Partners in UK offshore wind

MORGAN OFFSHORE WIND PROJECT: GENERATION ASSETS

Preliminary Environmental Information Report

Volume 1, chapter 3: Project description

Image of an offshore wind farm

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FINAL

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Glossary

Term	Meaning
Dynamic Positioning Vessel	A vessel which can control its movements automatically using propellers and thrusters in order to maintain a stationary position.
Geophysical surveys	Surveys of the seabed which collect data on seabed form and boulder mapping.
Geotechnical surveys	Surveys of the seabed which collect data on underlying seabed geology and rock layers.
High Voltage Alternating Current	Form of electricity that is used by the UK National Grid and is delivered to consumers.
Hydrodynamics	Physical processes of water movement (e.g. ocean currents).
Maximum design scenario (MDS)	The MDS represents the parameters that make up the realistic worst case scenario. This is selected from a range of parameters and may be different for different receptors and activities.
Micrositing	The final selection of the position of infrastructure which may move in the order of a few metres to avoid an obstruction.
OSP topside	The topside of an offshore substation is the section that is located above the sea surface and houses the electrical equipment
Project Design Envelope (PDE)	The PDE sets out the design assumptions and parameters from which the realistic MDSs are drawn for the Morgan Generation Assets EIA.
Unexploded Ordnance	Remains of explosive devices that did not detonate when they were deployed.

Acronyms

Acronym	Description
AfL	Agreement for Lease
BEIS	Business, Energy and Industrial Strategy
CAA	Civil Aviation Authority
CAP	Civil Aviation Publication
CBRA	Cable Burial Risk Assessment
CL:AIRE	Contaminated Land: Applications in Real Environments
CoCP	Code of Construction Practice
CPT	Cone Penetration Testing
CTV	Crew Transfer Vessels
DCO	Development Consent Order
DGC	Defence Geographic Centre
DPV	Dynamic Positioning Vessel
EIA	Environmental Impact Assessment
HAT	Highest Astronomical Tide
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
ICPC	International Cable Protection Committee
IR	Infra-red
JUV	Jack-Up Vessel
LAT	Lowest Astronomical Tide
MBES	Multi-Beam Echo-Sounder
MCA	Maritime and Coastguard Agency
MDS	Maximum Design Scenario
MHWS	Mean High Water Springs
NEQ	Net Explosive Quantity
NPS	National Policy Statement
OSP	Offshore Substation Platform
PDE	Project Design Envelope
PEIR	Preliminary Environmental Information Report
pUXO	Potential UXO
QSHE	Quality, Safety, Health and Environment
SAR	Search and Rescue
SBES	Single Beam Echosounder
SBP	Sub-Bottom Profiler
SOV	Service Operation Vessel
SPS	Significant Peripheral Structures
SWMP	Site Waste Management Plan
TCE	The Crown Estate
UHRS	Ultra High Resolution Seismic
UKHO	UK Hydrographic Office
UXO	Unexploded Ordnance

Units

Unit	Description
cd	Candela
kJ	Kilojoules

Unit	Description
kV	Kilovolts
km	Kilometres
km^2	Kilometres squared
m	Metres
m^3	Metres cubed
m^2	Metres squared
mm	Millimetres
nm	Nautical miles
%	Percentage

3 Project description

3.1 Introduction

3.1.1.1 Morgan Offshore Wind Limited (the Applicant), a joint venture of bp Alternative Energy Investments Ltd. (hereafter referred to as bp) and Energie Baden-Württemberg AG (hereafter referred to as EnBW) is developing the Morgan Offshore Wind Project. The Morgan Offshore Wind Project and the Morecambe Offshore Windfarm (developed by Morecambe Offshore Wind Farm Ltd a joint venture between Cobra Instalaciones Servicios, S.A. and Flotation Energy plc) have been scoped into the Pathways to 2030 workstream under the Offshore Transmission Network Review (OTNR). Under the OTNR, the National Grid Electricity System Operator is responsible for conducting a Holistic Network Design Review to assess options to improve the coordination of offshore wind generation connections and transmission networks. The output of this process concluded that the Morgan Offshore Wind Project and the Morecambe Offshore Windfarm should work collaboratively on a coordinated grid connection at Penwortham in Lancashire.

3.1.1.2 A coordinated grid connection for the Morgan Offshore Wind Project and the Morecambe Offshore Windfarm will be delivered as part of a separate transmission assets application for consent. The project description set out within this chapter of the Preliminary Environmental Information Report (PEIR) provides an outline description of the Morgan Offshore Wind Project Generation Assets (hereafter referred to as the Morgan Generation Assets).

3.1.1.3 The parameters required for the construction, operations and maintenance, and decommissioning phases of the Morgan Generation Assets are based on preliminary design information and the current understanding of the receiving environment.

3.1.1.4 The Applicant has, through the Environmental Impact Assessment (EIA) process (i.e. from Scoping to the PEIR), started to refine the proposed envelope and provide more detailed realistic Maximum Design Scenarios (MDSs) where available. These parameters will be further refined between the PEIR and the final Environmental Statement, taking into account responses from consultation. The refined parameters will be presented in the Environmental Statement and draft Development Consent Order (DCO). The final Morgan Generation Assets project design will be selected after development consent has been granted, from the parameters stated in the project description within the Environmental Statement.

3.2 Project design status

3.2.1.1 The Project Design Envelope (PDE) approach (also known as the Rochdale Envelope approach) will be adopted for the EIA of the Morgan Generation Assets, in accordance with industry good practice. The PDE sets out the design assumptions and parameters from which the realistic MDSs are drawn for the Morgan Generation Assets EIA. Information on the National Policy Statements (NPSs) is presented in volume 1, chapter 2: Policy and legislative context of the PEIR. Further information on the Rochdale Envelope approach is presented in volume 1, chapter 5: EIA Methodology of the PEIR.

3.2.1.2 The Morgan Generation Assets are in the early stages of the development process. Therefore, the project description is indicative and the ‘envelope’ has been designed to include flexibility to accommodate further project refinement during detailed design and procurement, post consent. Offshore wind is a continually evolving industry with a constant focus on cost reduction, therefore improvements in technology and construction methodologies occur frequently and an unnecessarily prescriptive approach could preclude the adoption of new technology and methods. Consequently, this chapter sets out a series of parameters.

3.2.1.3 This project description does not refer directly to the generation capacity of the wind turbines but rather their physical dimensions. As a result, the assessments are not linked directly to the wind turbine capacity (but rather their physical dimensions such as tip height and rotor diameter).

3.3 Morgan Generation Assets Boundary

3.3.1.1 The Morgan Generation Assets boundary is presented in Figure 3.1 below. The Morgan Generation Assets consists of the following:

- wind turbines, foundations, inter-array cables, Offshore Substation Platforms (OSPs) and interconnector cables.

3.4 Agreement for Lease area

3.4.1.1 The Applicant entered into Agreement for Lease (AfL) for the Morgan Offshore Wind Project in January 2023. The AfL for the Morgan Array Area covers approximately 322.2km^2 and is located in the east Irish Sea, 58.8km (31.7nm) from the Anglesey coastline, 36.3km (19.6nm) from the northwest coast of England, and 22.3km (12nm) from the Isle of Man (when measured from Mean High Water Springs (MHWS)). The Morgan Generation Assets infrastructure, including the wind turbines, OSPs, interconnector cables and inter-array cables will be located within the AfL area and is referred to as the Morgan Array Area throughout the PEIR (Figure 3.1). The term Morgan Generation Assets is used throughout the PEIR to refer to the project including all works associated with construction, operations and maintenance and decommissioning of the Morgan Array Area.

3.5 Consultation

3.5.1.1 Consultation is an important part of the EIA process and has been carried out to date with both statutory and non-statutory stakeholders through pre-scoping consultation and through the EIA Scoping Report. A summary of the key issues raised during consultation activities undertaken to date specific to the project description is presented in Table 3.1 below, together with how these issues have been considered in the design of the Morgan Generation Assets.

3.5.1.2 Consultation will continue throughout the pre-application phase of the Morgan Generation Assets. Wider consultation on the Morgan Generation Assets with stakeholders and local communities is described in volume 1, chapter 1: Introduction of the PEIR. Topic-specific consultation is presented in the relevant topic chapter of the PEIR.

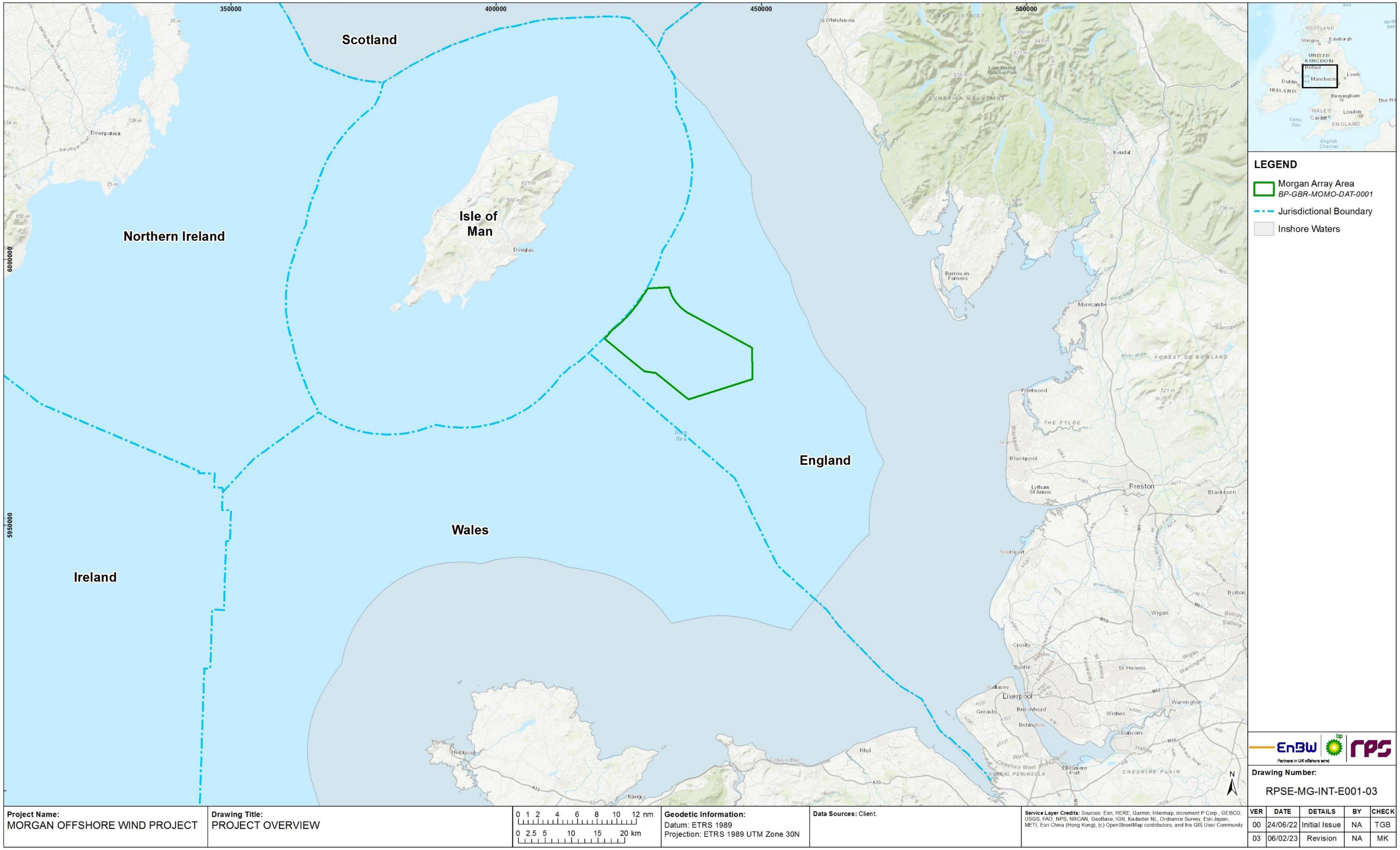

Figure 3.1: Overview of the Morgan Generation Assets location.

Table 3.1: Summary of key consultation issues raised during consultation activities undertaken for the Morgan Generation Assets relevant to the project design.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or were considered in this chapter
July 2022	The Planning Inspectorate - Scoping Opinion	The Environmental Statement should provide further detail on the proposed pre-construction activities and seabed preparation activities.	The seabed preparation activities are described in section 3.6.4 below. The assumptions around the number and type of Unexploded Ordnance (UXO) considered in the assessment are also presented in section 3.6.3. Any likely significant effects have been assessed in the relevant topic chapters (see volume 2, chapters 6 to 20 of the PEIR).
July 2022	The Planning Inspectorate - Scoping Opinion	The Environmental Statement should identify the likely site for disposal of drill arisings and include an assessment of effects from these activities.	Drill arisings will be disposed of in the vicinity of the source. This is described in section 3.6.8 below and assessed in the relevant topic chapters (see volume 2, chapters 6 to 18 of the PEIR).
July 2022	The Planning Inspectorate - Scoping Opinion	The Environmental Statement should provide a full description of the nature and scope of operational and maintenance activities, including types of activity, frequency, and how works will be carried out.	A description of offshore operational and maintenance activities for which consent is sought under the DCO are presented in section 3.8 below.

3.5.1.3 The AfL with The Crown Estate (TCE) allows the Applicant to apply for marine licences to carry out survey activities, to further inform and refine the design and construction of the Morgan Generation Assets. These surveys allow the Applicant to understand the environmental conditions in the area in advance of submitting the consent application.

Project infrastructure overview

3.5.1.4 The Morgan Generation Assets will be located in the east Irish Sea and will include up to 107 wind turbines. The capacity of the Morgan Generation Assets is over 100MW, therefore it is within the Planning Act 2008 thresholds for English offshore schemes. The final capacity of the Morgan Generation Assets will be determined based on available technology and constrained by the design envelope of the wind turbines presented in this chapter. The offshore infrastructure will also include up to 60km of interconnector cable and 500km of inter-array cable.

3.5.1.5 The key components of the Morgan Generation Assets are shown in Figure 3.2 and the key parameters are presented in Table 3.2.

3.5.1.6 The Applicant intends to commence construction of the Morgan Generation Assets in 2026 and for them to be fully operational by 2030 in order to help meet the UK Government's renewable energy targets.

Table 3.2: Key parameters for the Morgan Generation Assets.

Parameter	Value
Morgan Array Area (km^2)	322.2
Average water depth (m LAT)	-37.8
Maximum number of wind turbines	107
Maximum blade tip height above LAT (m)	324
Maximum number of OSPs	4
Maximum length of inter-array cables (km)	500
Maximum length of interconnector cables (km)	60

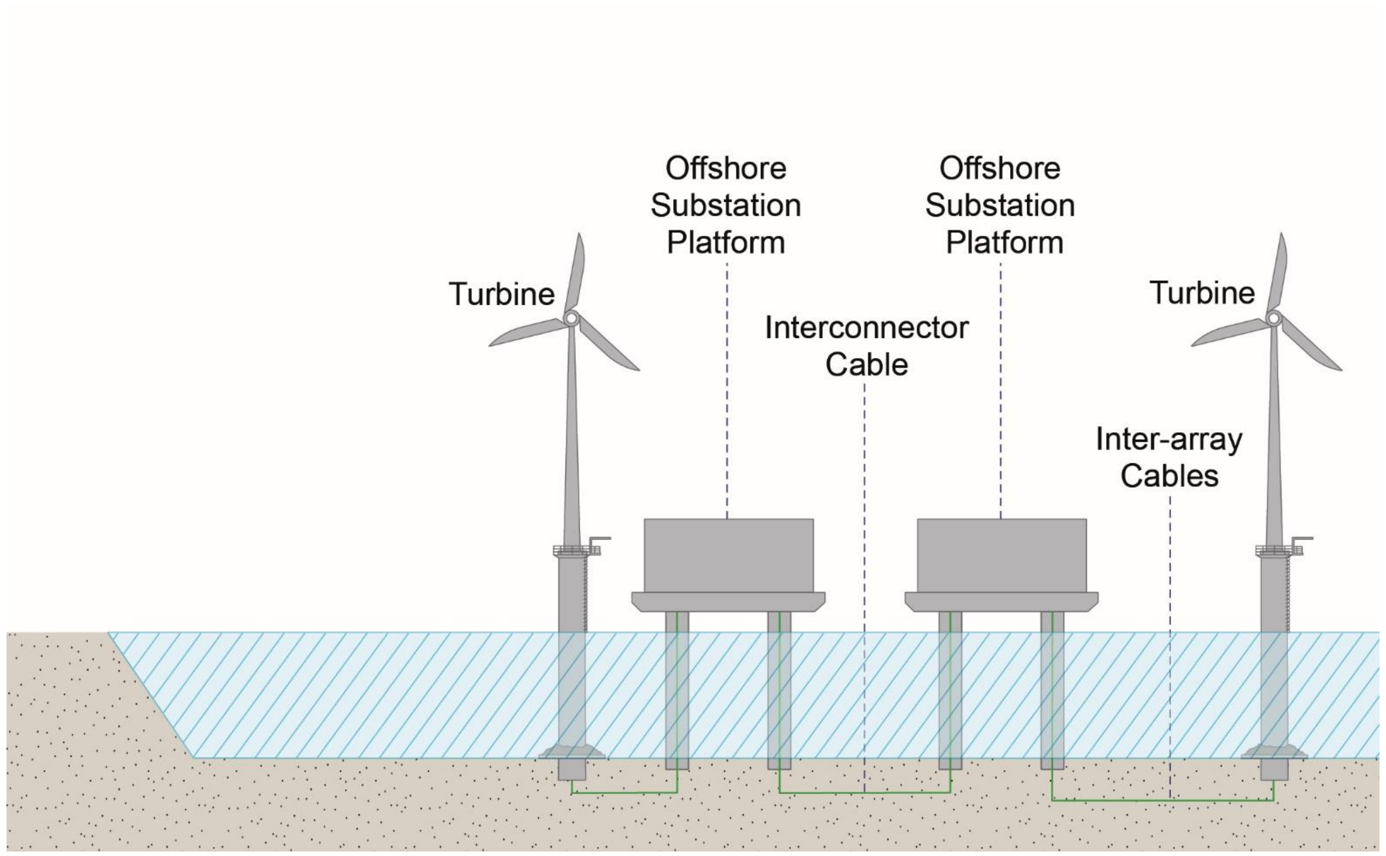

Figure 3.2: Overview of the Morgan Generation Assets infrastructure indicating foundations.

3.6 Offshore infrastructure

3.6.1 Overview

3.6.1.1 This section describes the geophysical and geotechnical site investigation surveys required to be undertaken before construction commences. Once these are completed, construction will commence with site preparation activities. Site preparation may include UXO clearance, boulder clearance, sandwave clearance and seabed preparation activities. This section then goes on to describe the offshore infrastructure that will be constructed within the Morgan Array Area following the completion of the site preparation activities. The offshore infrastructure will include wind turbines, OSPs, foundations, inter-array cables, interconnector cables, and scour and cable protection. This section also describes the aids to navigation and safety practices that the Applicant will adopt.

3.6.2 Pre-construction site investigation surveys

3.6.2.1 Pre-construction site investigation surveys will be undertaken to provide detailed information on seabed conditions, morphology and to identify the presence/absence of any potential obstructions or hazards and to verify the seabed geology layers as well as the subsoil geotechnical conditions. Pre-construction site investigation surveys are likely to include geophysical and geotechnical surveys which will be conducted within, and in the vicinity of, the footprint of the wind turbines and OSPs and along the cable routes. Geophysical survey works will be carried out to provide detailed UXO, bedform and boulder mapping, bathymetry, a topographical overview of the seabed and an indication of subsoil-layers. Geotechnical surveys will be conducted at specific locations within the Morgan Array Area.

3.6.2.2 The geophysical site investigation is anticipated to include the following activities which are commonly undertaken as best practice for offshore wind farms:

- Multi-beam echo-sounder (MBES) (200-400kHz; 180-240dB re 1 1μPa)
- Sidescan Sonar (SSS) (200-900kHz; 190-245dB re 1 1μPa)
- Single Beam Echosounder (SBES) (200-400kHz; 180-240dB re 1 1μPa)
- Sub-Bottom Profilers (SBP) (0.5-12kHz chirp, 4kHz pinger, 100kHz pinger; 200-240 chirp dB re 1 1μPa, 200-235 pinger (both) dB re 1 1μPa.)
- Ultra High Resolution Seismic (UHRS) (19.5-33.5kHz; 170-200dB re 11μPa)
- Magnetometer.

3.6.2.3 The geotechnical site investigation is anticipated to include the following activities which are commonly undertaken as best practice for offshore wind farms:

- Boreholes
- Cone penetration tests (CPTs)
- Vibrocores.

3.6.3 Unexploded Ordnance clearance

3.6.3.1 It is possible that UXO may be encountered during the construction of offshore infrastructure. This poses a health and safety risk where it coincides with the planned location of infrastructure and associated vessel activity and therefore it is necessary to survey for, and manage, potential UXO. In order to identify UXO, detailed surveys of the location where infrastructure will be located are required. This work cannot be conducted before a consent application is submitted because the detailed design work needed to confirm the location of infrastructure is reliant upon the pre-construction site investigation surveys outlined in paragraph 3.6.2.1. In addition, the survey for identification of potential UXO (pUXO) must be undertaken within approximately one year ahead of the start of construction due to the potential for hydrodynamics to uncover UXO that may not be detected in pre-application surveys. The Applicant commissioned a study to establish the potential for UXO presence at the Morgan Generation Assets array area. Based on the results of this study and a conservative estimate, the design envelope for UXO clearance is described in Table 3.3. Furthermore, a range of UXO sizes is predicted with the Net Explosive Quantity (NEQ) ranging between 25kg to 907kg with 130kg being the most likely maximum.

Table 3.3: UXO across the Morgan Array Area

Potential UXO constraint	Number
Potential UXO as constraints to operations	1883
Potential UXO requiring inspection	178
Percentage Potential UXO to Confirmed UXO	7.5%
Total UXO (above threat item) predicted to require clearance	**13**

3.6.3.2 The Morgan Generation Assets will submit a clearance method statement, confirmation of UXO for clearance and confirmation that clearance does not coincide with archaeology/sensitive seabed features to the MMO pre-construction once UXO surveys are complete.

Methodology

3.6.3.3 Potential UXO targets identified during the pre-construction site investigation surveys will be investigated to determine if they are UXO. If they are classified as a UXO, they can either be cleared or avoided. Where possible, UXO will be avoided through micrositing of infrastructure, cleared through *in-situ* clearance or recovery of the UXO for disposal at an alternate location. The method of clearance will depend on factors such as the condition of the UXO and will be subject to the UXO clearance contractors safety assessment.

3.6.3.4 There are a number of methodologies that may be used to clear UXO targets, including detonation of the UXO using an explosive counter-charge placed next to the UXO on the seabed (referred to as a ‘high order’ technique) or methods that neutralise the UXO to be safe without detonation (referred to as ‘low order’ techniques). These low order techniques include ‘deflagration’ which involves the use of a small charge to ‘burn out’ the explosive material without detonation.

3.6.3.5 The use of the low order techniques is dependent on the condition of the UXO and individual circumstances. Furthermore, the Applicant will not know what condition a UXO is in until it is investigated through the pre-construction site investigation surveys. Therefore, whilst the use of low-order techniques is a potentially viable solution for clearance of UXO, it is not possible to make a commitment to using them at this stage as it will not be known whether it is a feasible option.

3.6.4 Site preparation activities

Boulder clearance and out of service cables

3.6.4.1 Boulder clearance is commonly required during site preparation for installation of offshore wind farm infrastructure. Micrositing of cables around boulders would be onerous and impractical. Boulders would pose the risk of damage and exposure to the cable as well as an obstruction risk to the cable installation equipment. Therefore, any boulders that would impact on installation will be required to be cleared from the Morgan Array Area.

3.6.4.2 The pre-application site-specific geophysical surveys have identified that boulder clearance may be required in the vicinity of the foundation locations, along the inter-array cables and interconnector cables. Boulder clearance would occur within the footprint of other installation activities therefore the footprint is not presented to prevent double counting of the seabed footprint parameters.

3.6.4.3 If the final location of the Morgan Generation Assets infrastructure crosses any out of service cables these will be removed. Any cable removal will be undertaken in consultation with the asset owner and in accordance with the International Cable Protection Committee (ICPC) guidelines (2011). Cables will be retrieved to a vessel deck, where one end will be cut, pulled the cable past the crossing point and then cut again before being pulled to the surface where it will be removed from site by the vessel.

Sandwave clearance for cables, and sandwave clearance and/or seabed preparation for foundations

3.6.4.4 In some areas within the Morgan Array Area existing sandwaves and similar bedforms may require to be removed before cables and foundations are installed. Many of the cable installation tools require a stable, flat seabed surface in order to perform as it may not be possible to install the cable up or down a slope over a certain angle. In addition, the cables must be buried to a depth where they can be expected to stay buried for the duration of the lifetime of the Morgan Generation Assets. Sandwaves are generally mobile in nature therefore cables must be buried beneath the level where natural sandwave movement could uncover them. Wind turbine foundations need to be placed in level, pre-prepared areas of seabed. This can only be achieved by removing the mobile sediments before installation takes place.

3.6.4.5 Site-specific geophysical data from the Morgan Array Area and bathymetry data was used to identify sandwaves and it was determined that up to 50% of the inter-array and 60% of the interconnector would require sandwave clearance. Site-specific geophysical data from the Morgan Array Area and bathymetry data identified that up to 60% of foundation locations may require sandwave clearance. UXO and boulder clearance will also be required. These activities are discussed earlier in this section. Additional seabed preparation may be required for gravity base foundations, including dredging of the soft sediments. If dredging is required, it would be carried out by dredging vessels using suction hoppers or similar.

3.6.4.6 The MDS for sandwave clearance and seabed preparation in the Morgan Array Area is summarised in Table 3.4 below. The MDS for sandwave clearance and seabed preparation for foundations is based on the four-legged suction bucket foundation option (foundation options are further described in section 3.6.8). It should be noted that boulder clearance will occur over the same location as the sandwave clearance. The corridor width for boulder clearance is less than is required for sandwave clearance therefore boulder clearance represents repeat disturbance to the seabed.

3.6.4.7 It is expected that material subject to seabed preparation activities will be deposited in the vicinity of where they were removed. A dredging and disposal site characterisation for the disposal of seabed preparation material will be presented in a dredging and disposal site characterisation report as part of the Application.

Table 3.4: Maximum design parameters for sandwave clearance and seabed preparation in the Morgan Array Area.

Parameter	Maximum design parameters
Sandwave clearance impact width – inter-array and interconnector (m)	104
Sand-wave clearance: Inter-array cables (m^3)	11,843,641
Sand-wave clearance: Interconnector cables (m^3)	3,060,814
Sand-wave clearance and seabed preparation: Foundations (m^3)	10,149,455
Sand-wave clearance and seabed preparation: Total in Morgan Array Area (inter-array cables, interconnector cables, foundations) (m^3)	24,053,910

3.6.5 Wind turbines

Design

3.6.5.1 The Morgan Generation Assets will consist of up to 107 wind turbines, with the final number of wind turbines dependent on the capacity of the individual wind turbines used, and environmental and engineering survey results. Wind turbines with a range of generating capacities are being considered and are differentiated in the EIA as scenario 1 to 5 (Table 3.5). However, the physical parameters which form the basis of the MDS, such as maximum tip height or rotor diameter, will dictate the wind turbines that are ultimately installed, rather than these be limited by the maximum power ratings of individual turbines. The wind turbines will follow the traditional wind turbine design with a horizontal rotor axis with three blades connected to the nacelle of the wind turbine. The nacelle will be supported by a tower structure which is fixed to the transition piece and foundation. An illustration of this design can be seen in Figure 3.3 and a picture of an offshore wind turbine at the EnBW Hohe See Offshore Wind Farm is shown in Figure 3.4 below.

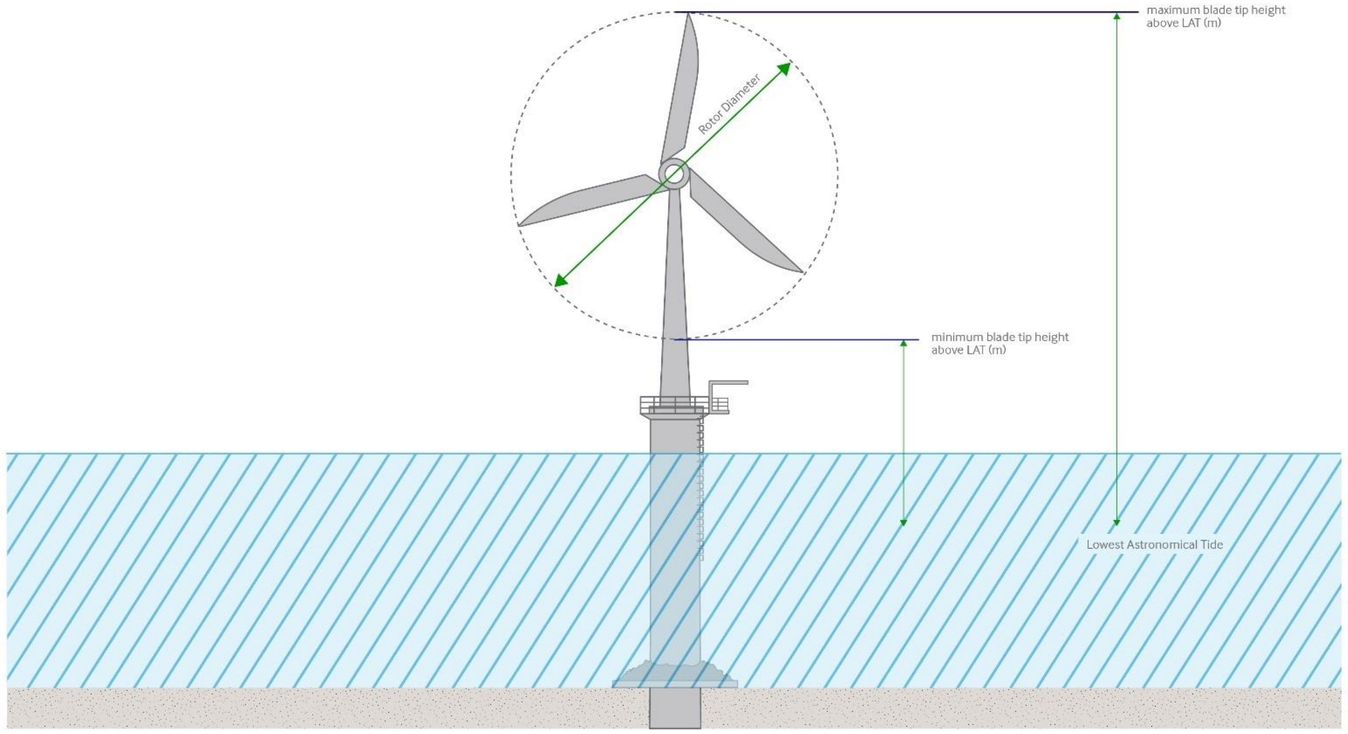

Figure 3.3: Schematic of an offshore wind turbine.

Figure 3.4: A picture of a wind turbine at the EnBW Hohe See Offshore Wind Farm in the German North Sea.

3.6.5.2 The MDS for wind turbines presented in Table 3.5 shows the scenarios being considered.

Table 3.5: Maximum design parameters: wind turbines.

Parameter	Scenario 1	Scenario 2
Number of turbines	107	68
Minimum height of lowest blade tip above Lowest Astronomical Tide (LAT) (m)	34	34
Maximum blade tip height above LAT (m)	293	324
Maximum rotor blade diameter (m)	250	280

Installation

3.6.5.3 Generally, wind turbines are installed using the following process:

1. Wind turbine components may be collected from a port in the UK, Europe or elsewhere and loaded onto barges or dedicated transport vessels at port and transported to the Morgan Array Area. Generally, blades, nacelles, and towers for a number of wind turbines are loaded separately onto the vessel.
2. Wind turbine components will be installed onto the existing foundations by an installation vessel. Each wind turbine will be assembled on site. The exact methodology for the assembly is dependent on the wind turbine type and installation contractor and will be defined in the pre-construction phase. Jack-Up Vessels (JUVs) are often used to ensure a stable platform for installation vessels when on site. JUVs are assumed to have up to six legs with an area of $350m^2$ per foot.

3.6.5.4 The total duration for wind turbine installation is expected to be a maximum of 24 months.

3.6.5.5 Each installation vessel or barge may be assisted by a range of support vessels. These are typically smaller and may comprise tugs, guard vessels, anchor handling vessels, or similar. These vessels will primarily shadow the same movements as the installation vessels they are supporting. For the purposes of the EIA, the assumptions in Table 3.6 have been made on the maximum number of installation and support vessels and the number of return trips to the Morgan Array Area from port that are required throughout wind turbine installation. These numbers have been used to inform the assessment within volume 2: chapter 12 Shipping and navigation of the PEIR.

3.6.5.6 It is likely that the maximum number of installation vessels will be lower than those presented for PEIR. These changes will be presented and assessed within the Environmental Statement for the DCO application.

Table 3.6: Maximum design parameters for the wind turbines installation.

Vessel type/helicopter support	Maximum number of vessels/helicopters on site at any one time	Maximum number of return trips per vessel type/helicopter over the construction period
Installation and support vessels	4	76
Survey vessels	1	12
Crew Transfer Vessels (CTVs)	4	365
Helicopter support	2	365

3.6.6 Wind turbine and surface infrastructure layouts

3.6.6.1 The layout of the wind turbines will be developed to best utilise both the available wind resource and suitability of seabed conditions, while seeking to minimise environmental effects and impacts on other marine users (such as fisheries and shipping routes). The Morgan Generation Assets will be developed on the basis of the principles set out in Table 3.7 below.

3.6.6.2 In order to inform the EIA, the Applicant has identified indicative layout scenarios which are presented in the relevant topic-specific chapters of the PEIR. However, the final layout of the wind turbines will be confirmed at the final design phase post-consent.

Table 3.7: Layout development principles.

Principle	Definition
Principle 1	All wind turbines and OSPs will be located within the Morgan Array Area. No blade overfly or structural overhang is permitted, therefore all wind turbines must be positioned at least half a rotor diameter inside the boundary of the Morgan Array Area.
Principle 2	Minimum separation of 875m between wind turbines at the boundary of the wind farm and 1,000m within the wind farm.
Principle 3	Search and Rescue (SAR) lanes shall be allowed for and shall be a minimum of 500m wide, measured from the perimeter of any offshore asset. In the case of wind turbines, SAR lanes will be measured from the blade tips that are transverse to the wind turbine. SAR lanes will cross the Morgan Array Area on the same bearing until the edge of the Morgan Array Area or until a Helicopter Refuge Area is reached.
Principle 4	All assessments will consider two lines of orientation with the final wind turbine layout respecting as a minimum one line of orientation. If the proposed final layout presents one line of orientation, a safety justification will be developed to demonstrate that risks to SAR and navigational safety are acceptable for such particular layout.
Principle 5	For all wind turbine positions, the tolerance allowance will be 100m, either side of the nominal wind turbine position whilst still complying with Principles 2 and 3.
Principle 6	For all wind turbine positions, the micrositing allowance will be 100m, either side of the target wind turbine position.

Principle	Definition
Principle 7	Packed boundaries are permitted, that is, wind turbines on the perimeter of the Morgan Array Area maintain minimum spacing whilst internal spacing can be greater. The minimum wind turbine spacing shall be compliant with Principle 2 (minimum spacing of 875m). SAR lanes will be compliant with Principle 3 and access to the SAR lane will be allowed between the perimeter wind turbines.
Principle 8	Where SAR Access Lanes are more than circa 10nm, a Helicopter Refuge Area perpendicular to the SAR Access Lanes will be included within the layout design. The Helicopter Refuge Area shall be at least 1nm (tip to tip) in width and allow access across the Morgan Array Area.

3.6.7 Offshore substation platforms

3.6.7.1 The OSPs will contain the equipment required to transform electricity generated at the wind turbines to a higher voltage for transportation onshore via the Morgan and Morecambe Offshore Wind Farms Transmission Assets which is being progressed via a separate DCO application. They may also house auxiliary equipment and facilities for operating, maintaining and controlling the substation. They are likely to have one or more decks, a helicopter platform, cranes and communication antenna (Figure 3.5).

Figure 3.5: OSP at the EnBW Hohe See Offshore Wind Farm in the German North Sea.

3.6.7.2 Up to four separate OSPs will be required, and they will all be located within the Morgan Array Area. The exact locations will be determined during the post-consent detailed design phase. Locations will take into account the ground conditions and the most efficient cable routing amongst other considerations. They will follow the layout principles set out in Table 3.7. The OSPs are planned to be unmanned type A according to DNVGL-ST-0145 but once commissioned will be subject to regular operations and maintenance visits.

3.6.7.3 The maximum design parameters for the OSPs are presented in Table 3.8 below and a schematic of an OSP is presented in Figure 3.6.

Table 3.8: Maximum design parameters for the OSPs.

Parameter	Maximum design parameters
Number of OSPs	4
Topside – main structure length (m)	80
Topside – main structure width (m)	60
Topside – height (excluding helideck or lightning protection) (LAT) (m)	70
Height of lightning protection and ancillary structures (LAT) (m)	95
Topside - area (m^2)	4,800

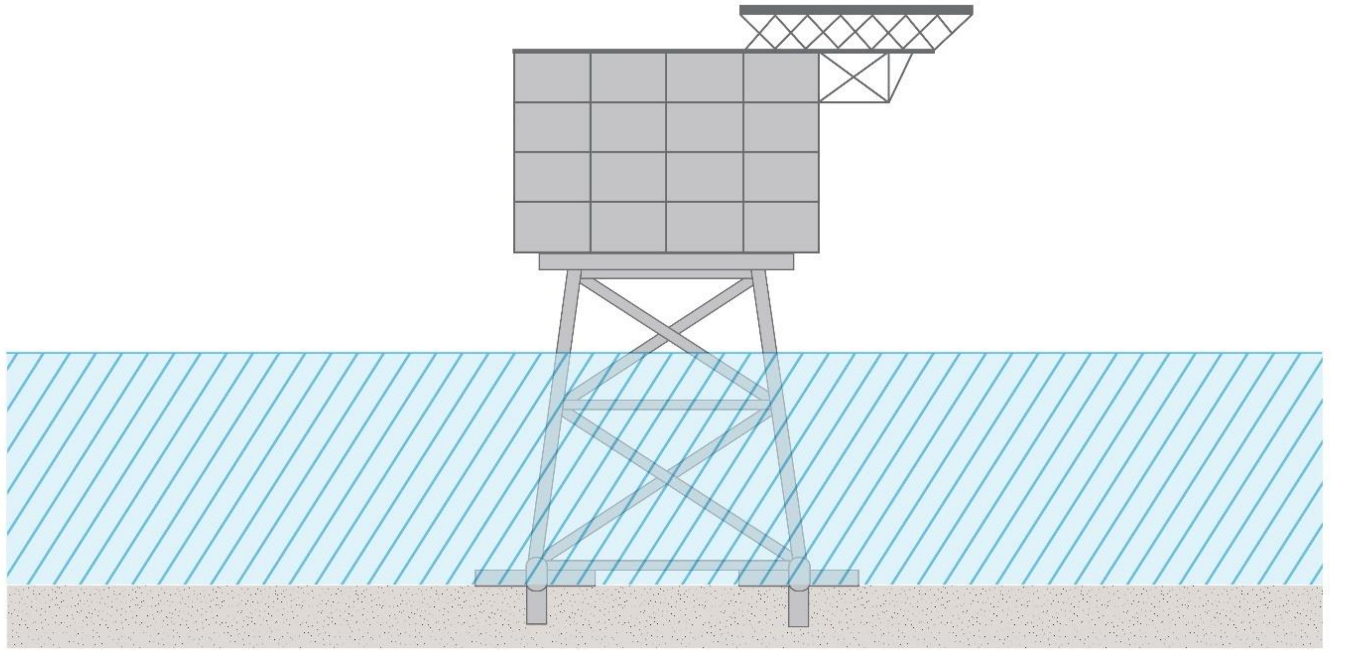

Figure 3.6: Schematic of an OSP.

Installation

3.6.7.4 OSPs are generally constructed by installing the foundation structure, then the topside will be lifted from a transport vessel/barge or float over onto the foundation. The foundation and topside may be transported on the same transport vessel/barge, or separately. The vessel requirements for OSP installation are presented in Table 3.9.

Table 3.9: Maximum design parameters for the OSP installation.

Parameter	Maximum number of vessels on site at any one time	Maximum number of return trips per vessel type over the construction period
Primary installation and support vessels	9	45
Tug/anchor handlers	2	10
Survey vessels	1	3
Seabed preparation vessels	1	2
CTVs	2	40
Scour protection installation vessels	1	1
Helicopters	2	365

3.6.8 Foundations for wind turbines and OSPs

3.6.8.1 The wind turbines and OSPs will be attached to the seabed by foundation structures. The Applicant requires flexibility in foundation choice to ensure that anticipated changes in available technology can be accommodated within the Morgan Generation Assets final design. The foundation types that are being considered for the Morgan Generation Assets are shown in Table 3.10.

3.6.8.2 The foundations will be fabricated offsite, stored at a suitable port facility and transported to site by sea (see paragraph 3.6.5.3 *et seq*.). Specialist vessels transport and install foundations. Scour protection (typically rock) may be required on the seabed and will be installed before and/or after foundation installation (see paragraph 3.6.8.23 *et seq*.).

Table 3.10: Foundation options for wind turbines and OSPs.

	Wind turbines	OSPs
Maximum number of structures	107	4
Monopile	Yes	Yes
Pin piled three-legged Jacket	Yes	Yes
Pin piled four-legged Jacket	Yes	Yes
Pin piled six-legged Jacket	No	Yes
Suction bucket three-legged Jacket	Yes	Yes
Suction bucket four-legged Jacket	Yes	Yes
Suction bucket six-legged Jacket	No	Yes
Gravity base	Yes	Yes

Monopile foundations

Design

3.6.8.3 Monopile foundations typically consist of a single steel tubular piece. A transition piece is commonly fitted over the monopile and secured via bolts, grout or friction (slip joint). The transition piece may include ancillary components (e.g. boat landing facilities, ladders and a crane) as well as the connection to the wind turbine tower (Figure 3.7). The transition piece is generally painted yellow and marked per relevant regulatory guidance and may be installed separately following the monopile installation. The maximum design parameters of the monopile foundations can be seen in Table 3.11 for wind turbines and Table 3.12 for OSPs.

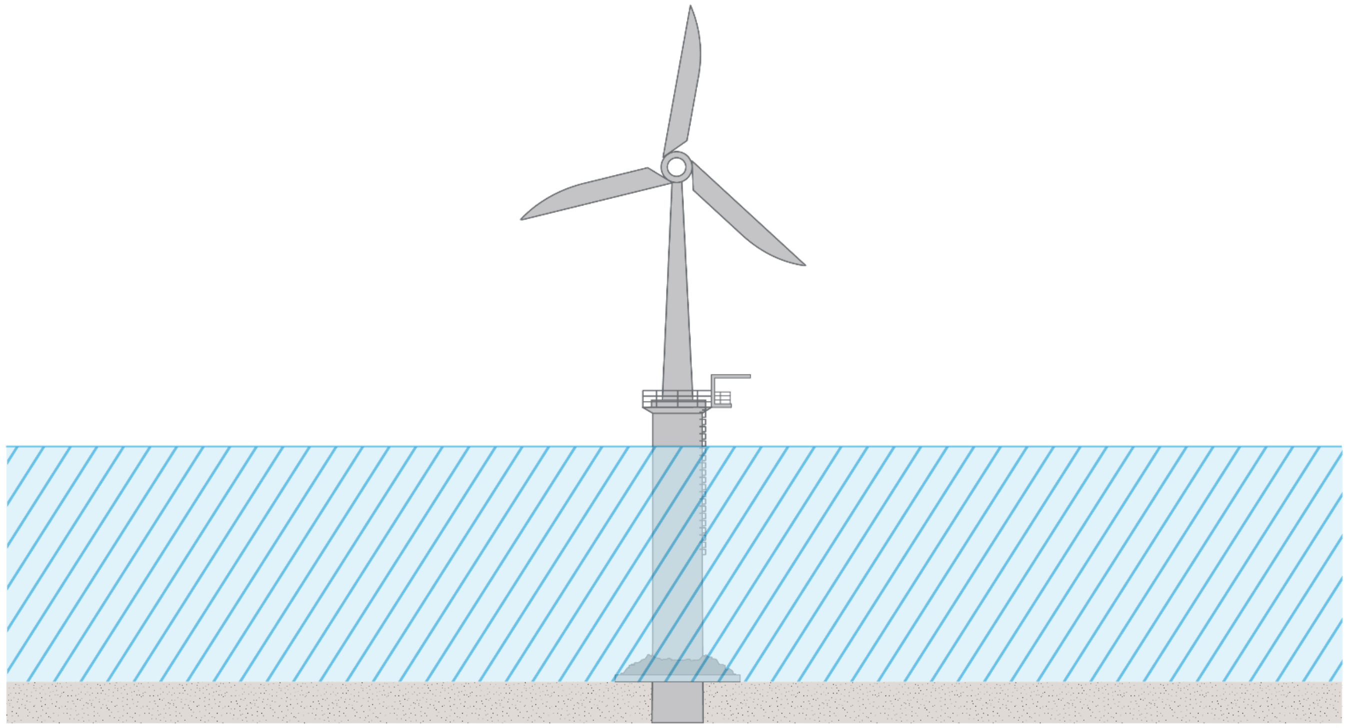

Figure 3.7: Schematic of an monopile foundation design.

Table 3.11: Maximum design parameters for monopile foundations - wind turbines.

[a] for the largest proposed wind turbine (noting that for the maximum number of turbines, the largest maximum design monopile diameter will be smaller).

Parameter	Maximum design parameters
Wind turbines	
Total number of structures (monopiles)	107
Diameter of a monopile (m)[a]	16
Diameter of transition piece (m)	12
Maximum embedment depth (below seabed) (m)	60
Hammer energy (kJ)	5,500
Seabed area –per monopile (m^2)	201.1
Seabed area – scour protection per monopile (m^2)	3,870
Seabed area – total foundation and scour protection for all foundations (m^2)	276,862
Scour protection volume – total for all foundations (m^3)	692,156
Total drill arisings for all foundations (m^3)	915,280

Table 3.12: Maximum design parameters for monopile foundations - OSPs.

Parameter	Maximum design parameters
Total number of structures	4
Number of monopiles per OSP	2
Diameter of a monopile (m)[a]	16
Diameter of transition piece (m)	12
Maximum embedment depth (below seabed) (m)	60
Hammer energy (kJ)	5,500
Seabed area –per monopile foundation (m^2)	201.1
Seabed area – scour protection per monopile (m^2)	7,741
Seabed area – total foundations and scour protection for all foundations (m^2)	15,884
Scour protection volume – total for all foundations (m^3)	22,902
Total drill arisings for all foundations (m^3)	27,315

Installation

3.6.8.4 Monopiles and transition pieces are likely to be transported to site either on the installation vessel (either JUV, Dynamic Positioning Vessel (DPV) or heavy lift vessel), as described in section 3.6.5. The details for the vessels and numbers of trips required are presented in Table 3.13. Monopile installation may take up to 24 months in total.

3.6.8.5 Seabed preparations for monopile installation are usually minimal. If pre-construction site investigation surveys show the presence of boulders or other seabed obstructions at the foundation locations, these may be removed if the foundation cannot be microsited to avoid the obstruction. Site preparation activities are discussed in more detail in section 3.6.3.

Table 3.13: Vessel and helicopter requirements for gravity base, monopile, piled jackets and suction bucket jacket foundation installation.

Vessel type	Maximum number of vessels on site at any one time	Maximum number of return trips per vessel type over the construction period
Installation and support vessels	9	400
Tug/anchor handler	6	64
Survey vessels	1	12
Seabed preparation vessels	2	12
CTVs	4	365
Scour protection installation vessels	2	40
Helicopters	3	365

Piling and drilling

3.6.8.6 Monopiles are driven and/or drilled into the seabed, relying on the frictional and end bearing properties of the seabed for support. Up to two vessels may be piling or drilling simultaneously.

3.6.8.7 The modelled piling scenario (see volume 3, annex 3.1: Underwater sound technical report of the PEIR) for monopiles and pin piles assumes a maximum 9.5 hour duration. However it is expected that piling of monopiles will generally be of a significantly shorter duration than 9.5 hours. Therefore, it is not expected that there will be an uninterrupted 9.5 hour start-finish hammer strike piling duration.

3.6.8.8 The maximum hammer energy for the Morgan Generation Assets is 5,500kJ for monopiles. Although a maximum hammer energy of 5,500kJ is considered as the MDS, the actual energy used when piling is likely to be significantly lower for the majority of the time. The hammer energy will only be raised to 5,500kJ when absolutely necessary. Hammer energies will start at the minimum required (10% soft start of 550kJ) and gradually increase to the maximum required energy required to install the pile, which is typically less than the maximum consented hammer energy.

3.6.8.9 If installation of the monopile is not possible through pile driving, a borehole will be drilled within the monopile using a drill bit with underreamer. Alternatively, a separate casing with a slightly bigger diameter than the monopile will be installed following the drill bit during lowering. In the latter case, the borehole will be grouted to seabed level when the monopile is installed and the casing removed in parallel with the grouting operation. If drilling is required, spoil arising from the drilling will be disposed of within the vicinity of where it was removed.

Piled jacket foundations

Design

3.6.8.10 Piled jacket foundations are formed of a steel lattice construction which is secured to the seabed by driven and/or drilled pin piles attached to the jacket feet. The transition piece and foundation structure is fabricated as an integrated part of the jacket. The Morgan Generation Assets may use either six-legged, four-legged or three-legged piled jacket foundations. An example of a pin piled jacket is shown in Figure 3.8.

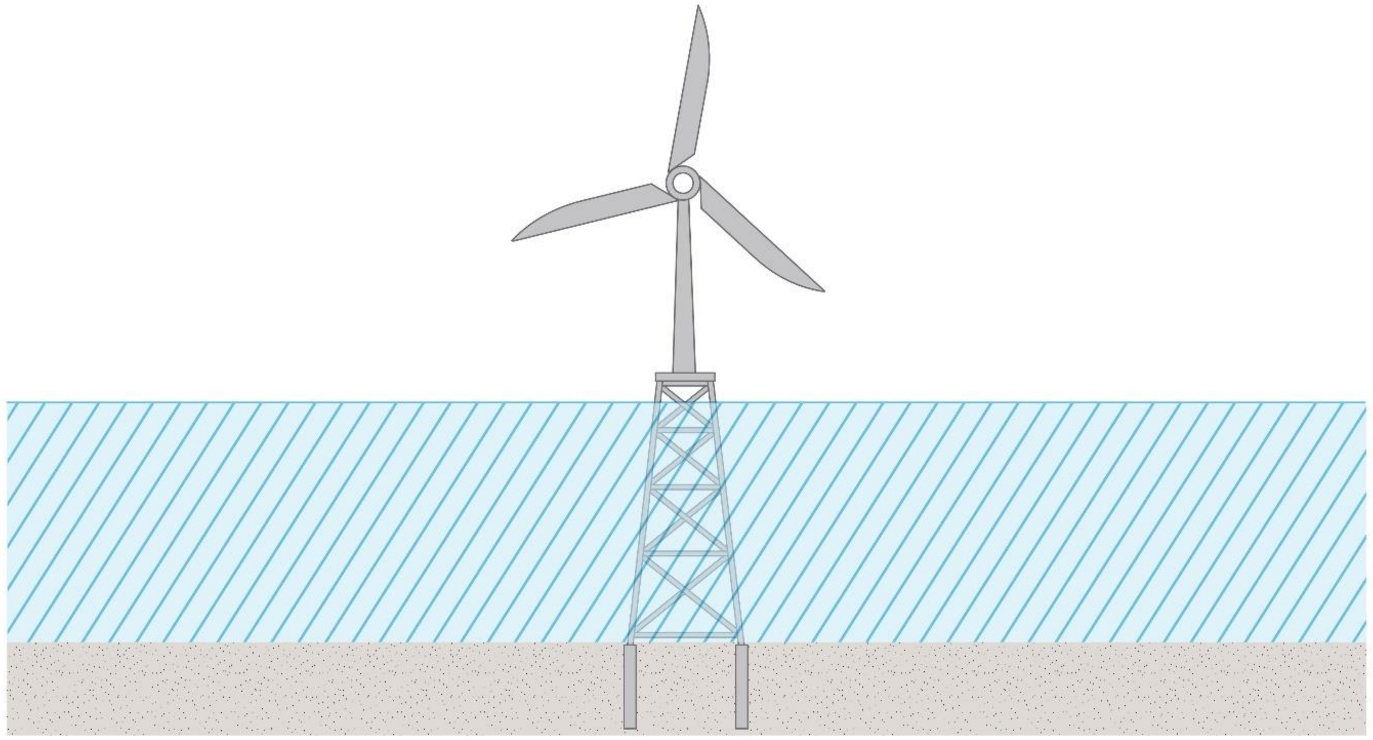

Figure 3.8: Schematic of a pin pile jacket foundation.

3.6.8.11 The maximum design parameters for jacket foundations with pin piles for wind turbines are shown in Table 3.14, with the maximum design parameters for jacket foundations with pin piles for OSPs shown in Table 3.15.

Table 3.14: Maximum design parameters for jacket foundations with pin piles - wind turbines.

Parameter	Maximum design parameter
Maximum number of jacket foundations	107
Number of legs per foundation	4
Piles per leg	2
Separation of adjacent legs at seabed level (m)	50
Separation of adjacent legs at LAT (m)	40
Leg diameter (m)	5
Pin pile diameter (m)	5.5
Maximum Embedment depth (below seabed) (m)	75
Hammer energy (kJ)	3,700
Seabed area – per foundation (m^2)	170
Seabed area – scour protection per foundation (m^2)	6,188
Seabed area – total foundations and scour protection for all foundations(m^2)	432,316
Scour protection volume for all foundations (m^3)	1,051,908
Total drill arisings for all foundations (m^3)	1,551,216

Table 3.15: Maximum design parameters for jacket foundations with pin piles - OSPs.

Parameter	Maximum design parameter
Maximum number of jacket foundations	4
Number of legs per foundation	6
Piles per leg	3
Separation of adjacent legs at seabed level (m)	70
Separation of adjacent legs at LAT (m)	50
Leg diameter (m)	5
Pin pile diameter (m)	5.5
Maximum Embedment depth (below seabed) (m)	75
Hammer energy (kJ)	3,700
Seabed area – per foundation (m^2)	428
Seabed area – scour protection per foundation (m^2)	8,406
Seabed area – total foundations and scour protection for all foundations (m^2)	10,622
Scour protection volume for all foundation (m^3)	25,602
Total drill arisings for all foundations (m^3)	37,926

Installation

3.6.8.12 The pin piles are driven and/or drilled into the seabed, in a similar way to monopiles. However, as pin piles are generally smaller than monopiles, the maximum hammer energy would be 3,700kJ. Up to two vessels may be piling and two drilling simultaneously. The maximum duration for wind turbine foundation installation across the Morgan Array Area would be 24 months.

3.6.8.13 The pin piles may be installed before or after the jacket is installed on the seabed. If they are installed first, a piling template is positioned onto the seabed to guide the pin-piles to the required locations. The piles are then installed through the template, which is recovered to the installation vessel. If the pin piles are installed after the jacket has been placed on the seabed, then a piling template is not required. The transition piece may include ancillary components (e.g. boat landing facilities, ladders and a crane) as well as the connection to the wind turbine tower.

3.6.8.14 The vessel movements for the installation would be as for monopile foundations, as described in Table 3.13 above.

3.6.8.15 The seabed preparation is described in section 3.6.3. The maximum design parameters for which are presented in Table 3.4.

Suction bucket jacket foundations

Design

3.6.8.16 Suction bucket jacket foundations are formed with a steel lattice construction fixed to the seabed by suction buckets installed below each leg of the jacket. The suction buckets are typically hollow steel cylinders, capped at the upper end, which are fitted underneath the legs of the jacket structure. They do not require a hammer or drill for installation. The transition piece and foundation structure is fabricated as an integrated part of the jacket structure and is not installed separately offshore. An example of a suction bucket jacket is shown in Figure 3.9. The maximum design parameters for jacket foundations with suction buckets are presented in Table 3.16.

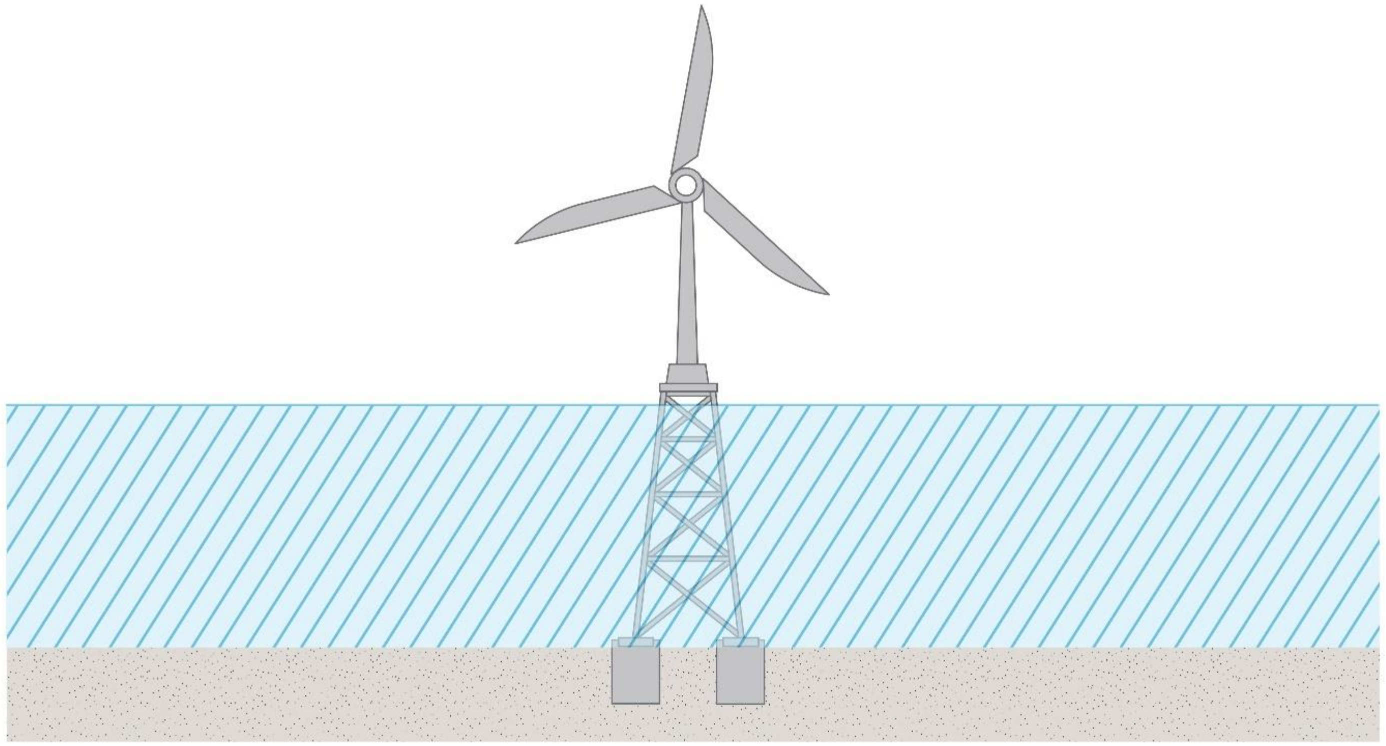

Figure 3.9: Schematic of a suction bucket jacket foundation.

Installation

3.6.8.17 The suction bucket jacket will be transported to site by sea, as described in section 3.6.5. The jacket foundation will then be lifted by the installation vessel using a crane and lowered towards the seabed in a controlled manner. When the steel buckets reach the seabed, a pipe above each bucket will begin to suck water out of each bucket. The buckets are pressed down into the seabed by the resulting suction force. When the bucket has penetrated the seabed to the desired depth, the pump is turned off. A thin layer of grout is then injected under the bucket to fill the air gap and ensure contact between the soil within the bucket, and the top of the bucket itself.

3.6.8.18 The seabed preparation is described in section 3.6.3. The vessel movements for the installation would be as for the monopile foundations, as described in Table 3.13.

Table 3.16: Maximum design parameters for jacket foundations with suction buckets-wind turbines.

Parameter	Maximum design parameter
Maximum number of jacket foundations	107
Number of legs per foundation	4
Suction bucket diameter (m)	18
Suction bucket depth (m)	25
Separation of adjacent legs at seabed level (m)	50
Separation of adjacent legs at LAT (m)	35
Seabed area per foundation (m^2)	804
Seabed area – scour protection per foundation (m^2)	10,012
Seabed area – total foundations and scour protection for all foundations (m^2)	735,488
Scour protection volume for all foundations (m^3)	1,701,998

Table 3.17: Maximum design parameters for jacket foundations with suction buckets - OSPs.

Parameter	Maximum design parameter
Maximum number of jacket foundations	4
Number of legs per foundation	6
Suction bucket diameter (m)	18
Suction bucket depth (m)	25
Separation of adjacent legs at seabed level (m)	70
Separation of adjacent legs at LAT (m)	50
Seabed area - per foundation (m^2)	1,527
Seabed area – scour protection per foundation (m^2)	13,502
Seabed area – total for all foundations (m^2)	15,029

Parameter	Maximum design parameter
Scour protection volume for all foundations (m³)	46,984

Gravity base foundations

Design

3.6.8.19 Gravity base foundations are generally made of concrete with steel reinforcements, or steel alone, and consist of a base, a conical structure and a smaller cylindrical top (generally called the shaft). This shape provides support and stability to the wind turbine. Gravity base foundations could also include skirts that embed into the seabed under the weight of the structure to improve the natural stability and scour resistance of the foundation. Ancillary structures (e.g. ladders) may be attached to the gravity base foundation or the transition piece and are usually made of steel but may be made of another metal. The main structure is filled with ballast, commonly sand, rock (such as olivine) or iron ore. An example of a gravity base foundation is shown in Figure 3.10.

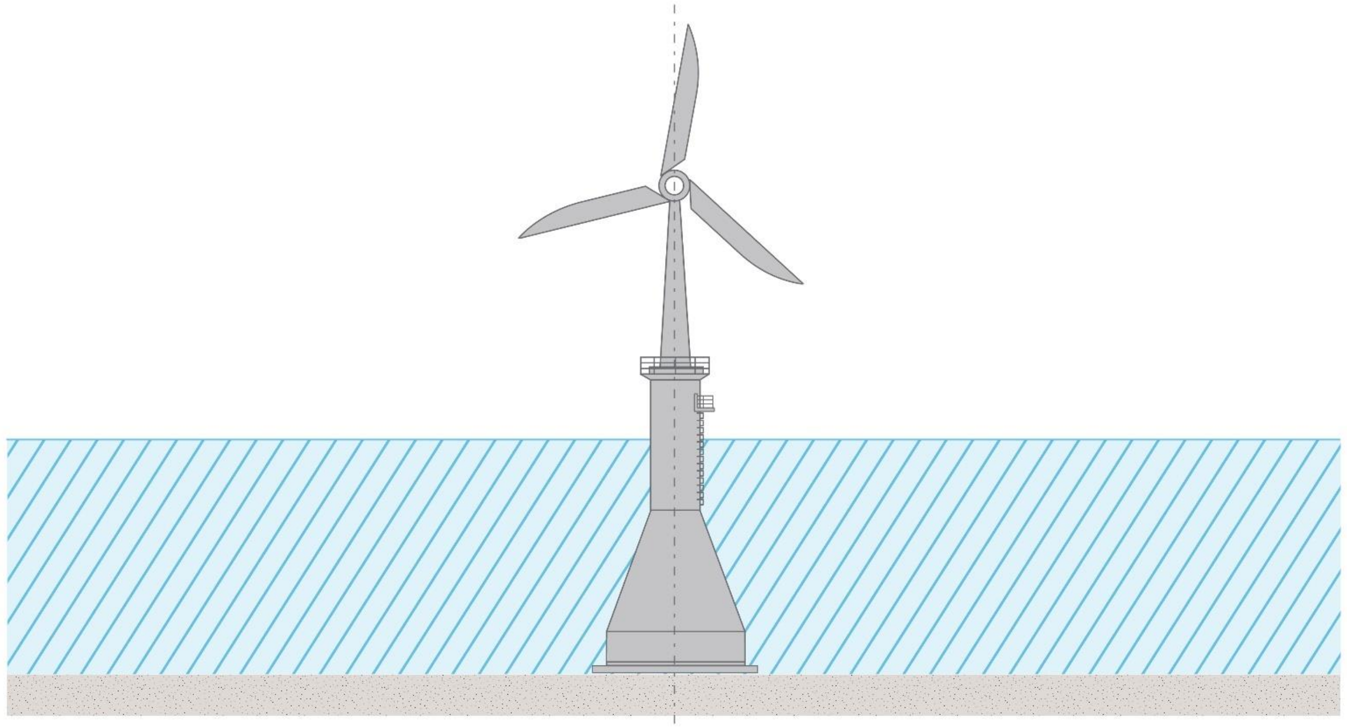

Figure 3.10: Schematic of a gravity base foundation.

3.6.8.20 The maximum design parameters for gravity base foundations for wind turbines are shown in Table 3.18, with the maximum design parameters for gravity base foundations for OSPs shown in Table 3.19.

Table 3.18: Maximum design parameters for gravity base foundations – wind turbines.

Parameter	Maximum design parameters
Total number of structures (gravity base)	107
Structural diameter at sea surface (m)	15
Structural diameter at seabed (base slab) (m)	56
Caisson diameter (m)	44
Transition Piece diameter (m)	15
Seabed area – per structure per foundation (m²)	2,463
Seabed area – scour protection per foundation (m²)	4,896
Seabed area – total foundations and scour protection for all foundations (m²)	650,787
Total scour protection volume for all foundations (m³)	1,522,842

Table 3.19: Maximum design parameters for gravity base foundations – OSPs.

Parameter	Maximum design parameters
Total number of structures (gravity base)	4
Structural diameter at sea surface (m)	20
Structural diameter at seabed (base slab) (m)	80
Caisson diameter (m)	70
Transition Piece diameter (m)	20
Seabed area – per structure per foundation (m²)	5,027
Seabed area – scour protection per foundation (m²)	13,600
Seabed area – total foundations and scour protection for all foundations (m²)	24,941
Total scour protection volume for all foundations (m³)	58,361

Installation

3.6.8.21 Gravity base foundations can be either transported by a vessel or barge to site or self-floated being pulled by tugs. Lowering at location will be conducted by flushing the gravity base foundation with seawater, for some designs assisted by a suitable crane from a heavy lift vessel to the seabed. Seabed preparation might be necessary in terms of levelling and/or stabilising the upper soil layer, this is described in section 3.6.3. After the gravity base foundation is installed, it will be ballasted with a suitable material before finally the transition piece will be installed on top, if applicable. The method to be used is dependent on the final gravity base design and the installation method would be confirmed following final design post-consent. The transition piece that is lifted on top of the gravity base may be either installed on site or installed prior to the transportation of the gravity base foundation.

3.6.8.22 The seabed preparation is described in section 3.6.3. The vessel movements for the installation would be as for monopile foundations, as described in Table 3.13 above.

Scour protection for foundations

3.6.8.23 Foundation structures for wind turbines and OSPs are at risk of seabed erosion and 'scour hole' formation due to natural hydrodynamic and sedimentary processes. The shape of the foundation structure is an important parameter influencing the potential depth of scour hole formation. Scour protection may be employed to mitigate scour around foundations. Several types of scour protection are under consideration, they are described below and presented in Figure 3.11:

- Rock: either layers of graded stones placed on and/or around structures to inhibit erosion or rock filled mesh fibre bags which adopt the shape of the seabed/structure as they are lowered on to it
- Concrete mattresses: several metres wide and long, cast of articulated concrete blocks which are linked by a polypropylene rope lattice which are placed on and/or around structures to stabilise the seabed and inhibit erosion
- Artificial fronds mattresses: mats typically several metres wide and long, composed of continuous lines of overlapping buoyant polypropylene fronds that create a drag barrier which prevents sediment in their vicinity being transported away. The frond lines are secured to a polyester webbing mesh base that is itself secured to the seabed by a weighted perimeter or anchors pre-attached to the mesh base.

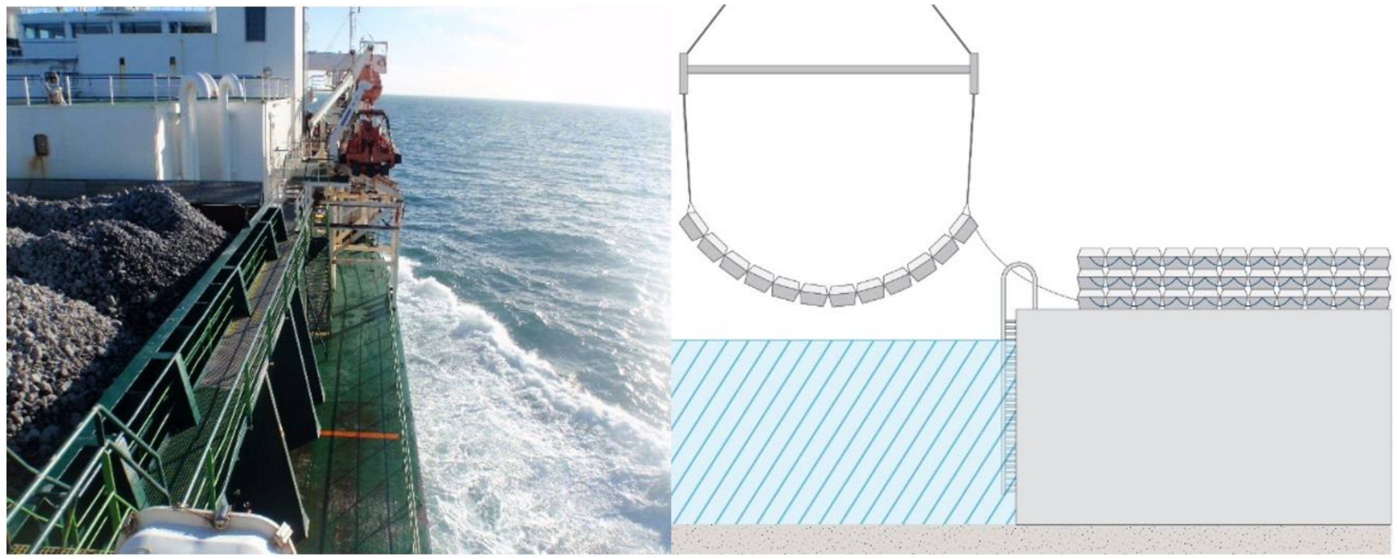

Figure 3.11: Illustrative scour protection types (Left: delivery of rock to EnBW's Hohe See Offshore Wind Farm; Right: concrete mattresses).

3.6.8.24 The amount of scour protection required will vary for the different foundation types being considered for the Morgan Generation Assets. Scour protection parameters for the different foundations being considered are presented in Table 3.11, Table 3.14, Table 3.16 and Table 3.18 above.

3.6.8.25 The final choice and detailed design of the scour protection will be made after detailed design of the foundation structure, taking into account a range of aspects including geotechnical data, meteorological and oceanographic data, water depth, foundation type and maintenance strategy.

3.6.9 Inter-array cables

3.6.9.1 Inter-array cables carry the electrical current produced by the wind turbines to an OSP. A small number of wind turbines will typically be grouped together on the same cable 'string' connecting those wind turbines to the OSP, and multiple cable 'strings' will connect back to each OSP.

Design

3.6.9.2 The maximum design parameters for inter-array cables are presented in Table 3.20 below.

Table 3.20: Maximum design parameters for inter-array cables.

Parameter	Maximum design parameters
Cable diameter (mm)	230
Total length of cable (km)	500
Voltage (kV)	132

Installation

3.6.9.3 The inter-array cables will be buried below the seabed wherever possible and protected with a hard-protective layer (such as rock or concrete mattresses) where adequate burial is not achievable. Possible installation methods include ploughing, trenching and jetting whereby the seabed is opened and the cable laid within the trench simultaneously using a tool towed behind the installation vessel. The installation method will be defined post consent based on a Cable Burial Risk Assessment (CBRA) (or similar) taking into account environmental and human conditions such as trawling and vessel anchors. Figure 3.12 shows an inter-array cable being installed.

3.6.9.4 The Applicant may also need to undertake seabed preparation within the Morgan Array Area prior to installation of inter-array cables in order to level sandwaves. This is discussed in section 3.6.3.

3.6.9.5 Inter-array cables will need to be protected where the route crosses obstacles such as exposed bedrock, pre-existing cables or pipelines that mean the cable cannot be buried. Cable protection methods include rock placement (rock protection), concrete mattresses, fronded mattresses and rock bags. Up to 10% of the total inter-array cable length may require protection due to ground conditions (this excludes cable protection due to cable crossings). The maximum design parameters for inter-array cable installation are presented in Table 3.21. The cable protection methods being considered are described below.

Figure 3.12: Example of inter-array cable installation at the EnBW Hohe See Offshore Wind Farm construction site in the German North Sea.

Table 3.21: Maximum design parameters for inter-array cable installation-cable protection.

[a] Typically the cable will be buried between 0.5 to 3m. A CBRA will inform cable burial depth, dependent on ground conditions as well as external risks. This assessment will be undertaken post-consent.

Parameter	Maximum design parameters
Installation methodology	Prelay plough, plough, trenching and jetting
Target burial depth	1m. Dependent on CBRA [a]
Width of seabed affected by installation per cable (m)	20
Duration: total (months)	36
Seabed disturbance – total for installation (m^2)	10,000,000
Height of cable protection (m)	3
Width of cable protection (m)	10
Percentage of route requiring protection (%)	10
Cable protection area (m^2)	500,000
Cable protection volume (m^3)	750,000
Indicative number of crossings	67
Cable/pipe crossings: total impacted area (m^2)	128,640
Cable/pipe crossings: cable protection volume (m^3)	80,400

Rock placements

3.6.9.6 Initially small stones are placed over the cable as a covering layer. This provides protection from any impact from larger size rocks, which may then be placed on top of this smaller scale level. Rock placement is often achieved using a vessel with equipment such as a ‘fall pipe’ which allows installation of rock close to the seabed. The length of the rock protection is dependent on the length of cable which is either unburied or has not achieved target depth.

Mattress placements

3.6.9.7 Concrete mattresses are constructed using high strength concrete blocks and U.V. stabilised polypropylene rope. Mattresses provide protection from direct anchor strikes but are not able to protect from anchor drag. The mattresses are lowered to the seabed from an installation vessel and once the correct position is confirmed, a frame release mechanism is triggered and the mattress is deployed on the seabed. This single mattress installation is repeated for the length of cable that requires protection. The mattresses may be gradually layered in a stepped formation on top of each other dependant on expected scour. Mattresses with sloped edges would be deployed to reduce the potential for fishing gear to snag the edges of the mattresses.

Frond mattresses placements

3.6.9.8 Mats typically several metres wide and long, composed of continuous lines of overlapping buoyant polypropylene fronds that create a drag barrier which prevents sediment in their vicinity being transported away. The frond lines are secured to a polyester webbing mesh base that is itself secured to the seabed by a weighted perimeter or anchors pre-attached to the mesh base. Frond mattresses are installed following the same procedure as general mattress placement operations. The fronds floating in the water column, however, can impede the correct placement of additional mattresses. The fronds are designed with the aim to catch and trap sediment to form protective, localised sand berms. SSCS Frond Mats installed in the North Sea in 1984 remain in place today and have required no maintenance since being deployed, as the mats are designed not to degrade with time (SSCS, 2022).

Rock bags

3.6.9.9 Prefilled rock bags consist of various sized rocks constrained within a rope or wire netting containment and can be placed above the cables with specialist installation beams. Rock bags are more suited for cable stability or trench/scour-related solutions. The number of rock bags required is dependent on the length of cable which requires protection.

3.6.9.10 Table 3.21 shows the details for the cable protection required for inter-array cables and Table 3.22 shows the envelope for vessel movements associated with inter-array cable installation.

Table 3.22: Maximum design parameters for inter-array cable installation vessel requirements.

Parameter	Maximum number of vessels on site at any one time	Maximum number of return trips per vessel type over the construction period
Cable lay and support vessels	4	8
Survey vessels	1	2
Seabed preparation vessels	4	4
CTVs	1	365
Cable protection installation vessels	2	2

3.6.10 Offshore interconnector cables

3.6.10.1 The Morgan Generation Assets will require cables to connect the OSPs to each other in order to provide redundancy in the case of cable failure. The interconnector cables will have a similar design and installation process to the inter-array cables. The parameters for design and installation of the interconnector cables are presented in Table 3.23, Table 3.24 and Table 3.25.

Table 3.23 Maximum design parameters for interconnector cables.

[a] Typically the cable will be buried between 0.5 to 3m. A CBRA will inform cable burial depth, dependent on ground conditions as well as external risks. This assessment will be undertaken post-consent.

Parameter	Maximum design parameters
Number of cables	3
Total cable length (km)	60
Voltage (kV)	275

Table 3.24 Maximum design parameters for interconnector cable installation and interconnector cable protection.

[a] Typically the cable will be buried between 0.5 to 3m. A CBRA will inform cable burial depth, dependent on ground conditions as well as external risks. This assessment will be undertaken post-consent.

Parameter	Maximum design parameters
Installation methodology	Prelay plough, plough, trenching and jetting
Target burial depth	1m. Dependent on CBRA [a]
Width of seabed affected by installation per cable (m)	20
Duration: total (months)	30
Seabed disturbance – total (m^2)	1,200,000
Height of cable protection (m)	3
Width of cable protection (m)	10
Percentage of route requiring protection (%)	20
Cable protection area (m^2)	120,000
Cable protection volume (m^3)	180,000
Indicative number of crossings	10
Cable/pipe crossings: total impacted area (m^2)	5,000
Cable/pipe crossings: cable protection volume (m^3)	30,000

Table 3.25 Maximum design parameters for interconnector cables - vessel requirements.

Parameter	Maximum number of vessels on site at any one time	Maximum number of return trips per vessel type over the construction period
Cable lay and support vessels	4	8
Survey vessels	1	2
Seabed preparation vessels	4	4
CTVs	1	365
Cable protection installation vessels	2	2

3.6.11 Ancillary works

3.6.11.1 Ancillary works are likely to form part of the final design of the Morgan Generation Assets, however, the requirement and nature of these would be determined at the detailed design phase. Ancillary works may include:

- Temporary landing places, moorings or other means of accommodating vessels in the construction and / or maintenance of the authorised development
- Buoys, beacons, fenders and other navigational warning or ship impact protection works

3.6.11.2 Buoys would be required across the Morgan Array Area and would be LiDAR, wave or guard buoys. Each buoy would include a lantern suitable for use as a navigational aid.

3.6.11.3 These devices would be attached to the sea bed using mooring devices such as common sinkers (small block of heavy material such as concrete and steel) or anchored by means of regular anchors. They could have one single mooring point or several points (usually up to three).

3.7 Construction programme

3.7.1.1 A high-level indicative construction programme is presented in Figure 3.13 below. The programme illustrates the likely duration of the major construction elements. It covers installation of the major components but does not include elements such as preliminary site preparation, and commissioning of the wind farm post-construction. Further details of where preliminary site preparation work will fit within the outline programme is discussed in section 3.6.3. Construction is currently planned to commence in 2026.

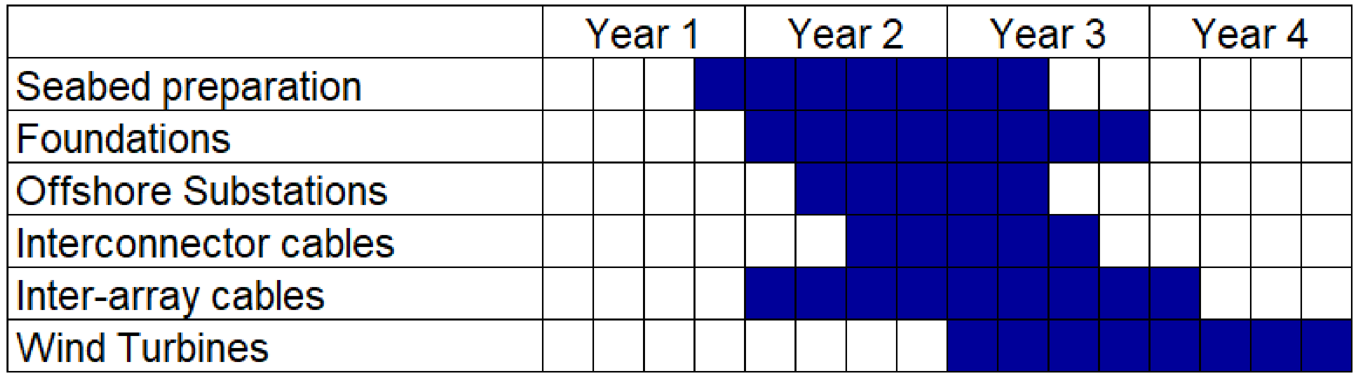

Figure 3.13: Indicative construction programme for the Morgan Generation Assets.

3.7.2 Aids to navigation, colour, marking and lighting

3.7.2.1 The Morgan Generation Assets will be designed and constructed in accordance with relevant guidance from:

- Trinity House (2016) (Provision and Maintenance of Local Aids to Navigation Marking Offshore Renewable Energy Installations)
- Civil Aviation Authority (CAA) (2016) Civil Aviation Publication (CAP) 764 Policy and Guidelines on Wind Turbines
- Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) (2021) (Recommendation G1162 on the Marking of Man-Made Offshore Structures)
- Maritime and Coastguard Agency (MCA) (2018) (Offshore Renewable Energy Installations: Requirements, Guidance and Operational Considerations for Search and Rescue and Emergency Response).

3.7.2.2 Appropriate marking, lighting and aids to navigation will be employed during the construction, operational and maintenance, and decommissioning phases as appropriate to ensure the safety of all parties. The nacelles, blades and towers will be painted light grey (RAL 7035) and the foundation structures, up to +15m from Highest Astronomical Tide (HAT), will be traffic light yellow (RAL 1023).

3.7.2.3 Appropriate lighting, in line with MCA (2018) guidance, will ensure the offshore structures are visible for search and rescue and emergency response procedures. In addition, Morgan Generation Assets lighting will conform to the following:

- Red, medium intensity aviation warning lights (of variable brightness between a maximum of 2000 candela (cd)) to a minimum of 10% of the maximum which would be 200cd) will be located on either side of the nacelle of significant peripheral wind turbines. These lights will flash simultaneously with a Morse W flash pattern and will also include an infra-red component
- All aviation warning lights will flash synchronously throughout the Morgan Array Area and be able to be switched on and off by means of twilight switches (which activate when ambient light falls below a pre-set level)
- Aviation warning lights will allow for reduction in lighting intensity at and below the horizon when visibility from every wind turbine is more than 5km (to a minimum of 10% of the maximum (i.e. 200cd)
- SAR lighting of each of the non-periphery turbines will be combi infra-red (IR)/200cd steady red aviation hazard lights, individually switchable from the control centre at the request of the MCA (i.e. when conducting SAR operations in or around the Morgan Array Area)
- All wind turbines will be fitted with a low intensity light for the purpose of helicopter winching (green hoist lamp). All wind turbines will also be fitted with suitable illumination (minimum one 5cd light) for ID signs
- Marine navigational lights will be fitted at the platform level on Significant Peripheral Structures (SPS). These lights will be synchronized to display simultaneously an IALA “special mark” characteristic, flashing yellow, with a range of not less than 5nm.

3.7.2.4 The location of all infrastructure (including wind turbines, OSPs, and cables) will be communicated to the UK Hydrographic Office (UKHO) so that they can be incorporated into Admiralty Charts and the Notice to Mariners procedures. These locations will also be provided to the Defence Geographic Centre (DGC).

3.7.2.5 A marking and lighting plan will be submitted to the MCA and Trinity House for review prior to construction.

3.7.3 Safety zones

3.7.3.1 During construction and decommissioning, some restrictions on vessel movements within the Morgan Array Area will be required to protect the health and safety of all users of the sea. The Applicant will apply for a 500m safety zone around all infrastructure that is actively under construction. Safety zones of 50m will be applied for vessels not associated with the Morgan Generation Assets around incomplete structures for which construction activity may be temporarily paused (and therefore the 500m safety zone is no longer applicable) such as installed foundations without wind turbines or where construction works are completed but the Morgan Generation Assets have not yet been commissioned.

3.7.3.2 During the operations and maintenance phase, the Applicant may apply for a 500m safety zone for infrastructure undergoing major maintenance works (for example a blade replacement). Further information regarding the Safety Zones which the Applicant intends to apply for post consent will be outlined in the Safety Zone Statement (to be provided alongside the Environmental Statement).

3.7.3.3 Guard vessels will be used during the construction and the operations and maintenance phases of the Morgan Generation Assets as necessary.

3.8 Operations and maintenance phase

3.8.1.1 The overall operations and maintenance strategy will be finalised once the technical specifications of the Morgan Generation Assets are known, including wind turbine type and final layout. The operations and maintenance requirements for the Morgan Generation Assets will be set out within an outline Offshore Operations and Maintenance Plan which will be submitted alongside the application for consent.

3.8.1.2 The general operational and maintenance strategy may rely on CTVs, Service Operation Vessels (SOVs), supply vessels, cable and remedial protection vessels and helicopters for the operations and maintenance services that will be performed at the Morgan Generation Assets. The maximum design parameters for the operations and maintenance vessels are presented in Table 3.26. The total operations and maintenance vessel and helicopter round trips per year for the Morgan Generation Assets are presented in Table 3.27.

3.8.1.3 Routine inspections of inter-array and interconnector cables will be undertaken to ensure that the cables are buried to an adequate depth and not exposed. The integrity of the cables and cable protection systems will also be checked. It is expected that on average the cables will require up to one visit per year. Maintenance works to rebury/replace and carry out repair works on inter-array and interconnector cables, should this be required, are presented below.

Table 3.26: Maximum design parameters for offshore operations and maintenance activities.

Parameter	Maximum number of vessels on site at any one time
CTVs	6
Jack-up vessels	3
Cable repair vessels	4
SOVs or other vessels	4
Excavators or backhoe dredgers	4
Helicopters	8
Inspection drones	5

Table 3.27: Maximum design parameters for offshore operations and maintenance activities per year.

Parameter	Maximum number of return trips per vessel type per year
CTVs	1,825
Jack-up vessels	25
Cable repair vessels	12
SOVs or other vessels	104
Excavators or backhoe dredgers	4
Helicopters	639
Inspection drones	214

3.9 Security

3.9.1.1 The Morgan Generation Assets will be appropriately secured throughout all phases of development to ensure the safety and security of those working on the Morgan Generation Assets. The offshore infrastructure is by nature inaccessible due to being situated offshore.

3.10 Quality, health, safety and environment

3.10.1.1 The Applicant has a strong focus on Health, Safety and Environment and the HSE Policy, together with processes and procedures ensure that the Applicant's wind farms are safe by design and that this is verified. All elements of the Morgan Generation Assets will be risk assessed according to the relevant government guidance as well as the Applicant's internal best practise. These risk assessments will then form the basis of the methods and safety mitigations put in place across the life of the Morgan Generation Assets.

3.11 Waste management

3.11.1.1 Waste will be generated as a result of the Morgan Generation Assets, with most waste expected to be generated during the construction and decommissioning phases. In accordance with Government policy contained in NPS EN-1 (DECC, 2011), consideration will be given to the types and quantities of waste that will be generated. Procedures for handling waste materials will be set out in the Offshore Environmental Management Plan.

3.12 Decommissioning phase

3.12.1.1 Section 105 of the Energy Act (2004) requires that the Morgan Generation Assets are decommissioned at the end of the operations and maintenance phase. A decommissioning plan must be submitted to and approved by the Secretary of State for Business, Energy and Industrial Strategy (BEIS), a draft of which will be submitted prior to the construction of the Morgan Generation Assets. The decommissioning plan and programme will be updated during the Morgan Generation Assets lifespan to take account of changing best practice and new technologies. The scope of the decommissioning works would be determined by the relevant legislation and guidance at the time of decommissioning.

3.12.1.2 At the end of the operational lifetime of the Morgan Generation Assets, it is anticipated that all structures above the seabed or ground level will be completely removed where feasible and practical. The decommissioning sequence will generally be the reverse of the construction sequence and involve similar types and numbers of vessels and equipment.

3.12.2 Offshore decommissioning

Wind turbines

3.12.2.1 Wind turbines will be removed by reversing the methods used to install them, as described in section 3.6.8.

Foundations

3.12.2.2 Piled foundations would likely be cut approximately 1m below the seabed, with due consideration made of likely changes in seabed level, and removed. Once the piles are cut, the foundations will be lifted and removed from the site. At this time, it is not thought to be reasonably practicable to remove entire piles from the seabed, but best practice will be employed to ensure that the sections of pile that remain in the seabed are fully buried.

3.12.2.3 Suction bucket foundations will likely be removed entirely by applying water injection into the buckets which will release the pressure holding them to the seabed. Gravity base foundations will likely be decommissioned by removing their ballast and either floating them or lifting them off the seabed.

3.12.2.4 Any scour protection will be left *in situ*.

Offshore cables

3.12.2.5 It is expected that the inter-array cables and interconnector cables will be decommissioned, however cable protection will be left *in situ*. At this time, it is difficult to foresee what techniques will be used to remove cables during decommissioning. However, it is not unlikely that equipment similar to that which is used to install the cables could be used to reverse the burial process and expose them. Therefore, the area of seabed impacted during the removal of the cables may be the same as the area impacted during the installation of the cables.

3.12.2.6 The Energy Act 2004 requires that a decommissioning plan must be submitted to the Secretary of State for BEIS prior to the construction of the Morgan Generation Assets and is typically prepared post-consent. The decommissioning plan and programme will be updated during the Morgan Generation Assets' lifetime to take account of changes in regulations, best practice and new technologies.

3.13 References

Civil Aviation Authority (CAA) (2016) CAP 764: CAA Policy and Guidelines on Wind Turbines. Available: https://publicapps.caa.co.uk/docs/33/CAP764%20Issue6%20FINAL%20Feb.pdf. Accessed November 2022.

Department of Energy and Climate Change (DECC) (2011) Overarching National Policy Statements for Energy (NPS EN-1). Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/47854/1938-overarching-nps-for-energy-en1.pdf. Accessed June 2022

International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) (2021) G1162 ED1.0 The Marking of Man-Made Offshore Structures. Available: https://www.iala-aism.org/product/g1162-ed1-0-the-making-of-offshoreman-made-structures/. Accessed November 2022.

International Cable Protection Committee (ICPC) (2011) Recommendation #1, Management of Redundant and Out-of-Service Cables, Issue 12B.

Maritime Coastguard Agency (MCA) (2018) Offshore Renewable Energy Installations: Requirements, Guidance and Operational Considerations for Search and Rescue and Emergency Response. Available: Offshore Renewable Energy Installations: Requirements, Guidelines and Operational Considerations for SAR and Emergency Response (publishing.service.gov.uk). Accessed July 2022

SSSC (2022) Scour Control Products. Available: https://sscsystems.com/scour. Accessed November 2022.

Trinity House (2016) Provision and Maintenance of Local Aids to Navigation Marking Offshore Renewable Energy Installations. Available: https://www.trinityhouse.co.uk/asset/2425. Accessed November 2022.

von Benda-Beckmann, A. M., G. M. Aarts, K. Lucke, W. C. Verboom, R. A. Kastelein, R. S. A. v. Bemmelen, S. C. V. Geelhoed, and R. J. Kirkwood. (2015) Assessment of impact of underwater clearance of historical explosives by the Royal Netherlands Navy on harbour porpoises in the North Sea. TNO, Den Haag.