore substation installation	30
O&M	Unplanned maintenance tasks when CTV access is not possible	100 (per year)

28. The total distance travelled by helicopters was determined by multiplying the number of trips by the average trip distance. As advised by the project team, it was assumed as a worst case that helicopter trips originated at an example airport in the South East of England[1] during the construction/commissioning phase. The distance from the airport to the centre of the project array area was assumed to be a straight line distance of approximately 190 km (one-way). As the O&M base for the Project is still not defined, it was also assumed that O&M phase helicopter trips originated at this example airport.

29. The likely type of helicopters used for these activities is unknown at this stage of the Project, so an indicative helicopter model (AW139) from previous project experience was used to determine fuel consumption. The average cruise speed and fuel consumption data for an AW139 was obtained from manufacturers specifications to estimate fuel consumption. Emission factors for aviation turbine fuel (or jet fuel), in $CO_2e.tonne^{-1}$ fuel, were obtained from the BEIS (2022).

30. GHG emissions from helicopters were calculated using the following equation:

$$E = \left(\frac{\frac{D}{S} * F}{1{,}000}\right) * EF$$

Where:

E = GHG emissions (CO_2e)

D = Average trip distance (km)

S = Cruise speed (km/hr)

[1] Shoreham Airport was used in the assessment as a worst case. This assumption will likely be revised and updated for the ES.

F = Fuel burn (kg/hr)

EF = Emission factor (kg CO_2e per tonne)

1.5 Road traffic vehicles

31. Road traffic vehicle movements associated with the construction and O&M phases of the Project will result in the release of GHG emissions. GHG emissions were calculated from the total miles travelled by heavy goods vehicles (HGVs) and staff transport to and from the onshore construction sites, and also during the O&M phase.

32. The total distance of vehicles travelled during the whole construction phase was provided by the Transport Consultants for the Project. To provide a conservative assessment, the fleet make up (in terms of fuel and Euro standards) for the earliest year of construction (2026) was used in the assessment for employee travel.

33. Emission factors for each vehicle type considered in the assessment were obtained from BEIS (2022), in kg CO_2e per km travelled. To provide a conservative assessment, it was assumed that there were no fuel efficiency improvements or reduction in emissions over the project period for each mode of transport in the assessment.

34. Distances travelled during the construction phase were calculated for HGVs and employee movements according to the following methodology:

- **General:**
    - Vehicle movements were collated by the Transport Consultants for the Project from Chapter 27 Traffic and Transport (Volume I); and
    - The approach adopted is considered to represent a worst case, noting that no reduction in traffic movements has been applied to account for the reassignment of traffic. For example, many HGVs would already be on the local network serving existing supply chains and would potentially reassign to serve North Falls without creating additional demand within the local area.
- **HGV movements:**
    - Chapter 27 Traffic and Transport (Volume I) identifies that bulk materials such as concrete and stone aggregate would make up the majority of the total HGV trips for the Project and that these deliveries would be expected to travel via the A120, either east from the A12 direction or west from the port of Harwich;
    - The distances from the A12 or Port of Harwich (via the A120) have been calculated to each of the project infrastructure destination sites for each stage of construction (this approach is considered to represent a worst-case scenario noting that deliveries from local suppliers would reduce the distance travelled); and
    - To calculate the total distance travelled, the total number of HGVs per project infrastructure destination (from Chapter 27 Traffic and Transport, Volume I) have been multiplied by the distance to the furthest

point of origin, i.e. either the A12 or Port of Harwich depending upon which is furthest.

- **Light vehicle movements:**
  - Chapter 27 Traffic and Transport (Volume I) 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 Chapter 27 Traffic and Transport (Volume I) has been informed by a review of the distribution of local and in-migrant labour;
  - Chapter 27 Traffic and Transport (Volume I) 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;
  - Distances between the employee origins and the project infrastructure destination sites for each stage of construction have been calculated; and
  - The total light vehicle movements (per project infrastructure destination sites) were multiplied by calculated distances. This provides the total light vehicle distance travelled in miles.

35. The construction phase movements used to calculate GHG emissions are provided in Table 5.

Table 5 Construction phase traffic movements

Vehicle	Total distance travelled (miles)
Cars or light vehicles	2,890,259
HGVs	3,445,433

36. The forecasted 2026 fleet composition (i.e. proportion of diesel, petrol and electric cars) was obtained from the Department for Transport (DfT) WebTAG data v1.17 (DfT, 2022). The proportion of diesel, petrol and electric cars in the UK fleet for 2026 was obtained from the DfT (2022) 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 6. Emission factors for each vehicle type were obtained from BEIS (2022).

Table 6 Calculation of emission factor used for light vehicle in assessment

Earliest year of construct-ion	Fleet composition (DfT, 2022)			Vehicle emission factor (kg CO_2e.km^{-1}) (BEIS, 2022)			Emission Factor Used in the Assessment (kg CO_2e.km^{-1})
	Diesel	Petrol	Electric	Diesel	Petrol	Electric*	
2026	39.0%	53.0%	7.0%	0.171	0.17	0.0684	0.162
* Assumed to be plug-in hybrid electric vehicle, as battery electric vehicle has 0 CO_2e emissions in the 2022 DfT dataset.							

37. It was assumed that all HGVs used on North Falls would be diesel powered. The emission factor for HGV movements (50% laden, to account for one trip fully loaded and return trip empty) was obtained from BEIS (2022) and was 0.850 kg $CO_2e.km^{-1}$. In the absence of suitable empirical data, it was assumed that the fleet composition of HGVs did not change over the temporal scope of the assessment to provide a precautionary approach.

38. During the O&M phase of the Project, traffic movements would be limited to those generated by the daily operation and periodic maintenance at the onshore substation and at link boxes along the onshore cable corridor. It was therefore assumed that there would be two traffic movements (i.e. one visit) per week during the 30-year lifespan of the operational phase of North Falls. This visit was assumed to a 40 km round-trip, i.e. 20 km each way, and amounted to approximately 2,080 km per annum.

1.6 Plant and equipment

39. Fuel consumption associated with the operation of Non-Road Mobile Machinery (NRMM) for the onshore components of the Project were calculated based on the estimated use of each item of plant and equipment. Indicative construction plant and equipment for construction activities at landfall and along the onshore cable route were provided by the design team for the Project and are specific for North Falls. The onshore substation is not currently at the outline design stage, therefore, estimates of construction plant and equipment numbers present at the onshore substation are based on other projects of a similar nature. These will be further refined for the ES.

40. The anticipated fuel demand over the duration of construction was calculated and the emission factor for gas oil consumption was obtained from BEIS (2022) to derive GHG emissions.

41. The following assumptions were adopted in the assessment:

- Plant and equipment are assumed to operate throughout the consented working hours for the Project (65 hours per week[2]). On-time factors were applied for each plant and equipment;
- 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 project team or obtained for NRMM typically required during construction activities, and from manufacturer specifications. It was assumed that engines operated at a load factor of 75%.

42. Indicative durations for plant and equipment at landfall and along the onshore cable route were provided by the project team.

[2] Note that detail as to the weekly operating hours for equipment associated with different construction tasks was not available at the time of drafting the PEIR, as so the indicative 65 hours has been used as a reasonable assumption. This figure will be revised and updated when further details becomes available in advance of submission of the ES.

43. The duration for each of the activities at the onshore substation is not known at this stage in the Application, and therefore the following assumptions have been made to calculation GHG emissions associated with onshore substation plant and equipment:

- Construction at the onshore substation is anticipated to occur over a three year period. Therefore, the eight site preparation, groundwork, civils and finishing activities listed in Table 8 were assumed to last for an equal amount of time over the three year period. This amounted to approximately 3.375 months (27 months divided by 8) for each activity.
- Construction of the onshore substation itself was assumed to last for an 18 month period (of the indicative 27 month construction programme for the onshore substation).

44. These will be further refined during the ES stage.

45. Plant and equipment used during the construction of the Project is provided below in Table 7 and Table 8. Table 7 details the number of plant required for five sections, which includes landfall and cable route. The information was provided by the project team and has been calculated specifically for North Falls.

46. The information provided in Table 7 represents the average monthly number of plant and equipment that could be present at each section. 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 landfall and onshore cable route, therefore average numbers of each plant and equipment per month were calculated (note: due to this approach, these average values may not be a whole number). The duration these plant and equipment were used was dependent on the construction programme. The total number of hours plant was operational during construction was calculated by multiplying the total number of plant/equipment required per month by the construction hours per month (65 hours per week).

47. Table 8 details the plant and equipment required for the onshore substation, which has been estimated by the project team using indicative information from a similar project and will be further refined, where possible, for the ES.

48. For the purposes of the assessment, it was assumed that plant and equipment operated using gas oil as fuel, which has an emission factor of 0.257 kg $CO_2e.kWh^{-1}$ (BEIS, 2022). All plant were assumed to operate at an average load factor of 0.75.

Table 7 Plant and equipment requirements (total construction) for each construction section (landfall and onshore cable route)

Plant	kW	On-time	No. of plant (on average) operational per month during 18-months of construction*					Total plant operational duration (hrs)**
			Section 1	Section 2	Section 3	Section 4	Section 5	
D6 Dozer	161	0.5	2.6	1.6	2.6	2.4	2.6	59,030
30T Excavator	204	0.83	3.1	2.3	2.9	2.9	2.9	72,305
20T Dumper	231	0.5	5.4	2.9	4.8	4.7	4.8	115,236
Smooth Drum vibrio road roller	142	0.1	1.5	0.9	1.3	1.2	1.3	31,633
21T excavator	128	0.83	2.7	1.7	2.4	2.4	2.4	59,030
5T Forward Tipping Dumper	62.5	0.5	2.7	1.7	2.1	2.1	2.1	54,511
Loading shovel	170	0.4	2.8	2.0	2.7	2.7	2.8	65,526
Trench Roller	142	0.1	1.2	0.5	1.2	1.1	1.2	26,832
Tractor & fencing kit	211	0.5	0.8	0.7	0.9	0.9	0.9	21,183
Tractor & trailer	211	0.85	2.4	1.3	2.3	2.2	2.4	54,511
Tractor & Fuel bowser (or self-propelled)	211	0.5	1.0	0.8	1.0	1.0	1.0	24,572
Tractor & Water bowser (for dust suppression)	211	0.5	1.0	0.8	1.0	1.0	1.0	24,572
Tractor & cable drum trailer	211	0.5	0.5	0.2	0.6	0.5	0.6	11,580
Tractor & soil tiller, roller, seeder	211	0.5	0.3	0.3	0.3	0.3	0.3	8,191
Cement mixer	216	0.73	0.2	0.0	0.0	0.0	0.0	847
Mobile crane	132	0.5	0.3	0.0	0.0	0.0	0.0	1,695
Grader	205	1	0.8	0.6	0.8	0.7	0.8	18,641
Cable laying tracked crane	107	0.5	0.2	0.0	0.0	0.0	0.0	847
Cable winch	19.1	0.85	0.5	0.2	0.6	0.5	0.6	11,580
Pre-cast concrete truck	216	0.73	0.2	0.0	0.0	0.0	0.0	847
Mobile concrete pump	216	0.85	0.7	0.2	0.6	0.5	0.6	12,710
Telehandler	107	0.85	2.2	1.1	2.1	1.9	2.1	47,168

Plant	kW	On-time	No. of plant (on average) operational per month during 18-months of construction*					Total plant operational duration (hrs)**
			Section 1	Section 2	Section 3	Section 4	Section 5	
Mobile self-contained welfare unit	8	1	1.0	0.8	1.0	1.0	1.0	24,572
Crawler Crane	107	0.5	0.6	0.2	0.6	0.5	0.6	12,145
Road surface paver & roller	142	0.1	0.1	0.1	0.1	0.1	0.1	2,824

*Number of plant provided by project's design team as whole numbers per month per section, however these are not the same across the construction period so dividing the total number of each plant needed for a month's duration by 18 (for presentation in the chapter) results in fractions of numbers

**assuming 65 hour work week

Table 8 Indicative plant and equipment to be used during the construction phase at the onshore substation

Plant	On time (%)*	Engine power (kW)*	Site preparation (topsoil stripping)	Groundwork			Civils			Finishing (topsoil replacement and landscape implementation)	Construction of onshore substation
				Pre-earthworks drainage	Excavation and installation of below ground cables ducts/pipes	Piling	Trench excavation and laying cable foundations	Back-filling	Pits, chambers, troughs, trays and ducting		
Dumper	50	306	2	2	2	0	0	0	2	2	0
Bulldozer	83	142	2	2	2	0	0	0	2	2	0
Wheeled loader backhoe loader	40	170	2	0	0	0	0	0	0	0	0
Wheeled backhoe loader - loading lorries	40	193	2	2	2	0	0	0	2	2	0
Excavator	83	102	2	0	0	0	0	2	0	2	2
Dump truck (tipping fill)	2-5	306	2	2	2	0	0	0	2	2	0
Dozer	50	107[A]/ 142	2	2	2	0	0	0	0	2	2
Wheeled backhoe loader - trenching	40	62[B]/ 102	0	2	2	0	0	2	2	0	0
Dewatering	10	20	0	1	1	0	1	0	1	0	0

Plant	On time (%)*	Engine power (kW)*	Site preparation (topsoil stripping)	Groundwork			Civils			Finishing (topsoil replacement and landscape implementation)	Construction of onshore substation
				Pre-earthworks drainage	Excavation and installation of below ground cables ducts/pipes	Piling	Trench excavation and laying cable foundations	Back-filling	Pits, chambers, troughs, trays and ducting		
Large concrete mixer (mixing concrete)	73	216	0	1	0	0	1	0	0	0	0
Truck mounted concrete truck with Boom arm (pumping concrete)	10	216	0	1	0	0	1	0	0	0	1
Directional drill (generator)	50	106	0	0	0	1	0	0	0	0	0
Mobile crane	20-50	132/ 440[C]	0	0	0	1	0	0	1	0	2
Piling rig	83	106	0	0	0	1	0	0	0	0	1
Drop hammer pile rig power pack	83	23	0	0	0	1	0	0	0	0	0
Excavator - trenching	83	102	0	2	2	0	2	0	2	0	0
ADT	80	187	0	0	0	0	0	2	0	0	0

Plant	On time (%)*	Engine power (kW)*	Site preparation (topsoil stripping)	Groundwork			Civils			Finishing (topsoil replacement and landscape implementation)	Construction of onshore substation
				Pre-earthworks drainage	Excavation and installation of below ground cables ducts/pipes	Piling	Trench excavation and laying cable foundations	Back-filling	Pits, chambers, troughs, trays and ducting		
Roller	10	142	0	0	0	0	0	2	0	0	0
Grader	100	205	0	0	0	0	0	2	0	0	0
Dump truck (empty) - moving	10	306	0	0	0	0	0	0	2	0	0
Wheeled backhoe loader - clearing site	40	62	0	0	0	0	0	0	0	2	0
Backhoe loader	40	170	0	0	0	0	0	0	0	0	2
Skip dumper	50	306	0	0	0	0	0	0	0	0	2
Cement mixer truck (discharging)	73	216	0	0	0	0	0	0	0	0	1
Generator	50	106	0	0	0	0	0	0	0	0	2
Lorries	10	0	0	1	1	0	2	0	1	0	0
Vibratory compactor	50	0	0	0	1	0	0	0	1	0	0

Plant	On time (%)*	Engine power (kW)*	Site preparation (topsoil stripping)	Groundwork		Civils				Finishing (topsoil replacement and landscape implementation)	Construction of onshore substation
				Pre-earthworks drainage	Excavation and installation of below ground cables ducts/pipes	Piling	Trench excavation and laying cable foundations	Back-filling	Pits, chambers, troughs, trays and ducting		
HGV delivering CBS	10	0	0	0	0	0	0	1	0	0	0

*Provided by project design team (and have been taken from an indicative example project of a similar size to North Falls)

[A]Finishing

[B]Pre-earthworks

[C]Construction

1.7 References

Cableizer (n/a). Embodied energy and carbon. [Online] Available at: https://www.cableizer.com/documentation/EEC/

Department for Business, Energy & Industrial Strategy (BEIS) (2022). Greenhouse gas reporting: conversion factors 2022. [Online] Available at: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022

Department for Transport (DfT) (2022). TAG Data Book, Table A1.3.9. May 2022 v1.18. [Online] Available at: https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fassets.publishing.service.gov.uk%2Fgovernment%2Fuploads%2Fsystem%2Fuploads%2Fattachment_data%2Ffile%2F1079119%2FTAG-data-book.xlsm&wdOrigin=BROWSELINK

Jin, H., Afiuny, P., McIntyre, T., Yih, Y., Sutherland, J. W. (2016). Comparative Life Cycle Assessment of NdFeB Magnets: Virgin Production versus Magnet-to-Magnet Recycling. 23rd CIRP Conference on Life Cycle Engineering.

Jones, C., Hammond, G. (2019). Circular Economy and University of Bath ICE (Inventory of Carbon & Energy) Database, Version 3. [Online] Available at: https://drive.google.com/drive/folders/1vHpIGkpgkplmItn_0IaPXQ-5Fxnr08Wz?usp=sharing