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Morlais Project
Environmental Statement

Chapter 4: Project Description

Volume I

Applicant: Menter Môn Morlais Limited

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Chapter 4: Project Description

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GLOSSARY OF ABBREVIATIONS

ADCP	Acoustic Doppler Current Profilers
BPEO	Best Practicable Environmental Option
dB	decibels
DP	Dynamic Positioning
ECC	Export Cable Corridor
EIA	Environmental Impact Assessment
ES	Environmental Statement
FEED	Front End Engineering and Design
GBS	Gravity Based Structures
HDD	Horizontal Directional Drilling
HGV	Heavy Good Vehicles
IALA	International Association of Lighthouse Authorities
ICS	Impressed Current System
km	Kilometres
kV	Kilo volts
LAeq	A-weighted equivalent continuous sound level
LAT	Lowest Astronomical Tide
LV	Low Voltage
MCA	Maritime and Coastguard Agency
MDZ	Morlais Demonstration Zone
MFE	Mass Flow Excavator
MV	Medium Voltage
MVA	Megavolt-ampere
MW	Megawatts
nm	nautical miles
NRW	Natural Resources Wales
OfDA	Offshore Development Area
ODA	Onshore Development Area
O&M	Operation and Maintenance
PDE	Project Design Envelope
ROV	Remotely Operated Vehicle
rpm	Rotations per Minute
SESM	Surface Emergent Seabed Mounted
TEC	Tidal Energy Convertors
TH	Trinity House
TWAO	Transport and Works Act Order
UKC	Under Keel Clearance
UXO	Unexploded Ordnance

GLOSSARY OF TERMINOLOGY

Active hub	Hub containing a transformer, switchgear and possible control equipment.
Axial Flow	Horizontal axis rotors.
Category 1 tidal device	Seabed Mounted Sub-Surface Tidal Devices.
Category 2 tidal device	Buoyant Mid-water Column Tidal Devices.
Category 3 tidal devices	Floating and / or Surface Emergent Tidal Devices.
Cross Flow	Vertical axis rotors.
Multicat	Multi-purpose catamaran workboat for offshore works and transport,
Megaripples	Undulations on a non-cohesive surface produced as a result of the interaction of waves or currents on a sediment surface.
Nacelle	A cover that houses all of the generating components in a TEC, including the generator, gearbox, drive train, and brake assembly.
Passive Hub	Hub containing a busbar joining multiple TECs together.
Screw Piles	Steel piles with helical steel plates welded to the pile shaft in accordance with the ground conditions.
Visually Prominent	A visually prominent tidal device is a tidal device where the large proportion of the support structure is visible above the water, to the extent it is visually prominent, together with ancillary elements such as navigation lights, railings and mast.

4. PROJECT DESCRIPTION

4.1 INTRODUCTION

1. This chapter of the Environmental Statement (ES) presents details of the Project Design Envelope (PDE) for the Morlais Project (the Project) as revised in September 2025 to include a device type that is a hybrid of the devices already described, being both Surface Emergent and Seabed Mounted (SESM).

2. The Project will provide a consented area for the installation and commercial demonstration of multiple arrays of tidal energy devices, to a maximum installed capacity of 240 Megawatts (MW).

3. The Project will also provide permanent communal infrastructure through the provision of electrical infrastructure, including substations and onshore electrical cable route to grid connection. The Project is being developed by Menter Môn Morlais Limited (hereafter 'Menter Môn'), a not for profit social enterprise company. When consented, the Project's infrastructure will be operated by Menter Môn.

4. This chapter describes the following stages of the proposed development for both the onshore and offshore elements:

   - Construction;
   - Operations;
   - Maintenance;
   - Repowering; and
   - Decommissioning.

5. **Figure 1-1** (**Volume II**) shows the location and boundary of the Morlais Demonstration Zone (MDZ) and Export Cable Corridor (ECC). The two areas combined can be referred to as the Offshore Development Area (OfDA).

6. **Figure 1-2** (**Volume II**) shows the location and boundary of the Onshore Development Area (ODA) which includes the landfall site, onshore cable route, substations and grid connection location.

7. The OfDA and the ODA represent the extent of assessment for the technical chapters in this Environmental Statement. This area is larger than the order limits proposed within the TWAO.

8. A Front-End Engineering Design (FEED) study was undertaken by ITP Energised (ITPE) on behalf of Menter Môn in 2018, to provide the proposed design of the project necessary to inform the EIA project description for consent (**Appendix 4.1, Volume III**). Further to a revision of proposed installed project capacity to 240 MW, an addendum to the study was undertaken for the MDZ elements (**Appendix 4.2, Volume III**), also by ITPE. In parallel, Black & Veatch Ltd. (B&V) have been responsible for further design of, and updates to, the onshore infrastructure within the ODA.

4.2 FLEXIBILITY THROUGH PROJECT DESIGN ENVELOPE

9. Consent for a broad PDE is sought, to ensure maximum flexibility in the tidal technology types consented for deployment by the Project. This approach allows for deployment of a variety of currently available technologies, whilst also allowing for evolution of the designs of tidal devices over time.

10. However, the range and flexibility sought within the consent application has been limited by careful consideration of development scenarios designed to rationalise the likely approach to development and to set workable limits on potential impacts. The PDE approach used in this ES, has been tested in planning law and is often referred to as the 'Rochdale Envelope' approach (see **Chapter 2, Policy and Legislation**).

4.2.1. PDE to Inform Impact Assessment

11. The project description outlined within this Chapter has been used to shape the impact assessments undertaken in this ES. Characterisation of the PDE for the Environmental Impact Assessment (EIA) has focussed on those characteristics known to interact with environmental receptors, i.e. foundations, cables, moving parts and visible components. The approach considers a range of design parameters and identifies the likely worst-case of each parameter, for each specific receptor.

12. To inform FEED studies and provide information for the EIA project description, consultation with tidal device developers was undertaken between 2017 and 2019. The results of this consultation have been used to determine the technical and physical parameters of tidal devices, any requirements for deployment of the tidal devices and the level of interest from device developers in deploying their devices at the Project. Based on this consultation, appropriate devices were used to define parameters in the PDE. In addition, the hybrid SESM device parameters have been determined through consultation in 2024 and 2025 with the developers of this technology.

13. Due to the wide range of tidal devices currently available, any specific tidal devices referred to within this document are provided as examples for reference only and should therefore be viewed as representative of several device types which may be deployed by the Project. Review of tidal device parameters has allowed the identification of realistic worst-case parameters for a number of generic tidal device types. These worst-case parameters have been used to define the PDE in terms of both tidal device parameters and realistic worst-case scenarios for the deployment of arrays of tidal devices and for the deployment of the Project as a whole.

14. Following consent award, tidal device developers will be allocated locations or "berths" within the MDZ, within which they will be able to deploy anything from one device to arrays of multiple tidal devices. Repowering is the replacement of one array of tidal devices with another array of tidal devices, normally with a different, newer or / and updated technology. Array deployments will vary in duration; therefore, the allocation of berths may be repeated throughout the life of the Project, as one berth is removed, its capacity within the Project become available, and a new array is then be deployed, either at the same berth or at a different location.

15. The intention is that the flexibility within the PDE, carried forward into the EIA and reflected in appropriate consent conditions, will allow the Project to encompass many current technologies as well as future technological development. This allows for continued development of tidal devices, their infrastructure and its management, in areas such as:

- Tidal device installation techniques;
- Health and safety;
- Operation and maintenance (O&M); and
- Improved efficiency and reductions in the cost of energy.

16. Consideration of a broad PDE during the EIA and a flexible consent is particularly important in the following areas:

- The total number of tidal devices deployed within the MDZ;
- Layout of tidal devices within the MDZ (location, density, array spacing);
- Device types;
- Foundation/mooring types;
- Location of electrical hubs and monitoring equipment;
- Number and routing of inter-array and export cables; and
- Location and lighting/marking requirements of navigational aids.

4.2.2. PDE Refinement During the Detailed Design Stage

17. To support a variety of tidal device types within the Project and to accommodate different developer requirements, the shared infrastructure installed by the Project will be as flexible as possible. **Section 4.3.5** details the shared infrastructure that will be installed at the Project.

18. The design of key aspects of parts of the permanent works (onshore infrastructure and offshore export cable landfall) is relatively advanced and refined; whereas, the positioning of marine infrastructure (offshore export and array cables, hubs) will be developed via detailed design work post consent.

19. The design of arrays of tidal devices and related moorings, anchors or foundations will be determined on a case by case basis by the tenants to the Project, prior to deployment of their devices. This will be dependent on the requirements of the device type and influenced by a number of factors, including:

- Physical environmental parameters such as:
  - Depth;
  - Tidal resource; and,
  - Seabed substrate.
- Mitigation requirements identified in the ES and enforced as consent conditions; and,
- Wake effects, depending on the tidal technology and number of tidal devices to be installed.

20. In addition to the flexibility within the MDZ, options are included within the onshore infrastructure to allow flexibility to avoid constraints if identified during pre-construction site investigations. In particular, the ODA, which defines the extent of the Project for EIA purposes encompasses sufficient area to allow the micro-siting of onshore infrastructure if required.

4.2.3. Pre-Deployment Stage

21. Even though site-specific information on these types of factors will be available from the EIA characterisation surveys, final positioning of tidal devices may require additional studies to be undertaken by each tenant prior to construction. Such surveys, if required, could include targeted high definition site investigations for geology and archaeology.

22. The information presented in this chapter has been used to inform the technical chapters contained within the ES and is considered to represent the PDE for use within the EIA.

23. Prior to each array deployment, it is expected that there will be consent conditions requiring documentation to be submitted to the licensing authorities (Welsh Government and Natural Resources Wales, NRW) outlining the parameters of the tidal devices to be installed as well as providing details of the construction methodology, O&M strategy, and the array removal (decommissioning) methodology. This will allow review of each array's characteristics against the consented PDE.

24. A statement of confirming that each array deployment fits within the PDE will be submitted by Menter Môn to the Welsh Government and NRW for approval.

25. The Project will comprise an OfDA including the MDZ covering an area of 35 km², combined with an ECC with an area of 4.75 km^2, plus associated onshore infrastructure (see **Section 4.2.4** and **4.2.5** below) contained within an ODA of 1 km^2.

26. The total installed capacity of the project will be no more than 240 MW. The currently programmed life of the project is 37 years, which has been the basis of impact assessments. This period includes time required for construction, commissioning, repowering and decommissioning.

4.2.4. Offshore

27. The MDZ is located to the west of Holy Island, Anglesey. The ECC connects the MDZ to the landfall location at Abraham's Bosom on the west coast of Holy Island. The location, scale and co-ordinates for the MDZ and ECC are shown in **Figure 1-1** (**Volume II**).

28. The seabed across the MDZ and much of the ECC is dominated by outcropping rock at surface and coarse sediment types such as gravel, with consistent boulders overlaying. There are a number of wreck features within and around the MDZ and ECC, but no historic wrecks. No presence of Unexploded Ordnance (UXO) is indicated within the MDZ or the ECC.

29. Water depths across the MDZ reach over 72 m Lowest Astronomical Tide (LAT) in the northwest of the site, with an average depth across the main site of approximately 40 m LAT. Depths within the ECC range from over 38 m LAT to the intertidal at landfall. All depths in this chapter shown as depth at LAT.

30. Throughout the MDZ, megaripples features occur sporadically. However, within the ECC, the area to seaward of the proposed landfall at Abraham's Bosom has an almost linear deposition of finer material across the entrance which is up to 7 m deep in parts. The intertidal (landfall)

area is bedrock interspersed with discrete patches of barren shingle and occasional areas of sandy sediment.

31. The key components of the offshore works associated with the Project are outlined in the following paragraphs.

32. Tidal devices will be deployed in multiple arrays within the MDZ, to a maximum installed capacity of 240 MW. The tidal devices installed by the Project and within the PDE will have the following key elements:

- A foundation or anchor on or within the seabed;
- A supporting substructure or mooring;
- Tidal Energy Convertors (TEC); and
- Cable connections.

33. Each single array will be comprised of the same type of tidal device (technology type) and located within a discrete location, or berth, within the MDZ. The installed capacity per array is expected to generally be up to 30 MW, but may in practice be greater or smaller than this, being determined by a number of factors including the individual capacity of the export cables supporting each array, the installed capacity of the Project in full, and the requirements of the tidal devices. The installed capacity of individual arrays is not a parameter of bearing upon the ES, and all installed arrays, when summed, will fall within the total installed capacity for the Project of 240MW.

34. For deployment of arrays, the MDZ may be spilt into a series of subzones, with the zones allowing the demarcation of different technology types. Eight indicative subzones within the MDZ are shown in **Figure 4-1** (**Volume II**), however, these indicative zones may be modified to meet the requirements of tenants and regulators. Arrays and associated tenant infrastructure to be deployed in the MDZ are described further in **Section 4.3.1** to **Section 4.3.4**.

35. A phased approach to deployment of the project may be taken, with scale and timeframe of phasing determined by assessments and consideration of mitigation and management undertaken within the ES. Further detail is provided in **Chapter 11, Marine Ornithology**, **Chapter 12, Marine Mammals**, and **Chapter 25, Socioeconomics, Tourism and Recreation**, with the number and scale of each phase of deployment linked to the outcomes of and Environmental Mitigation and Monitoring Plan (EMMP), which is provided in outline to support this ES. The implementation of mitigation, monitoring and management measures will be agreed with regulators and overseen by an independent advisory group. Indicative examples of potential phases of deployment are:

- **Phase 1**: Installed capacity (MW) at which no significant impact is predicted. This commitment ensures an initial level of mitigation in place at the start of the EMMP.
  The scale of the Phase 1 deployment (MW) will be determined by the outcome of modelling of potential collision and encounter risk for marine mammals and diving birds, which is in dependent upon:
  - The type of Tidal Energy Converters (TECs) to be installed in the array.
  - The physical characteristics of the location of the array.

- **Phase 2**: If the results of monitoring of the first phase of deployment do not indicate a significant effect on marine mammals, and then the next phase of deployment would begin. An example of a commercial level of deployment for a second phase of deployment is suggested in **Chapter 25, Socio-economics, Tourism and Recreation**, as 40 MW. A potential 40 MW commercial deployment is considered within **Chapter 11, Marine Ornithology**, and within technical appendices of **Chapter 12, Marine Mammals**.
- **Phase 3**: An example of the next commercial level of deployment of 100 MW is suggested, however, this is indicative;
- **Phase 4**: Deployment to the maximum installed capacity of 240 MW.

36. Dependent on the type of tidal device, full deployment to 240 MW could comprise up to a maximum of 620[1] tidal devices, supporting up to 1,648 TECs and up to 740 inter-array cables within the MDZ. This represents the worst-case scenario as outlined in **Section 4.3.1.2**.

37. Water depths and tidal resource vary across the MDZ. The eight indicative subzones are located in parts of the MDZ that support stronger tidal resource, while also offering a range of depth parameters. Across indicative subzones 1, 2 and 3 approximate water depths are mainly between 30 and 40 m, with some deeper areas of 40 to 45 m, whilst within the majority of indicative subzones 4, 5, 6 and 7 the approximate water depths are generally in the range 30 to 35 m. Across indicative subzone 8 approximate water depths range from 40 m to 60 m.

38. The MDZ and ECC will also contain the following ancillary infrastructure;

- Up to nine export cables;
- Up to nine export cable tails (shared with onshore components);
- Navigation and environmental monitoring equipment;
- Mooring and foundation structures; and
- Offshore electrical infrastructure, including submerged, floating or surface emergent hubs.

4.2.5. Onshore

39. The boundary for the ODA is provided in **Figure 1-2** (**Volume II**). Landfall will be located within the bay on the western coast of Holy Island known as Abraham's Bosom. Because of the overlap of marine and terrestrial planning jurisdiction in the intertidal, an area of 15,102 m^2 (0.0151 km^2) of the intertidal is shared between the terrestrial and marine areas of the Project. This area will be included in both the Transport and Works Act Order (TWAO), deemed planning permission and Marine Licence applications for consent.

40. The key components of the onshore works associated with the Project include:

- Cable landfall works, including;
    - Up to nine HDD ducts or trenched equivalents,

[1] Based on an indicative worst-case maximum deployment scenario of 240MW deployment of arrays of small devices (each device 0.2 to 0.5 MW).

- Up to nine transition pits or bays, and
- Up to nine export cable tails (shared with offshore components).

- A landfall substation at Ty-Mawr (hereafter referred to as 'Landfall Substation');
- A switchgear building at Parc Cybi (hereafter referred to as 'Switchgear Building');
- A grid connection substation at the existing Orthios Eco-Park to the east of Holyhead (the site of the former Anglesey Aluminium works) (hereafter referred to as 'Grid Connection Substation');
- Onshore cable circuits installed between Landfall Substation, Switchgear Building and Grid Connection Substation; and,
- Onshore cable route joint bays (along onshore cable route between Landfall Substation, Switchgear Building and Grid Connection Substation).

41. The landfall consists of exposed rocky shore, backed by a hinterland of coastal heath and farmland. The Landfall Substation location is within currently farmed land, in the area of Holy Island known as Penrhos Feilw. From transition pits or bays, export cables will be trenched to the Landfall Substation. From the transition pits to landfall, HDD is the preferred method for installation of export cables. However, if HDD is not feasible then an alternative method consisting of trenching marine cables from transition pit to shallow subtidal, with installation and pinning of ducting and cables to cliff face using split-pipe.

42. From the Landfall Substation the majority of the onshore cable will be trenched within the existing minor road network (**Figure 1-2, Volume II**). The proposed cable corridor follows South Stack Road, Porthdafarch Road and Mill Road towards the Switchgear Building. The cable will be trenched from the Switchgear Building to the Grid Connection Substation, with a section installed via Horizontal Directional Drilling (HDD) beneath the A55 and the Holyhead to Bangor rail line.

4.2.6. Mitigation

43. During the development of the detailed engineering design, a number of embedded mitigation measures have been included to reduce the potential impacts of the project. Where significant adverse impacts have been identified as a result of the Project, additional mitigation measures are proposed to seek to reduce residual impacts to acceptable (non-significant) levels, full details are provided in the relevant technical chapters (**Chapter 7** to **Chapter 25** and **Chapter 27, Summary**).

44. Those measures embedded into the project design, within both the OfDA and ODA are outlined in **Table 4-1**.

Table 4-1 Mitigation Measures Embedded into Project Design

Project Infrastructure	Embedded Mitigation Measure
MDZ	Deployment of seabed mounted or buoyant mid water tidal devices in the north of the MDZ to maintain under keel clearance of 20 m or more, as appropriate to large vessels using those parts of the MDZ.

Project Infrastructure	Embedded Mitigation Measure
	Mitigation through the application of the spatial measure shown and defined in Figure 4-1, shown in the purple area labelled “Submerged tidal devices with 20 m Under Keel Clearance (UKC) only”.
	Maintenance of an area inshore of any floating / surface emergent arrays deployed in the MDZ, with a minimum distance of 1 km from floating / surface emergent arrays to the nearest coastline, and within which a minimum Under Keel Clearance (UKC) of 8 m is maintained to allow safe passage of small vessels. Maintenance of a minimum separation distance of 1 km from the coastline to any visually prominent tidal devices, to increase the separation distance between such structures from the coastline. A visually prominent tidal device is a tidal device where the large proportion of the support structure is visible above the water to the extent it is visually prominent, together with ancillary elements such as navigation lights, railings and mast Mitigation through the application of the spatial measure shown and defined in Figure 4-1, where a light blue area is labelled “Submerged tidal devices with an 8 m UKC only”. When combined with the export cable corridor (where no devices are deployed) and shown in Figure 4-1 as a blue cross hatched area, a minimum distance of 1km to shore from any floating / surface emergent array is achieved.
	Mitigation through the deployment of surface emergent devices in the south of the MDZ, including the extra gold triangle as shown in Figure 4-5 Potential in the future for deployment of visually prominent tidal devices in more northern parts of the MDZ will be kept under review on a case by case basis with regulators *.
	Minimising visually prominent elements of the Project as much as practicable within the MDZ to help ensure the composition of offshore elements is as simple as possible. A shown in Figure 4-5 the SESM devices which are 18m above sea level are restricted to the green hatched area.
	Project Design Envelope for tidal devices defined using parameters available from established tidal device technologies, which has been assumed will be developed sufficiently for commercial use at time of deployment.
	Mitigation by micro-siting and avoidance or modification of construction foundation design for potential channel areas (unless archaeological value confirmed as low).
ECC	Selection of cable corridor to minimise length of export cables within the marine environment.
Landfall Substation	Selecting a recessive location in the landscape, in a relatively low-lying position and using the landform to help integrate the Landfall Substation (cutting into the valley side rather than building a platform out).
	Arrangement of plant and equipment at the Landfall Substation within three buildings, resulting in a collection of buildings that break up the scale of the development and create a form and massing that is comparable with local agricultural buildings.
	Using colours and materials (including natural materials) that are consistent with the vernacular associated with agricultural buildings and are recessive in the local context.
	Using the buildings to define the boundaries of the substation, reducing the requirement for security fencing.
	Considering limited application of planting to help integrate the substation, acknowledging the limitations associated with this in the open and exposed coastal landscape.
	Using stone walls and stock proof fencing as part of new boundaries.
	Minimising the use of external lighting in this rural location.

Project Infrastructure	Embedded Mitigation Measure
	A 3.5 m high acoustic demountable fence will be installed around the HDD equipment and a 2 m high solid hoarding fence will be built around the works compound boundary.
Onshore Cable Corridor	Use of underground cabling to provide the connections between all Project elements, avoiding the need for overhead cables.
	Routing the underground cable within the local road corridors to minimise potential disruption to field boundaries.
Grid Connection Substation	Positioning of the substation in a location where industrial structures form an established part of the baseline context, and where established vegetation surrounding the site provides effective visual enclosure.
Switchgear building	Positioning of this element within an allocated employment site, adjacent to an existing substation and where surrounding development will be comparable in form, massing and appearance.
* 'Case by case' review allows for the development of floating / surface emergent technology in future, which may not be visually prominent, and may therefore be appropriate for deployment in this part of the MDZ.	

45. Embedded mitigation measures relating to navigational safety in **Table 4-1**, above, are derived from the Navigation Risk Assessment (**Appendix 15.1, Volume III**), undertaken for **Chapter 15, Shipping and Navigation**. These measures are not taken into consideration as embedded mitigation measures within that chapter, due to the requirement to consider only safety measures as embedded mitigation within the impact assessment. All arrays will be subject to an assessment of navigation risk prior to their deployment.

4.3 OFFSHORE INFRASTRUCTURE

46. The key components of the offshore works associated with the Project are detailed in this Section, in the following order:

- Tidal device;
- Foundations;
- ECC and electrical infrastructure (i.e. hubs); and
- Navigation and monitoring equipment.

4.3.1. Tidal Device Envelope

4.3.1.1. Review of Existing Tidal Technologies

47. Based on the developer consultation undertaken over the period 2017 to 2019, significant consideration has been given to which types of tidal devices to include in the PDE of the Project. The device types included in this project description chapter, and therefore assessed in this EIA (as updated in September 2025 to include the SESM device type), are deemed to represent the most realistic parameters for deployment by the Project.

48. Tidal devices comprise of the TEC, the supporting structure, and the anchor or foundation. **Plate 4-1** shows the two forms of TEC that may be mounted on a tidal device, either horizontal axis or vertical axis TECs.

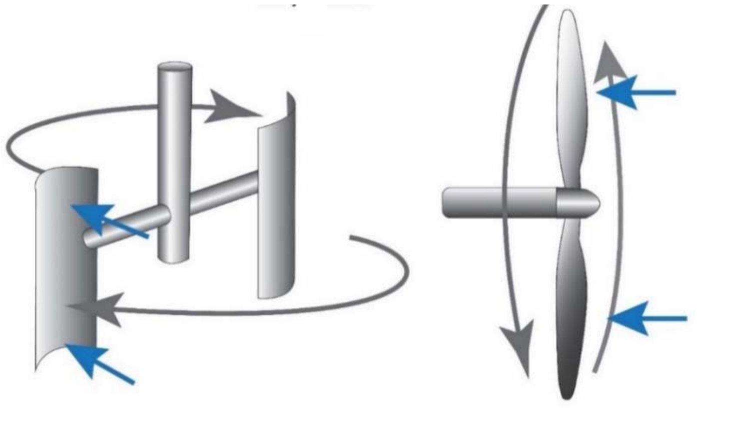


Plate 4-1 Illustration of Vertical (Left) and Horizontal (Right) Axis TEC Types

49. **Plate 4-2**, **Plate 4-3**, **Plate 4-4 and Plate 4-4a** show the tidal devices and their respective components, using three generic types of tidal device as exemplars and a fourth as a hybrid device type of Surface Emergent and Seabed Mounted (SESM). Note that the actual form of tidal devices and numbers of TECs supported will differ between the technologies deployed.

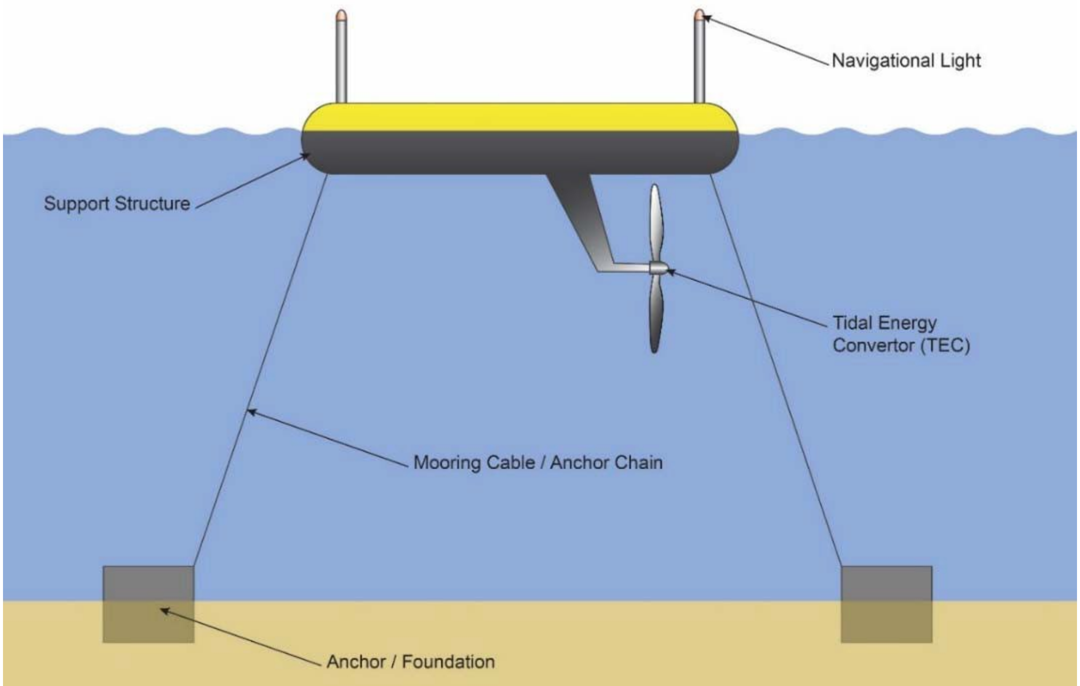


Plate 4-2 Generic Tidal Device Exemplar 1 – Floating or Surface Emergent Tidal Device, Comprised of TEC, Support Structure, Mooring Cables / Anchor Chains and Anchors / Foundations

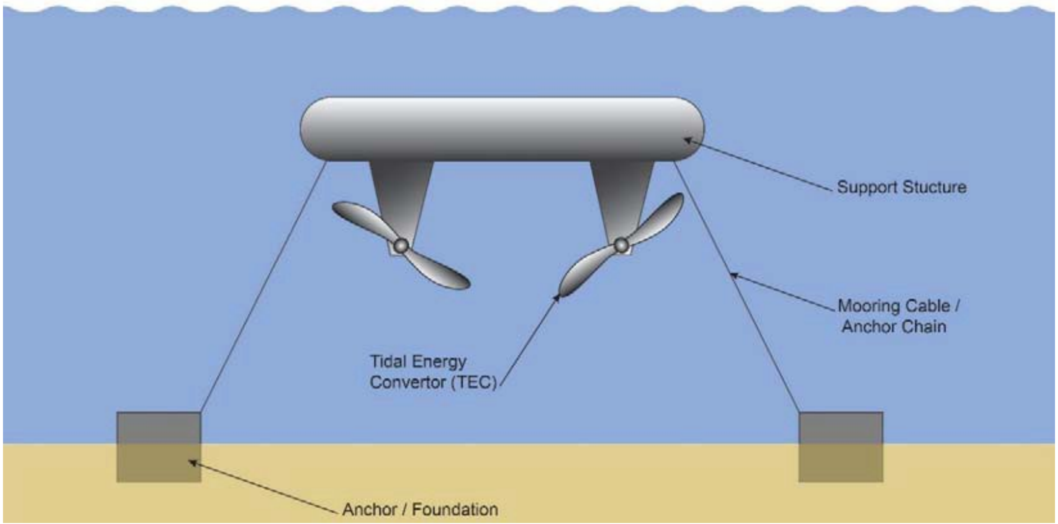


Plate 4-3 Generic Tidal Device Exemplar 2 – Mid Water Column Tidal Device, Comprised of TEC, Support Structure, Mooring Cables / Anchor Chain, and Anchor / Foundation[2]

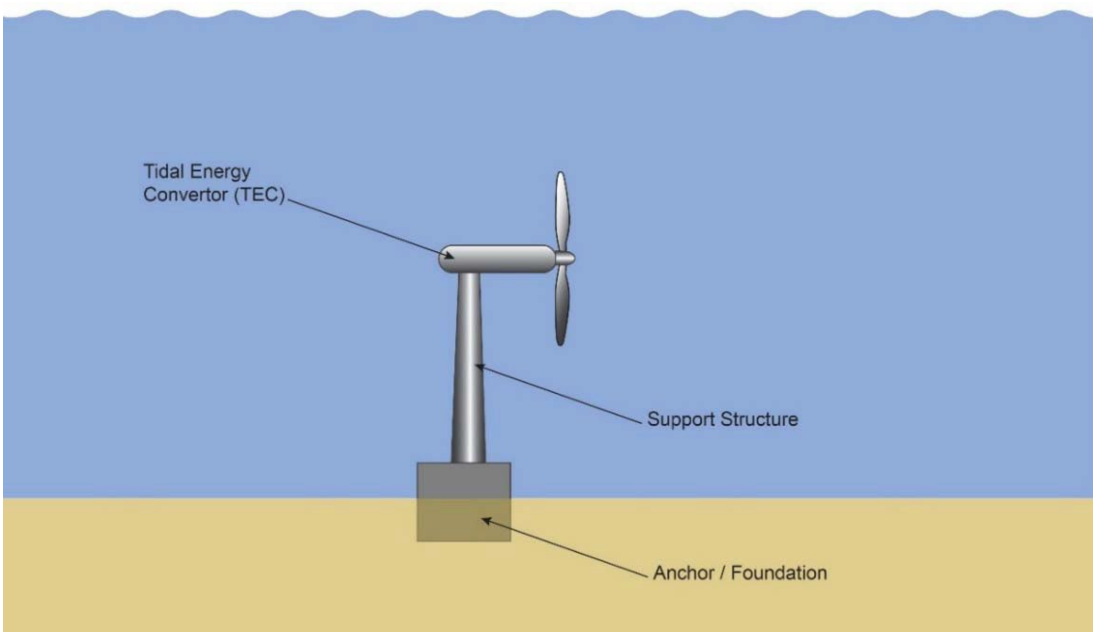


Plate 4-4 Generic Tidal Device Exemplar 3 – Seabed Mounted Sub Surface Tidal Device with TEC Supporting Structure and Foundation

[2] Note this device is shown facing into direction of current flow

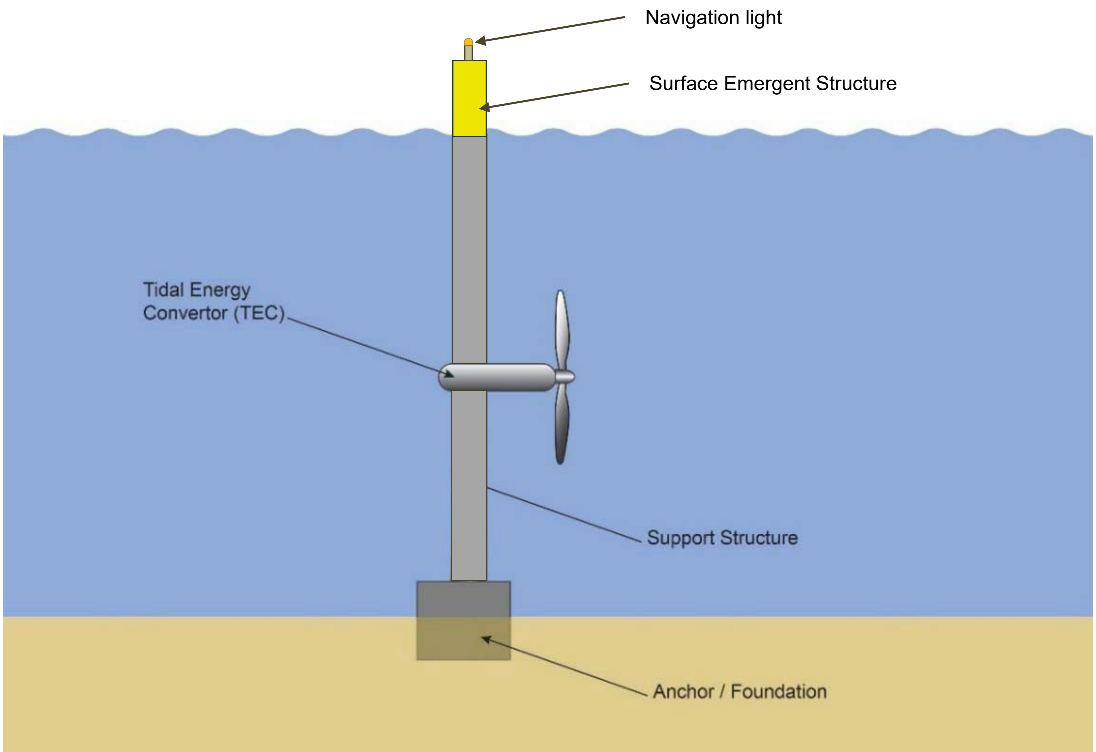


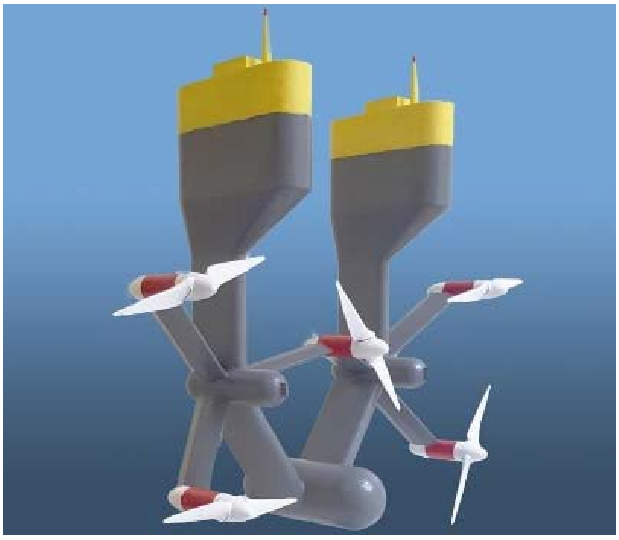
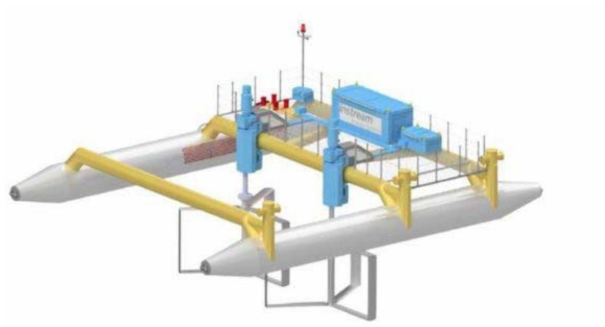
Plate 4-4a SESM Tidal Device Exemplar 4 – Hybrid of Seabed Mounted and Floating or Surface Emergent Tidal Device.

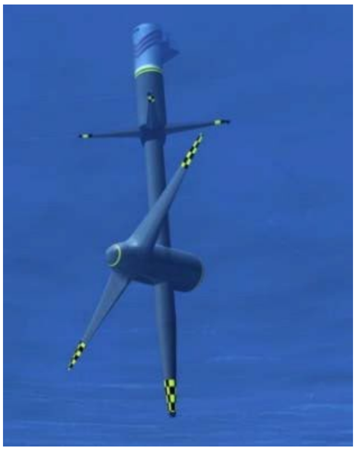
50. The device types considered suitable for the PDE are shown in **Table 4-2**, with example technologies for each TEC.

Table 4-2 Categorisation of Devices for the Project Design Envelope

Sub-Category	**Exemplars (Developer or Device Names)**	
Category 1: Seabed Mounted Sub-Surface Devices		
Large rotor(s) (>10 m diameter)	▪ SIMEC Atlantis Energy ▪ Andritz Hydro Hammerfest	 Developer: SIMEC Atlantis Energy Source: (https://twitter.com/simecatlantis/-status/534996023178178560
Small (<10 m diameter) rotors	▪ Verdant Power ▪ QED Naval SubHub ▪ Nova Innovation ▪ Sabella	 Device/Developer: Gen5Tidal/Verdant Power Source: Verdant Power  Device/Developer: D10-1000/Sabella Source: Sabella

Sub-Category	Exemplars (Developer or Device Names)	
Vertical axis turbine	▪ Repetitive Energy	 Developer: Repetitive Energy Source: http://www.repetitiveenergy.com/our-technology/
Category 2: Mid-Water Column Devices		
Multiple small (<10 m diameter) rotor upon submerged buoyant platform	▪ SME PLATO platform or similar with Tocardo or Schottel TECs ▪ Renewable Devices Marine Ltd.	 Developer: Renewable Devices Marine Ltd. Source: https://www.theenergytimes.com/ distributed-energy-ecosystem/scots-push-new-tide-turbine-tech
Category 3: Floating or Surface Emergent Devices		
Large rotor (>10 m diameter) floating or emergent devices	▪ Orbital Marine Power ▪ Magallanes	 Developer: Orbital Marine Power Source: https://marineenergy.biz/2018/11/16/orbital-marine-unveils-o2-turbine-blueprints/

Sub-Category	Exemplars (Developer or Device Names)	
Small rotor (<10 m diameter) floating devices	▪ Tocardo TFS	 Developer: Tocardo Source: https://marineenergy.biz/2018/06/06/-tocardo-strengthens-management-with-finance-appointments/
Floating vertical axis devices	▪ Instream	 Developer: Instream Source: https://www.marineenergywales.co.uk/-instream-and-itpenergised-full-scale-demonstrator/

Sub-Category	Exemplars (Developer or Device Names)	
Large rotor (>10 m diameter) surface emergent spar buoy	▪ Aquantis	 Developer: Aquantis Source: https://www.f6s.com/aquantisinc
Category 4: Hybrid of Seabed Mounted and Floating or Surface Emergent Devices		
Sub-Category	**Exemplars (Developer or Device Names)**	
Surface Emergent Seabed Mounted (SESM)	• Tidal Technologies Ltd	 Source: Tidal Technologies Ltd

4.3.1.2. Tidal Energy Convertor Parameters

51. Several representative tidal technologies have been considered in order to capture the likely range of TECs that may be demonstrated within the MDZ. The TECs to be installed will fall into one of two main types as shown in **Plate 4-1**:

- Horizontal axis (axial flow) rotors; or
- Vertical axis (cross flow) rotors.

52. As shown in **Plates 4-2** to **4-4a**, the TEC support structure may be:

- Seabed mounted and submerged;
- Buoyant and mid-water column;

- Floating; or
- Surface Emergent and Seabed Mounted

53. The nominal outputs of tidal devices considered within the ES range from 200 kW to 4 MW, with individual devices potentially supporting one or several TECs. The potential output of individual TECs within tidal devices could range from 50 kW to 2 MW. Tidal devices with a maximum installed capacity value of 2 MW exist, however, it is anticipated that with improvements in efficiency of technologies, devices of up to 4 MW may become available, while all other PDE parameter maximums remain unchanged.

54. Under Keel Clearance (UKC) of devices below LAT will take account of shipping and navigation constraints (as detailed in **Chapter 15, Shipping and Navigation**). Across much of the MDZ the UKC of seabed mounted sub-surface devices or buoyant mid water column devices will be greater than 8 m, however, this may be reduced where a lack of navigation constraints allows shallower deployment of appropriate devices. In deeper parts of the MDZ (in the north and north west of the MDZ), the UKC will be greater to accommodate larger vessel navigation requirements, with the Project maintaining an UKC of at least 20 m below LAT in these areas.

55. Where floating and surface emergent tidal devices are deployed in the MDZ, their physical support structures are present at surface and therefore there can be no UKC. It should be noted, however, that the uppermost point of TECs deployed on these devices will be located several metres below water surface.

56. The number of TECs per device will be typically between one and four, although for some multiple TEC surface platforms this may increase to up to five per device. For those devices, if each TEC is assumed to have three rotor blades, then the maximum number of blades could be 15 for each single device.

57. The number of rotor blades associated with each TEC is typically two or three per TEC, although the ES considers TECs with up to six rotor blades. The PDE required for consent does not seek to limit the maximum number of blades for a TEC, as this would limit the potential for technology development over time. Instead proposed mechanisms for assessment of the impact of blade number and other parameters is presented in Chapter 11, Ornithology and Chapter 12, Marine Mammals, of the ES and the outline Environmental Mitigation and Monitoring Plan (EMMP), which accompanies the ES.

58. The maximum TEC rotor diameter considered in the ES and taken forward within the PDE for consent is 27 m. Typically, the rotor diameters will be between 10 to 16 m. The area of leading edge per rotor will be between 1.5 and 15 m².

59. The average speed of TEC rotation considered within the ES is between 7.5 and 26.7 rotations per minute (rpm). For smaller (10 m or less in diameter) open rotor devices the average speed of TEC rotation considered were between 13.6 and 26.7 rpm. For larger (more than 10 m in diameter) open rotors the average speed of TEC rotation is generally lower, between 7.5 and 10.1 rpm. The maximum speed taken forward within the PDE for consent is 22 rpm.

60. The ES assessed a maximum number of individual TECs within the Project to limited to up to 1,648 TECs spread across up a maximum number of devices taken forward within the PDE for consent of 620 tidal devices and with up to 4,750 rotor blades. This assumes the Project at full

240 MW capacity and a deployment scenario which is dominated by devices with larger numbers of TECs per device. The actual number of tidal devices, associated TECs and their rotor blades deployed to achieve 240 MW may be much smaller, but maxima are used here to define the worst-case in this PDE.

4.3.1.3. Seabed Mounted Sub-Surface Devices (Category 1)

61. **Table 4-3** provides a review of parameters for the example tidal technologies outlined in **Table 4-2**, in order to define the worst-case scenario for seabed mounted sub-surface device types in terms of TEC parameters, numbers of devices and swept area. A range of capacities are provided for each device type and the maximum number of devices per subzone is based on the smallest capacity from each range as a factor of a proposed potential array capacity of 30 MW.

Table 4-3 Seabed Mounted Sub-Surface Device Parameters (Worst-Case Highlighted in Blue)

Device Type	Number of devices (in a 30 MW array)	Number of TECs per device	Average TEC speed (rpm)	Max. diameter (m)	Max. device swept area (m^2)	Max. array swept area (m^2)
SIMEC Atlantis Energy	30	1	7.5	26	531	15,930
Andritz Hydro Hammerfest	30	1	7.5	26	531	15,930
Verdant Power	25	3	22	10	235	5,875
QED Naval SubHub	10	3	Assume as Verdant	Assume as Verdant	Assume as Verdant	Assume as Verdant
Nova Innovation	100	1	22	10	78.5	7,850
Sabella	30	1	7.5	15	176.7	5,301

4.3.1.4. Buoyant and Mid-Water Column Devices (Category 2)

62. **Table 4-4** provides a review of parameters for the example tidal technologies outlined in **Table 4-2**, in order to define the worst-case scenario for buoyant and mid-water column device types in terms of TEC parameters, numbers of devices and swept area. A range of capacities are provided for each device type and the maximum number of devices per subzone is based on the smallest capacity from each range as a factor of the largest subzone capacity (30 MW).

Table 4-4 Buoyant and Mid-Water Column Device Parameters (Worst-Case Highlighted in Blue)

Device Type	Number of devices (in a 30 MW array)	Number of TECs per device	Average TEC speed (rpm)	Max. diameter (m)	Max. device swept area (m^2)	Max. array swept area (m^2)
Generic mid water platform with Tocardo TEC	20	5	18	10	392.8	7,857

4.3.1.5. Floating / Surface Emergent Devices (Category 3)

63. **Table 4-5** provides a review of parameters for the example tidal technologies outlined in **Table**

4-2, in order to define the worst-case scenario for floating device types in terms of TEC parameters, numbers of devices and swept area. A range of capacities are provided for each device type and the maximum number of devices per subzone is based on the smallest capacity from each range as a factor of the largest subzone capacity (30 MW).

Table 4-5 Floating / Surface Emergent Device Parameters (Worst-Case Highlighted in Blue)

Device Type	Number of devices (in a 30 MW array)	Number of TECs per device	Average TEC speed (rpm)	Max. diameter (m)	Max. device swept area (m^2)	Max. array swept area (m^2)
Orbital Marine Power and / or Magallanes	15 (8*)	2	8.71	25	982.1	14,732
Tocardo (TFS)	20	5	18	10	392.8	7,857
Instream	50**	2	13.6	5	19.92	996
Aquantis	30 (15*)	1	10.1	27m	572.7	17,183

* Values in brackets for Orbital / Magallanes and Aquantis assume a future tidal device with improved TEC efficiency to give up to 4 MW installed capacity per device.

** Values for Instream type device are for a 10 MW array.

4.3.1.5a. Surface Emergent Seabed Mounted Devices (Category 4)

65a. Table 4-5a provides a review of parameters for the example tidal technologies outlined in **Table 4-2**, in order to define the worst-case scenario for SESM device types in terms of TEC parameters, numbers of devices and swept area. A range of capacities are provided for each device type and the maximum number of devices per subzone is based on the smallest capacity from each range as a factor of the largest subzone capacity (30 MW).

Table 4-5a Surface Emergent Seabed Mounted Device Parameters (Worst-Case Highlighted in Blue)

Device Type	Number of devices (in a 30 MW array)	Number of TECs per device	Average TEC speed (rpm)	Max. diameter (m)	Max. device swept area (m^2)	Max. array swept area (m^2)
Tidal Technologies	15	2	10	25	1000	15,000

4.3.1.6. Corrosion Protection and Antifoulants

64. The majority of devices will utilise some form of corrosion protection system; those proposed are broadly similar to those adopted within other marine industries. These may include systems such as offshore grade protective paint systems, impressed current systems and sacrificial anodes.

65. Structures will typically be painted with modified epoxy or acrylic based abrasion-resistant paints suitable for subsea and splash zone, plus similar primer. Individual devices are each expected to use between 500 and 1,200 litres of paint. All protective coatings and paints used will be suitable for use in the marine environment and, where necessary, approved by the Health and Safety Executive.

66. Impressed Current System (ICS) or sacrificial anodes are both commonly used on ships and subsea structures and may form part of the tidal devices deployed by the Project. Sacrificial anodes are commonly used to supplement the ICS as a back-up or located on parts of the structure where ICS cannot be used. The anodes are standard products for offshore structures, which are welded onto the steel structures and consist of aluminium (98 to 96%) and zinc. The number and size of anodes will vary dependent on device design.

67. Antifoulants may be applied in areas of tidal devices considered particularly susceptible to the build-up of marine growth, for example TECs (rotors and nacelle) and heat exchangers, to ensure devices maintain optimum performance.

68. The majority of antifouling paints produced and available for use in the UK are copper-based, in which the main biocide is cuprous oxide, the natural form of copper. Some antifouling paints contain a less potent form of copper (cuprous thiocyanate) and can be referred to as 'copper free' paints. The paints may also contain other biocides in smaller quantities. The use of antifouling paints will be limited to areas of specific need by tenants.

69. A teflon based antifoulant (such as Intersleek 900) has also been commonly used on tidal devices. Intersleek 900 is a non-leaching antifoulant that works by physically preventing species' attachment as opposed to having biocidal activity.

70. Antifoulant products are generally installed before the first deployment of an array and may be reapplied as required during maintenance activities. A decision on what presents the Best Practicable Environmental Option (BPEO) will be made for each deployment, in compliance with a review of the parameters of each array deployment for compliance with the PDE. The requirements for antifouling may vary between categories of tidal devices.

71. In summary, the following worst-case scenario footprints for the MDZ will be used in the impact assessment:

- Use of sacrificial anodes to each tidal device deployed; and
- Use of copper based anti-fouling paints.

4.3.1.7. Summary of Worst Case Tidal Energy Convertor Parameters

72. Where relevant, technical chapters (**Chapters 7** to **Chapter 26**) of this ES will identify which device type presents the worst-case scenario for their specific receptors. **Table 4-6** below details the worst-case scenario for TEC parameters and device numbers within a 30 MW array, and these values are considered to be within the PDE of this EIA.

Table 4-6 Worst Case Scenario based on Full 240 MW Deployment (Worst-Case Highlighted in Blue)

Parameter	Seabed Mounted Sub- Surface Devices (Category 1)	Buoyant and Mid-Water Column Devices (Category 2)	Floating / Surface Emergent Devices (Category 3)	Surface Emergent Seabed Mounted (Category 4)
TEC diameter	26 m	10 m	27 m	25m
TEC speed	22 rpm	18 rpm	18 rpm	10 rpm
30 MW array swept area	15,930 m^2	7,857 m^2	17,183 m^2	15,000m^2

Number of devices in a 30 MW array	100	20	50*	15

* Values for Instream type device are for a 10 MW array, with no deployment of this technology at greater scale within the PDE. This represents the greatest number of floating devices.

4.3.2. Foundation Systems

73. There are two types of foundation systems proposed for use by developers within the MDZ, seabed mounted and anchored (mooring) systems. Within both types there are various options which could be adopted.

74. Anchored devices may be either surface floating or mid water column and buoyant. Seabed mounted foundations in the PDE include Gravity Based Structures (GBS) (including tri-frames), drilled socket multi-piled structures (including tripods and quadrapod) and drilled socket monopiles.

75. The worst or 'extreme case' values for foundations and anchors presented below are based on different scenarios of deployment across the site. Each scenario is based on the maximum number of devices that represents a 'worst-case' for potential receptors, based on 30 MW of a technology that represented the 'worst-case' impact, followed by 30 MW of the technology with the second 'worst-case' impact, 30 MW of third 'worst-case' impact and so on until the full potential across the site is reached. It is important to note that more than 30 MW of any of the device type examples could be deployed in multiple arrays, however, the total worst case calculated will not be exceeded.

76. The values for each technology are based on those provided by developers during a developer consultation exercise and captured in a FEED report commissioned to form the basis for the PDE for the Project (**Appendix 4-1, Volume III**)[3]

4.3.2.1. Gravity Based Structures

77. For some of the tidal devices and infrastructure that may be deployed at the MDZ, the preferred foundation concept is a GBS. GBS utilise the submerged mass of a structure to resist environmental and operational loading on the device and maintain its stability. GBS may be used as foundations or anchors for all four categories of tidal devices included within the PDE, as well as for project infrastructure such as hubs.

78. The footprint (the element of the foundation in direct contact with the seabed) of GBS, proposed within the MDZ would typically be very small (<10 m^2) for each tidal device, with some GBS using 'feet' that focus the weight of the foundation on a small area of seabed. The weight of the foundations can sometimes cause the feet to penetrate the seabed (by up to 0.5 m). The use of feet minimises requirements for seabed levelling as well as also reducing the surface area of the foundation that is in direct contact with the seabed.

[3] The first part of Appendix 4-1 was produced in 2018 and was based on an initial anticipated project capacity of 180 MW. Following submission of this report, a design decision was made to increase the capacity of the proposed Morlais Project to 240 MW and an updated Addendum to the original report was produced (pg82 of Appendix 4-1) which revised earlier values (based on 180 MW project) to reflect the 240 MW capacity. Therefore, values in the original ITPE report may not match with values presented in Chapter 4 of the ES, however, the values in the addendum report do match the values presented in Chapter 4, and are also used as basis of assessments undertaken in topic-specific chapters. In any instances where values in the ITPE addendum report do not match values in Chapter 4 of the ES, the ES values remain the basis for assessment.

79. In a few limited cases some clearing (or grouting) of the seabed might be necessary below a GBS if a sufficiently level area could not otherwise be found. However, this is not anticipated to be widespread.

80. For a 240 MW capacity deployment of tidal devices and supporting infrastructure (such as hubs) using only GBS for foundations and anchors, the total (worst-case) footprint would equate to 74,790 m^2 [4]. The additional seabed footprint (m^2) for navigation and environmental monitoring equipment moorings as well as other project components such as cable protection are defined in **Table 4-25** Hubs and buoys, navigation and monitoring equipment worst case parameters, **Table 4-26** Worst-Case Parameters for Permanent Seabed Habitat Disturbance including Repowering and **Table 4-28** Worst-Case Parameters for Temporary Seabed Habitat Disturbance during Construction, Operation (including repowering) and Decommissioning**.**

4.3.2.2. Drilled Pile Foundations

81. For some of the tidal devices and infrastructure that may be deployed at the MDZ, the preferred foundation concept is a tripod or quadropod structure typically using three or four drilled socket pin piles.

82. Due to the hard substrate (bedrock) in the MDZ, drilling will be required to install drilled pile foundations (pin piles or monopiles). For each pile a socket is drilled into the seabed, typically between 1.0 to 2.5 m in diameter and the pile is inserted into the socket. The pile is then grouted or swaged in place to secure it into the seabed. Some piles will be self-drilling, others will require an annulus to be drilled, of sufficient size to accommodate the pile. This will create spoil arisings from the drilling process.

83. In some cases, screw piles may be used; these are steel piles with helical steel plates welded to the pile shaft in accordance with the ground conditions. Screw piles are wound into the seabed much like a screw into wood, using (temporary) rotary hydraulic equipment. The pile diameters and thus drill arisings are broadly similar to drilled pin piles.

84. For a 240 MW capacity deployment of tidal devices and supporting infrastructure (such as hubs) using only piled foundations the worst-case scenario is total footprint on the seabed would be 5,889 m^2 [5]. The worst-case seabed footprint for piled foundations is significantly less than worst-case seabed footprint for GBS; therefore, GBS will be used as worst-case footprint for impact assessment of seabed impacts.

85. Drill arisings are produced during pin pile installation, with up to 117,780 m^3 [6] generated for the 5,889 m^2 footprint detailed earlier in this section. Disposal of this material would be *in-situ,* directly to the surrounding sea bed. The duration for each will be between two and three days.

86. A total of 1,490 drills will be required for the worst-case outlined above, taking up to 3,990 drilling

[4] Worst-case GBS footprint based on 240MW deployment achieved using 590 tidal devices with the largest foundation footprints and 120 hubs to maximise footprint, as follows: 120 devices @ 4x36m2 each; 120 devices @ 2x60m2 each; 15 devices @ 4x78m2 each; 20 devices @ 2x78m2 each; 15 devices @ 4x78m2 each; 150 devices @ 1x9m2 each); 30 devices @ 4x78m2 each; 120 devices @ 1x36m2 each; 60 electrical hubs @ 4x40m2 each; and 60 electrical hubs @ 1x100m2 each.
[5] Worst-case drilled pin pile footprint based on 240MW deployment achieved using 290 tidal devices and 120 hubs to maximise the footprint: 80 devices @ 4 x drills of 2.6m diameter (21m2) each device; 120 devices @4 drills of 1.2m dimeter (4.5m2) per device; and 90 devices @ 3 drills of 2.6m diameter (15.9m2) per device; then 60 large hubs @ 3 drills of 2.6m diameter (15.9m2) per hub; and 60 small hubs @ 4 drills of 2.6m diameter (21m2) per hub. Total number of drills 1,490.
[6] Assumes 5,889m2 footprint of piles and 20m depth of drilling.

days to achieve[7].

87. For repowering, an additional 50 % of drilling arisings, footprint and drilling time would be generated.

4.3.2.3. Monopile Foundations

88. The use of drilled socket monopiles falls within the PDE, with potential to be used within the MDZ to house electrical hub infrastructure. If they are required, then in a similar way to pin pile foundations, monopiles will be inserted into sockets which have been previously drilled into the seabed and the monopiles then grouted in place. The PDE assumes monopiles which extend up to 18 m above sea surface at LAT may be used. Eight such monopiles (one for each potential subzone within the MDZ) might be deployed, each of 6 m diameter giving a significant internal space for array connection infrastructure.

89. For eight monopiles used to house surface-piercing electrical hubs, the worst-case footprint for monopiles is 226.2 m^2. The worst case seabed footprint value of 74,790 m^2 already includes hubs assumed to be mounted on GBS foundations. Therefore, this figure of 226.2 m^2 is not additional seabed footprint.

4.3.2.4. Mooring Systems

90. A number of tidal devices utilise a buoyant support structure on which to mount the TECs. These can be held in a fully submerged and mid water column position (**Table 4-2**, Category 2 devices) or have a partially surface emergent support structure (**Table 4-2**, Category 3 devices).

91. Floating tidal devices, typically using catenary moorings are considered in this PDE, with each tidal device requiring four GBS, to which catenary mooring chains are attached. At any time, a portion of the mooring chains will lay upon the seabed and a portion will be suspended. The suspended weight of chains between the GBS and the tidal device keeps the device in position by maintaining a dynamic tension. The amount of chain suspended at any time is adjusted by the movement of the tidal device in response to the tidal state, wider surface conditions, and in particular to wave climate.

92. **Plate 4-5** illustrates the potential use of catenary moorings for one of the floating tidal devices included within the PDE and is representative of catenary moorings generally for floating devices.

[7] Total of 1,490 drills, 1.2m diameter drill taking 2 days each, and all other drills taking 3 days each.

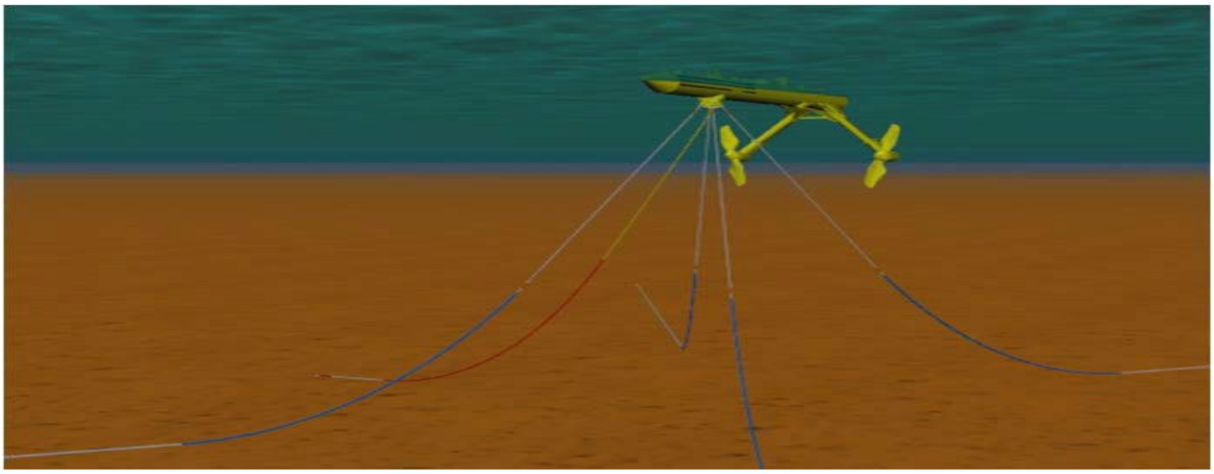


Plate 4-5 Example of Catenary Mooring System (Source: Orbital Marine Power)

93. Buoyant mid-water column devices will typically use a tension mooring system, with the buoyancy of the submerged tidal device holding mooring cables between the tidal device and GBS in constant tension. Such a system does not have to be able to manage surface weather conditions and is subject to less movement than catenary systems, with constant tension maintained on mooring cables as the buoyant tidal device 'seeks' to reach the surface and the moorings restrain it. All cable between tidal device and GBS is in tension and no cable is in contact with the seabed.

94. **Plate 4-6** illustrates and compares catenary and tension moorings.

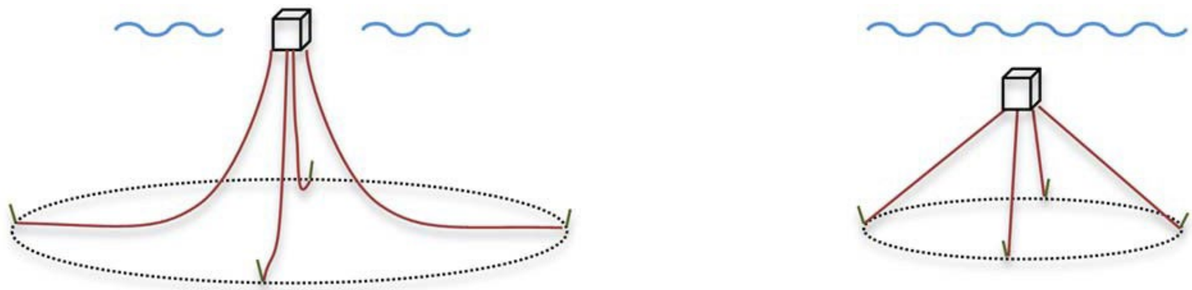


Plate 4-6 Schematic of a Catenary (Left) and a Tension (Right) Based Mooring System

95. The use of catenary moorings for floating / surface emergent tidal devices, leads to a 'Catenary Swept Area' (an area that could be subject to chain drag) where a portion of the mooring chain between a tidal device and a GBS is in contact with the seabed at any point in time. Chains within a catenary mooring system may 'sweep' a portion of seabed as the tidal device moves within a window in response to external forces (wind, wave and tides). In these instances, the swept area may be significantly greater than the footprint of the gravity anchors themselves. This effect does not apply to tension moorings as the cables in tension lines do not drag on the seabed.

96. Based on a deployment to 240 MW capacity using only tidal devices that may use catenary mooring systems, the total Catenary Swept Area across the entire MDZ could be up to 2,055,000 m^2[8]

4.3.2.5. Summary of Worst Case Foundation Parameters

97. A combination of GBS footprint and the use of catenary mooring is the worst-case scenario for seabed footprint of a mooring / foundation system. The worst-case scenario for seabed impact is based on the full 240 MW capacity being installed using 30 MW arrays of tidal devices, using

[8] Worst-case catenary footprint based on 240MW deployment achieved using 410 tidal devices of types which may use catenary moorings to maximise the potential seabed footprint as follows: 30 tidal devices each with catenary swept area of 9,500m2 each (large devices); 140 devices having swept area of 7,500m2 each (medium scale devices) floating devices; and 240 tidal devices having swept area of 3,000m2 each (small scale devices). All catenary footprint measured using CAD to calculate using maximum excursion criteria.

Thi

gravity-based foundation systems, with GBS anchor blocks used for floating and mid water devices.

98. The footprint associated with the alternative foundation method of pin-piling device foundations, plus the footprint of associated drill arisings produced by this method are less than the footprint of gravity base foundations. If such foundations are used, their potential seabed footprint impact is considered to be included within that of GBS foundations.

99. Where relevant, technical chapters (**Chapters 7** to **Chapter 26**) of this ES will identify which foundation type presents the worst-case scenario for each receptor. Any devices/arrays with foundation footprints or drill arisings that fall within the worst-case scenarios outlined in **Table 4-7** are considered to be within the PDE of this EIA.

Table 4-7 Worst Case Scenario based on Full 240 MW Deployment

Parameter	**Value**
Total GBS footprint	74,790 m^2
Catenary or anchor / mooring swept area	2,055,000 m^2
Drilled pile foundations	5,889 m^2
Drilled socket arisings	117,780 m^3

4.3.3. Superstructures and Floating or Surface Emergent Elements

100. The MDZ may incorporate floating or surface emergent structures, visible above the sea surface, such as:

- Floating or SESM tidal devices up to a maximum of 130 devices;
- Hubs (up to 93 floating hubs or up to eight seabed mounted surface emergent hubs);
- Environmental monitoring buoys (up to 5); and
- Communication and navigational buoys (up to 60 in total) (see **Section 4.3.6**).

101. In terms of maximum dimensions of tidal devices, some of the large rotor diameter floating devices could have lengths of up to 72 m, while other devices, whilst shorter (up to 22 m length), are also wider, with maximum widths of up to 30 m.

102. The supporting structure of tidal devices deployed in the MDZ will not emerge more than 18 m above the sea surface at LAT. Note that this will be restricted to the green hatched area shown in Figure 4-5. Surface emergent structures will continue to be a maximum of 6.5m above sea level at LAT elsewhere in the MDZ.

103. Electrical hubs may be within surface emergent piled structures which may extend up to 18 m above the sea surface at LAT. The electrical equipment would be housed within the pile.

104. Indicative array layouts used for assessment purposes are detailed further in **Section 4.3.4**. The following summary outlines the number and type of surface emergent devices which could be present across the MDZ and therefore within the PDE of this EIA, with reference to embedded mitigation contained in both Table 4-1 and **Figure 4-1 (Volume II)**:

- Deployment of visually prominent floating / surface emergent devices in the south of the

MDZ, to take account of potential for visual impacts. The potential for deployment of floating / surface emergent tidal devices, which are not visually prominent, in more northern parts of the MDZ will be kept under review on a case by case basis with regulators to allow for ongoing development of technology and innovation;

- As shown in the updated Figure 4-5, the worst-case height above sea level[9] for any tidal device in the Green Restricted Area will be 6.5 m; and
- The worst-case height above LAT for any SESM device in the Green Hatched Restricted Area will be 18 m; and
- The worst-case height above LAT is 18 m for up to eight surface-piercing hub structures.

4.3.4. Array Layout

4.3.4.1. General

105. The layout of the tidal devices and associated infrastructure (inter-array cables, hubs etc.), will be dependent on the tidal resources across the MDZ as well as the bathymetry and water depths, which the tidal devices require to operate. Therefore, final layout and configuration of visible and fully sub surface elements of the project cannot be predicted. However, based on current understanding of separation distances between certain devices, indicative project layouts can be anticipated and some examples, for illustration purposes only, have been provided (see **Section 4.3.4.4**).

106. Floating devices, which rely on catenary of anchor chains or tension of mooring cables to maintain position will have some movement during changes in tidal conditions, however, this is within the surface area defined by the extent of their anchors or foundations.

4.3.4.2. Device and Array Spacing

107. Array layouts will be identified post consent, following a berth selection and allocation process. Over the life of the Project, layouts will evolve at each new array deployment, or during repowering, when tidal devices within existing arrays may be replaced, or full arrays replaced with new arrays deployed at new locations. The shape of the array layout will depend on the physical requirements of the specific tidal devices deployed. The final detailed device locations will be developed based on further site investigation works conducted post-consent to determine detailed construction constraints. These details will be communicated to the Welsh Government and NRW pre-deployment via a process of site management connected to the discharge of consent conditions.

108. Seabed mounted devices may have a spacing of 50 to 100 m between centres of devices perpendicular to the flow and 100 to 250 m parallel to the flow. Such spacings may need to be modified to allow for seabed conditions, and this could alter spacings considerably, resulting in larger spacings.

109. The maximum case in terms of spacing would be floating tidal devices sharing moorings or those which are surface emergent. Such devices may require up to 200 m between structure centres perpendicular to the flow and 500 m parallel to the flow.

[9] Note that for a floating surface emergent tidal device, the device will rise and fall with the tide.

110. Each device could move by up to 80 m (±40 m) in the direction parallel to the flow and 60 m (±30 m) in the direction perpendicular to the flow.

4.3.4.3. Potential Array Surface Area

111. A potential maximum surface area taken up by arrays for the Project has been calculated. The maximum surface area includes the space occupied by tidal devices (including TEC, supporting structures and foundations or anchors), as well as separation spaces between tidal devices. In other words, the surface area of a tidal device or array of tidal devices is greater than the seabed footprint as it includes the full area occupied by the tidal device(s) plus appropriate separation spaces between tidal devices. Surface area values for potential arrays have been derived via Computer Aided Drawings (CAD) of layout parameters for a series of 30 MW arrays, combined to achieve a full 240 MW deployment scenario. This configuration of devices selected to represent a realistic worst-case scenario for surface area of full deployment is therefore based on the maximum potential area taken up by all arrays, including spaces between devices, and should not be confused with the swept areas of tidal device TECs discussed in **Table 4-3** Seabed Mounted Sub-Surface Device Parameters (Worst-Case Highlighted in Blue)**Table 4-4** Buoyant and Mid-Water Column Device Parameters (Worst-Case Highlighted in Blue), **Table 4-5** Floating / Surface Emergent Device Parameters (Worst-Case Highlighted in Blue), **Table 4-5a** Surface Emergent Seabed Mounted Device Parameters (Worst-Case Highlighted in Blue), and **Table 4-6** Worst Case Scenario based on Full 240 MW Deployment (Worst-Case Highlighted in Blue), or for seabed footprint as discussed in **Table 4-7** Worst Case Scenario based on Full 240 MW Deployment.

112. In order to identify a realistic worst case for potential surface area for a deployment to 240 MW, the surface area associated with 30 MW arrays of a range of tidal device technologies were compared via CAD. The surface areas of the eight arrays thus identified were then summed to derive a maximum potential surface area for a 240 MW deployment. The value derived in this manner is 12,459,500 m^2 (12.5 km^2) for a full 240 MW capacity project, shown in **Table 4-8**. Regarding the consideration of Magallanes and Orbital together in Table 4-5 but separately in Table 4-8, this is purely a presentational issue. In terms of the parameters presented in Table 4-5 and 4-8, the values are the same for both Magallanes and Orbital so both have been used. For further clarity, the entry in Table 4-5 should be better read as "Orbital Marine Power and/or Magallanes".

Table 4-8 Assumptions used for worst-case surface area

Array No.	Device Category	Device Type	Max. Surface Area
1	Fully submerged seabed mounted device	QED Naval	1,838,600 m^2
2		Nova	1,241,800 m^2
3	Buoyant mid water device	SME PLAT-O	2,159,800 m^2
4	Surface emergent device	Magallanes	1,155,100 m^2
5		Orbital	1,155,100 m2
6		Aquantis	1,773,200 m2
7		Instream	2,070,400 m2
8		Tocardo UFS	1,065,500 m2
TOTAL			**12,459,500 m^2**

113. **Table 4-9** outlines the likely worst-case spacing and device areas based on indicative layouts. These parameters are therefore within the PDE of this EIA.

Table 4-9 Worst-Case Spacing Parameters for Devices within the MDZ

Device Category	Spacing between tidal device centres		Maximum extent of surface movement	
	Perpendicular to flow	Parallel to flow	Perpendicular to flow	Parallel to flow
Fully submerged seabed mounted device	50 to 100 m	100 to 250 m	NA	NA
Surface emergent and buoyant mid water device	50 to 200 m	120 to 500 m	60 (±30 m)	80 (±40 m)
Surface Emergent Seabed Mounted (SESM)	50 to 200 m	120 to 500 m	NA	NA

4.3.4.4. Indicative Layout for Assessment

4.3.4.4.1. Indicative Layout for SLVIA and Shipping and Navigation

114. The worst-case parameters presented so far within this Chapter will be sufficient to inform the majority of the assessments undertaken during the EIA. For most receptors, deployment scenarios will remain within the levels of worst-case scenarios identified and no further definition is required.

115. However, for receptors such as shipping and navigation (**Chapter 15, Shipping and Navigation**), and Seascape and Landscape Visual Impact Assessment (SLVIA) (**Chapter 24, Seascape and Landscape Visual Impact Assessment**), the assessments undertaken require consideration of the location of arrays within the MDZ. For this purpose, an indicative layout, taking account of consultation with regulators and consultees has been derived. Although the layouts presented can only be indicative because the technology for deployment is not yet known, they are realistic in terms of the spacing of arrays and location within the tidal resource, and the requirements of regulators and consultees.

116. **Figure 4-2 (Volume II)** shows an indicative surface emergent only layout, taking into account the following considerations:

- Intention to manage the deployment of visually prominent devices as detailed in **Section 4.2.6** and summarised as:
  - Deployment of visually prominent devices focused on subzones 4 to 8;
  - Future deployment in subzones 1 to 3 under review on a case by case basis with regulators;
- Measures to manage shipping and navigation issues, summarised as:
  - Preference for the deployment of seabed mounted or buoyant mid water tidal devices in subzones 1 to 3, to maintain under keel clearance appropriate to vessels using those parts of the MDZ;
  - Maintenance of an area inshore of surface emergent arrays deployed in the MDZ of a minimum width of 1 km from shore and with a minimum UKC of 8 m;

117. The technologies used for illustration in the indicative array scenario assessed for SLVIA include up to 130 visually prominent surface emergent devices (note that this was for the original SLVIA and an addendum has now been produced with SESM devices taken into consideration) within subzones 4 to 8, as follows:

- 60 MW of large dual TEC tidal devices (30 devices);
- 30 MW of large spar buoy single TEC tidal devices (30 devices);
- 10 MW of multiple vertical axis TEC tidal devices (50 devices) and 30 MW of multiple TEC tidal devices (20 devices).

118. Under this indicative scenario, non-visually prominent surface emergent devices, seabed mounted devices or buoyant midwater devices would be deployed in other zones (1 to 3), subject to the requirements of other constraints, such as navigation.

4.3.4.4.2. Indicative Layout for Marine Mammals and Ornithology Assessments

119. In order to illustrate a potential full deployment to 240 MW and inform the assessment of potential impacts on seabirds and marine mammals (**Chapter 11, Marine Ornithology** and **Chapter 12, Marine Mammals**), the indicative surface emergent tidal device layout shown in **Figure 4-2** (**Volume II**) was used as the starting point for an indicative full deployment to 240 MW.

120. The indicative array of surface emergent outlined in **Figure 4-2** (**Volume II**), shows an indicative deployment of surface emergent tidal devices to 130 MW, with potential sub surface deployments not shown. **Figure 4-3** (**Volume II**) and **Figure 4-4** (**Volume II**) show the surface emergent indicative layout used to inform the SLVIA (**Figure 4-2, Volume II**) with the addition of a further 110 MW of non-surface emergent tidal devices, including seabed mounted and buoyant mid water devices. Two potential indicative layouts are shown, illustrated with the following technologies deployed in each:

- 35 MW of buoyant mid-water platform multiple TEC tidal devices (23 devices);
- 15 MW of small seabed mounted single TEC tidal devices (50 devices);
- 30 MW of seabed mounted multiple TEC tidal devices (25 devices); and
- 30 MW of large seabed mounted single TEC tidal devices (30 devices).

4.3.5. Offshore Electrical Infrastructure and Cabling

4.3.5.1. Export Cables

121. Up to nine export cables will be installed between the MDZ and the landfall. These subsea export cables are required to connect the tidal devices/arrays to the Landfall Substation, where the power is subsequently exported to the local distribution network via the Grid Connection Substation. The export cable corridor is shown in **Figure 1-1** (**Volume II**).

122. The size of the cables will be dependent on a number of factors. The required conductor size will be primarily determined by the necessary current carrying capacity which is influenced by transmission voltage, installation conditions (e.g. buried, in a duct etc), ambient temperature, phase spacing and arrangement, as well as the proximity of other cables.

123. Medium Voltage (MV) subsea power cables of the type used for offshore projects are generally built up with three single-cores (three phases), with a cross-section of between 50 to 500 mm^2, surrounded by filling material and covered by armouring, in addition to Low Voltage (LV) cables and multiple optical fibre elements for control and communications.

124. Cable armour is typically made of one layer of round 5 to 6 mm thick steel wire armour. Alternatively, flat strands may be used though these may not offer as much force protection. Where cable protection is a particular concern or where the integrity of the cable under pulling stresses is a concern, a second layer or more of armour may be added.

125. Burial will be difficult, or impossible, to achieve across much of the MDZ and the export cable corridor. An armoured cable will provide additional protection where suitable burial and protection cannot be achieved by other means or risk is perceived to be present. Due to the hard and rocky nature of the seabed, it is expected that the majority of the cables will be free laid with strategic protection (rock bags, concrete mattresses or split-pipe) at locations along the length. The main purpose of this cable protection will be to secure the cable to the seabed sufficiently to manage movement, without the need to protect all laid cable.

126. Armour will delay the onset of faults due to abrasion and less serious impacts, as well as increasing cable strength against pulling forces. This will improve cable survivability where it is exposed to mobile seabed material, currents and wave action, and, where it is potentially exposed (or part exposed) to bottom fishing activity. Armour will also assist with protection from anchor damage; however, heavy strikes will still likely result in failures.

127. The key parameters of the export cables are shown in **Table 4-10**. These parameters contribute to the total seabed footprint of the Project and the PDE for which consent is sought, as detailed in **Table 4-26 Worst-Case Parameters for Permanent Seabed Habitat Disturbance including Repowering**.

Table 4-10 Key Parameters of the Export Cables

Parameter	Value
Export cable diameter	Up to 120 mm
Cable diameter with split pipe cable protection	Up to 170 mm
Individual cable route lengths from each subzone	Between 1.2 and 6 km
Individual rock bags or concrete mattresses	Up to 270 (with a seabed footprint of up to 18 m^2 each) = 4,860 m^2
Total seabed footprint (nine cables plus cable protection systems and rock bags/mattresses)	11,745 m^2 [10]

[10] Export cable length: 40.5 km: Diameter of split pipe: 170 mm: Area (40,500 m x 0.17 m = 6,885 m^2 Number of rock bags: 120: Footprint area of rock bags: 18 m^2 (4.8 m diameter): Area of all rock bags 270 x 18 m2 = 4,860 m^2
Total seabed footprint export cable + protection (6,885+4,860) = 11,745 m^2

128. More detailed cable route investigations will be required pre-installation (post-consent) to identify exact routes to shore. These studies will take account of the following criteria:

- Minimum spacing requirements to avoid derating of the cables and to ease laying operations and subsequent access;
- Avoiding key ecological (reef) features to minimise impacts on the seabed ecology and reduce physical risks to the export cable, in particular:
  - Avoid or minimise crossing of slopes beyond 10° which pose risks of cable movement and damage when surface laid
  - Avoid crossing scarps, ridges, scour lines or other areas where there are rapid variations in bathymetry which could lead to damage of the cables if laid across such a feature
  - Using appropriate cable protection to avoid cable moving around on the seabed; and
- Following a direction which runs parallel to the flood and ebb tidal current flows to maximise lateral stability of the cable on the seafloor.

129. Seabed morphology data collected via a project-specific geophysical survey during summer 2018 (Partrac, 2018) identified a significant sandwave feature, an estimated 27,258 m^2, located in the northern half of the MDZ and export cable corridor. Cables will be installed over this feature, potentially with jet trenching, and an as-laid survey will be undertaken to identify any areas where the cable is in suspension, followed by targeted remedial work at that time. If remedial work is required, the sand wave could be reduced using a mass flow excavator or dredger.

130. There is limited sediment in the nearshore sections within 'Abraham's Bosom' where burial may be feasible via jet trenching. Feasibility will be confirmed by pre-installation geotechnical site investigations informing detailed design, however, sediment depth is limited and surface laying of cable, with cable protection is expected.

4.3.5.2. Inter-Array Cables

131. Inter-array cables will be laid between tidal devices; an electrical hub may be used or multiple devices may be connected in a 'daisy-chain' format. Tenants would be expected to install their own inter-array cabling where more than one device is being deployed within a subzone, and to connect their project to the export cable at its termination point.

132. The total length of inter-array cabling would be dependent on the array layout within each of the berths, dictated by geotechnical and bathymetric considerations (among others). The final length and layout of inter-array cabling will be determined by tenants prior to installation of their respective devices. The maximum inter-array cable length for the site is based on the maximum number of berths (eight). As per the export cables, for certain parts of the site, additional cable protection may be required to secure the cable to seabed at strategic points and prevent movement.

133. The key parameters of the array cables are shown in **Table 4-11**. These parameters are therefore within the PDE of this EIA.

Table 4-11 Key Parameters of the Array Cables

Parameter	Value
Number of individual cables (full 240 MW capacity)	Up to 740
Cable length	Up to 2.5 km per cable (majority will be less than 1 km)
Total length of array cables	Up to 204.5 km
Total seabed footprint (up to 204.5 km of array cables plus protection, plus rock bags on max 100m intervals)	30,040 m^2.

4.3.5.3. Offshore Cable Tails

134. Up to nine export cables connecting the landfall substation to the offshore arrays will be installed. These may be installed as follows:

- As a continuous export cable from landfall substation; or
- As a cable tail installed from the landfall substation each up to 620 m long to a location several hundred metres offshore. Each 'tail' would be terminated in the near shore of the export cable corridor, shortly after the 'break out' of planned HDD. As arrays are deployed, they would then connect through an export cable to the cable tail via a junction box or joint.

135. If HDD is not feasible, the proposed alternative method is to trench across the foreshore region. An excavator will create up to nine separate shallow trenches between 480 m to 740 m long (or installed within a single trench if possible) between the landfall and the transition pits, including the intertidal. If trenching is not possible, then cables will be surface laid and secured using concrete mattress and or rock bags. Quantities of rock bags or concrete mattresses for the export cable route, including the intertidal area, are included in Table 4-10. It is anticipated that at least double armoured cables of up to 300 mm² cross section may be used; resulting in a diameter of 120 mm.

4.3.5.4. Hubs

136. Hubs would typically connect and aggregate power from a number of individual devices. Hubs may be 'passive', with a busbar joining multiple tidal devices together; or 'active', containing a transformer, switchgear and possible control equipment (convertors).

137. Seabed mounted hubs are likely to be largely cylindrical structures, between 2 and 6 m in diameter, up to 10 m long. They may also have 'external' sealed transformers that would fit into a similar footprint. Height of the structure off the seabed is likely to be approximately 5 to 8 m. Keel clearance will depend on the water depth and the type of hub, with a minimum of 20 m UKC at all locations with seabed mounted hubs.

138. Some hubs may be on a surface emergent structure; a small jacket or monopile structure (2 to 6 m diameter monopile, up to 18 m above the sea surface at LAT). The electrical equipment will be within a larger diameter pile.

139. It is estimated up to 120 separate electrical hubs may be required to aggregate output from multiple devices. The following scenarios are anticipated:

- Up to 120 seabed mounted hubs, fully submerged; or
- Up to 93 floating surface emergent hubs; or
- Up to eight seabed mounted, surface emergent hubs.

4.3.5.5. Summary of Cabling Offshore and Electrical Infrastructure Parameters

140. The worst-case scenario for the cabling and electrical infrastructure to be used in the impact assessment, is presented in **Table 4-12**.

Table 4-12 Worst-case Scenario for Cabling and Electrical Infrastructure

Parameter	**Value**
Export Cables	
Number of export cables (including cable tails, if required)	9
Total length of export cables	40.5 km
Maximum length of individual export cables	6 km
Minimum length of individual export cables	1.2 km
Footprint of export cables and split-pipe protection	6,885 m^2 (4,860 m^2 cable + 2,205 m^2 split-pipe protection)
Footprint of additional cable protection (rock bags)	4,860 m^2
Footprint of export cables, split-pipe protection and rock bags	**11,745 m^2**
Inter-Array Cables	
Number of inter-array cables	740
Total length of inter-array cables	204.5 km
Maximum length of individual array cable	2.5 km
Footprint of inter-array cables, split-pipe protection and rock bags	**30,040 m^2**

4.3.6. Navigation and Monitoring Equipment

141. The MDZ will be marked by navigation buoys. The exact location, number and nature of the marking and navigation buoys will be determined through consultation with Trinity House (TH), the Maritime and Coastguard Agency (MCA) and navigation stakeholders. Buoys will be provided in accordance with International Association of Lighthouse Authorities (IALA) standards.

142. As a minimum, the northerly, easterly, southerly and westerly boundaries of the MDZ will need to be marked with the appropriate IALA cardinal mark. There may be additional cardinal markers or special marker buoys required, particularly along the northern and southern boundaries of each array. The exact requirements for marking will be confirmed by appropriate regulators and applied via consent condition and their discharge.

143. Cardinal buoys will be required to have flashing white lights with a visibility of not less than 5 nautical miles (nm). Special marker buoys to have flashing yellow lights with a visibility of not less than 5 nm. Buoys may also be required to have automatic acoustic signals that are triggered in low visibility.

144. Substantial yellow colouring is the worst-case in terms of the appearance of any surface-emergent elements of the PDE, in compliance with IALA guideline O-139 Section 2.4.1 2F. Tidal devices will be lit at night in conformance with guidance from TH and IALA. Fully submerged devices and electrical hubs may have a marker buoy to assist with access, communications and retrieval.

145. There may be a requirement for some floating and seabed mounted environmental monitoring platforms or monitoring buoys to be deployed throughout the MDZ. Seabed mounted platforms may require special marker buoys at surface.

146. A number of Acoustic Doppler Current Profilers (ADCPs) will also be deployed across the site to measure current flow speeds and directions. Each ADCP is expected to be a seabed mounted unit, deployed in a stainless-steel seabed frame and may also be buoyed.

147. The layout options considered may include combinations of surface emergent and fully submerged devices. As such appropriate consideration will be required to ensure that the method and type of marking are appropriate for the device type and infrastructure.

148. The key parameters of the navigation and monitoring equipment are shown in **Table 4-13.** These parameters are the PDE for which consent is sought as detailed in **Table 4-25** Hubs and buoys, navigation and monitoring equipment worst case parameters.

Table 4-13 Worst-case Scenario for Navigation and Monitoring Equipment

Parameter	Value
Number of IALA cardinal marks	Four
Dimensions of IALA cardinal marks	Up to 3 m, with a focal plane height (position of light) of 6 m
Number of buoys (including IALA Cardinal marks) and special marker buoys, marking location and extent of arrays, groupings of tidal devices within arrays and other equipment as required.	60
Dimensions of navigation and other marker buoys	Up to 3 m, with a focal plane height (position of light) of 6 m
Number of environmental monitoring buoys and platforms in addition to navigation and marker buoys	Five
Dimensions of environmental monitoring platforms	Up to 3.6 m above sea level
Number of ADCPs	Up to 40
Diameter of ADCP	Approximately 1.5 m
Footprint of individual ADCP (and total across MDZ)	7 m^2 (378m^2)
Seabed footprint of anchors	Concrete weight up to 2 m in diameter, with a chain catenary in contact with the seabed of up to 30 m
Visibility of fully emergent/floating devices	Coloured yellow above water and with navigation lights

4.4 ONSHORE INFRASTRUCTURE

149. The boundary for the ODA is provided in **Figure 1-2** (**Volume II**). The Landfall Substation is within land currently farmed by Ty-Mawr farm, in the area of Holy Island known as Penrhos

Feilw. From the Landfall Substation location, the majority of the onshore cable route follows the minor road network to towards the A55 and Holyhead to Bangor rail line.

150. The cable will be routed via trenching to the Switchgear Building and be subsequently routed via trenching, with a trenchless crossing under the A55 and rail line, to the Grid Connection Substation.

151. The key components of the onshore works associated with the Project are detailed in this Section, in the following order:

- Cable landfall;
- Landfall Substation;
- Onshore cable corridor;
- Switchgear Building; and
- Grid Connection Substation.

4.4.1. Cable Landfall

152. Landfall will be located within the bay on the western coast of Holy Island known as Abraham's Bosom. There are two main methods which could be used for cable installation at landfall:

- HDD; or
- Open cut trenching.

153. HDD is the preferred method to achieve landfall. If HDD is not feasible, the proposed alternative method is to trench across the foreshore region. An excavator will create up to nine separate shallow trenches between 480 m to 740 m long (or installed within a single trench if possible) between landfall and transition pits. This will be followed by installation and pinning of ducting and/or subsea cable within the trench across the cliff top and fore shore, with a split-pipe used to carry cabling down the cliff face. If trenching is not possible in the foreshore, then cables will be surface laid and secured using concrete mattress and or rock bags. Quantities of rock bags or concrete mattresses for the export cable route, including the intertidal area, are included in **Table 4-10**.

4.4.1.1. HDD Compound and Transition Pits

154. As noted earlier, HDD is the preferred method of cable installation. The proposed route to the HDD exit point measures approximately 0.55 km in length, from Abrahams Bosom in the north, passing under South Stack Road, beneath a campsite and into Ty-Mawr farm field. The route and other works will be accessed by a temporary track.

155. The transition pit and HDD drilling rig compound will be located in Ty-Mawr farm field, immediately south-west of the existing farm buildings. There will be one transition pit, up to 15 m x 85 m x 1.5 m deep, equating to a footprint of 1,275 m^2, excavated volume 1,912.5 m^3 in addition to trenching excavation or HDD cutting volumes. All transition pits will be buried upon completion of the works and covered by a depth of approximately 200 mm topsoil (recovered from excavated materials) and seeded with grass mix. The final volume is subject to confirmation of geology and drill geometry.

156. Material excavated will be re-used on site if possible. If it cannot be re-used it will be removed from site for appropriate re-use elsewhere.

157. Within the transition pit, each of the nine submarine cables may be jointed and transitioned to 9 sets of separate onshore cables. Each of the 9 sets of onshore cables will then require between 2 and 8 ducts depending on the specific requirements of the tidal energy devices. The maximum case of 8 ducts comprise, 3 x HV, 1 x fibre optic, 1 x LV and a spare, 1 x Extra Low Voltage and a spare. The minimum case of 2 comprise a single, multi-core HV cable and a fibre optic. This gives a maximum case of 72 ducts and a minimum case of 18 ducts.

158. The cable route from transition pit to the Landfall Substation may be up to 0.4 km in length and will be trenched. Up to nine draw pits may be required within that route to allow for changes in direction of the trench. Each draw pit will be approximately 2 m x 2 m x 1.5 m deep, subject to final detailed design.

159. A precast concrete box culvert will be installed beneath the Ty-Mawr Access Road to allow the onshore cable ducts to pass through to the Landfall Substation whilst minimising disruption to the existing access.

160. Within the HDD compound, plant (i.e. generator, drilling rig) will be present to support HDD operations. The HDD compound will be bounded by a 3.5 m high acoustic demountable fence located around the equipment and a 2 m high solid hoarding fence built around the compound boundary.

4.4.1.2. Landfall Trench/Surface Laying Option

161. As discussed above, should HDD not be feasible, an alternative approach would be open cut trenching. This would involve cutting shallow trenches across the beach and pinning and/or ducting the subsea cable, within a split-pipe to the cliff face. Should trenching not be possible, then cables will be surface laid, with cables crossing the intertidal area requiring protection using rock bags or concrete mattresses. From the cliff top, cables will be buried in trenches that cross the fields and South Stack Road to the transition pits and onwards to the landfall substation.

162. Up to nine shallow trenches (slots within the cliff face) would be created using a rock cutter and then the cables would be ‘surface laid’ over the cliff using a split pipe or J-tube. A J-tube type solution is essentially very similar to the split pipe, or duct approach. In this way, cable ducts will be fixed to the cliff face. The J tubes would extend above the top of the cliffs and then the cables would emerge before being buried across the fields to the transition pits. As much as possible the pipes would be marshalled to a common location and brought down the cliff in as small an area as possible. Up to 500 mm separation between J-tube centres is proposed. The total width of grouped J-tubes would be up to 30 m.

163. Depending on the geology of the foreshore, an individual trench width up to 600 mm, or a single trench with all nine cables laid within it of up to 10 m width and 0.5 to 1.2 m deep will be constructed using open cut trenching. Alternatively, split pipes could also be used in the foreshore region, and the cables surface laid and protected, should trenching not be feasible.

164. A temporary working corridor width of 30 m is assumed for the foreshore and cliff works.

4.4.1.3. Temporary Works

165. It is expected that up to one temporary access track to the transition pit or to a temporary construction compound will be required during the construction phase.

166. To create the temporary works areas and access track, it is anticipated that 0.15 m of topsoil will be stripped back, stockpiled and protected during storage whilst the construction works progress. This will be reinstated, so there will be no waste topsoil arising from this activity. It has been assumed that 0.3 m of hardstanding (permeable gravel aggregate underlain by geotextile) will be placed over each area during construction. A layer of tarmac may also be placed over the temporary works areas that will use/store heavy machinery/equipment. Any surface vegetation removed as part of excavation works will be separately stockpiled and sent for recovery at a composting or an anaerobic digestion facility.

4.4.1.4. Summary of Landfall Installation Parameters

167. The requirements for installation of the landfall by HDD and trenching are presented in **Table 4-14.**

Table 4-14 Construction Parameters for Installation of the Landfall by HDD and Trenching Methods

HDD Installation (preferred)	Trenching (worst-case)
Up to nine cable tails.	Up to nine cable tails.
Up to nine separate drills; each up to 550 m long, nominally 450 mm diameter.	Up to nine separate shallow trenches (slots within the cliff face).
Separation of 10 m between HDD entry points.	Trenches between 480 m and 740 m long from transition pit to intertidal.
Separation of 20 m between HDD exit points.	Individual trench widths of up to 600 mm. Or a single trench with all nine cables laid within it of approximately 10 m width and 0.5 to 1.2 m deep.
Total drill cuttings volume could be up to 900 m^3 (total amount for all nine drills).	Duct or split pipe over 370 to 550 m of each cable, up to 350 mm external diameter.
Trenching works from transition pit to Landfall Substation.	Up to 500 mm separation between J-tube centres.
Transition pit up to 15 m x 85 m x 1.5 m deep, equating to a footprint of 1,275 m^2, excavated volume 1,912.5 m^3.	Total width of grouped J-tubes would be up to 30 m.
Up to 9 draw pits of 2 m x 2 m x 1.5 m deep equating to a footprint of 36 m^2, excavated volume 54 m^3.	Total material removed from site could be approximately 8,880 m^3 [11]; with the majority of material replaced to backfill the trench after the ducts / cables were installed. Worst case assumption all material removed in onshore or offshore dependent on receptor.

[11] Based on calculation of trenches of 740 m length, 10 m width and 1.2 m depth.

HDD Installation (preferred)	Trenching (worst-case)
HDD compound will be bounded by a 3.5 m high acoustic demountable fence located around the equipment and a 2 m high solid hoarding fence.	Cables crossing the intertidal area may also require protection using rock bags or concrete mattresses or equivalent methods.
Temporary works area up to 120 m by 70 m (total area for HDD rig, site office and equipment plus laydown area).	Temporary works area up to 100 m by 50 m (for site office and equipment plus laydown area). A temporary working corridor width of 30 m.
From transition pit to Landfall Substation, each of the 9 onshore cables will require between 2 and 8 ducts depending on the specific requirements of the tidal energy devices. The maximum case of 8 ducts comprise, 3 x HV, 1 x fibre optic, 1 x LV and a spare, 1 x Extra Low Voltage and a spare. The minimum case of 2 comprise a single, multi-core HV cable and a fibre optic. This gives a maximum case of 72 ducts and a minimum case of 18 ducts.	From transition pit to Landfall Substation, each of the 9 onshore cables will require between 2 and 8 ducts depending on the specific requirements of the tidal energy devices. The maximum case of 8 ducts comprise, 3 x HV, 1 x fibre optic, 1 x LV and a spare, 1 x Extra Low Voltage and a spare. The minimum case of 2 comprise a single, multi-core HV cable and a fibre optic. This gives a maximum case of 72 ducts and a minimum case of 18 ducts.

168. There are currently two HDD scenarios to installing the export and onshore cables that may be possible:

- **Scenario 1:** HDD boreholes, onshore cable ducts and infrastructure are installed and subsequently pull through export and onshore cables. This work would take place during the construction phase.
- **Scenario 2:** HDD boreholes, onshore cable ducts and infrastructure are installed during the construction phase. Each developer will pull through their export and onshore cables and therefore these operations will be staggered during the service life of the facility.

169. Scenario 1 represents the worst-case scenario for cumulative noise, visual and disturbance impacts and therefore is assessed as such within the relevant ES chapters.

4.4.2. Landfall Substation

170. The landfall substation will house the connection between the offshore export cables and the onshore cable to the grid connection substation. The landfall substation will be positioned within a single field adjacent to South Stack Road to the west of Tŷ-Mawr Farm. It will comprise three separate buildings of differing footprints, all up to approximately 7 m high. There would also be a separate transformer compound and external working areas and parking. The layout also comprises a facility for electric vehicle charging.

171. The site comprises a fenced compound approximately 80 m by 80 m and contains three buildings: the first 62 m by 22.5 m by 7 m high (or equivalent area); second to 28 m by 10 m by 7 m high (or equivalent area) and the third to 8 m by 8 m by 7 m high. The third building is within a substation compound to 28 m by 36 m by 7 m high (or equivalent area). The estimated total footprint of the landfall substation compound is 6,400 m^2.

172. An indicative site layout for the Landfall Substation is provided in **Plate 4-7**, which may be subject to further refinement.

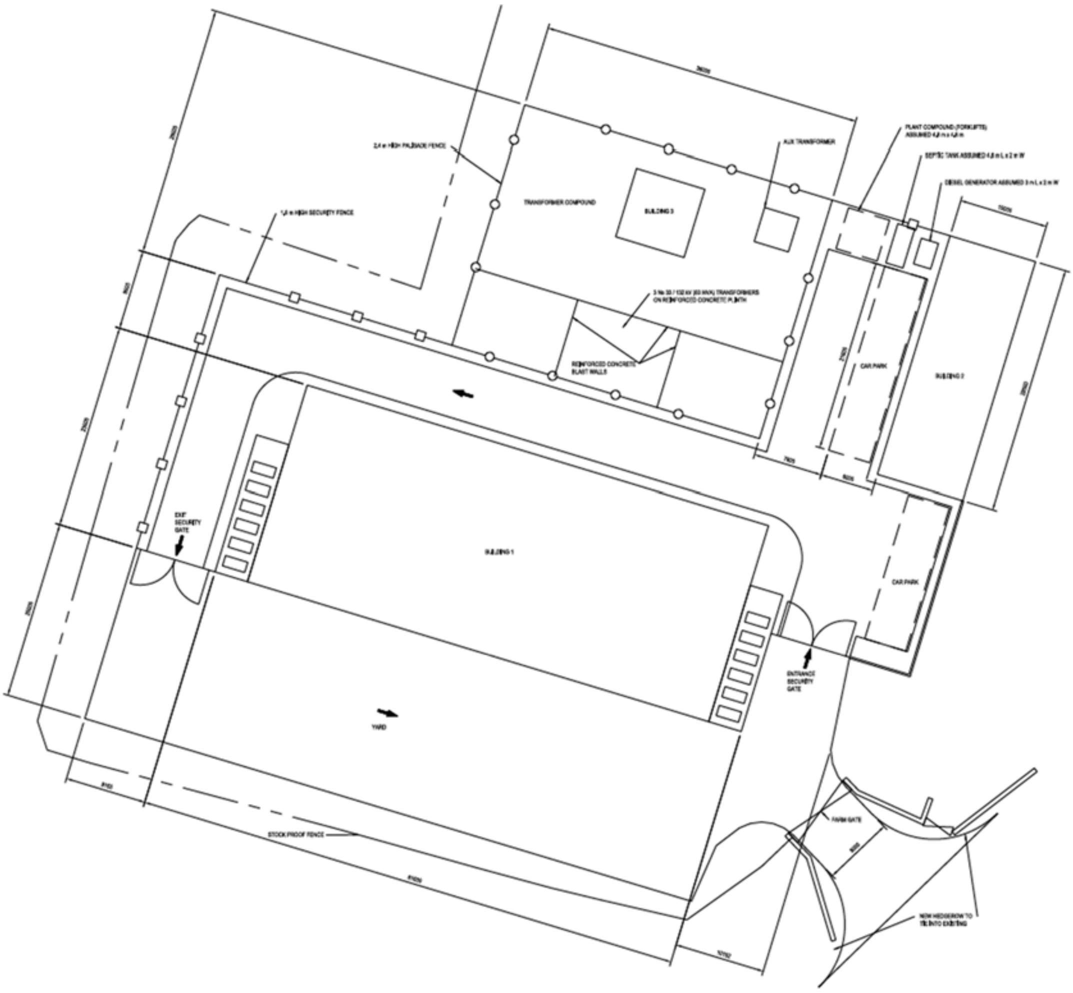


Plate 4-7 Indicative Site Layout – Landfall Substation

173. The main building will contain up to nine electrical plant rooms for developers to contain step-up transformers. The building will also support external (within a dedicated enclosure) Cooling/Ventilation systems. The buildings will be of a mainly steel portal frame construction with a pitched roof. The walls will be clad in preformed steel and, if necessary, timber batons. The walls of the flanking cooler compounds will be clad with ventilation louvres.

174. The landfall substation is positioned within a recessive location in the landscape, within a valley, and uses the landform to help integrate the substation into the landscape. The landfall substation will be cut into the valley side rather than building a platform out from the valley slope. There will be a retaining structure (to reduce the amount of cut) along the western and northern edges of this landfall substation site, assumed to be constructed of stone filled gabions, possibly combined with underlying rock. Approximately 13,900 m^3 will be cut in to the landscape and a fill of approximately 130 m^3.

175. There will be a temporary construction compound and laydown area with a footprint of 50 m by 100 m, or the equivalent area, located to the south west of the landfall substation.

176. Permanent access is proposed to the landfall substation location during construction and operation.

4.4.3. Onshore Cable Corridor

4.4.3.1. Onshore Corridor Overview

177. The onshore cable route will feature up to two 132 kV cable circuits. Each circuit would consist of three power cables plus a fibre optic cable. This results in up to six power cables and two fibre optic cables in total, each of up to 110 mm diameter cable for each circuit (up to six in total).

178. The onshore cable route will be of up to 8.1 km total route length, dependent on final detailed route design, with the cables trenched into the local road network so much as is practicable, given constraints in road width and services already within the road. It is assumed, based on Design Manual for Roads and Bridges (Highways Agency, 2019), that the profile of the trench comprises 0.3 m porous asphalt, 0.3 m base course and the remaining 1.1 m is road base. However, it is acknowledged that some more rural roads are less likely to have as comprehensive a make-up.

179. There are two trench types as shown in **Table 4-15**, one from the Landfall Substation to Switchgear Building and one from the Switchgear Building to the Grid Connection Substation.

Table 4-15 Cable Route Trench Parameters

Cable route parameter	Landfall Substation to Switchgear Building	Switchgear Building to Grid Connection Substation
Circuit	132 kV	33 kV
Trench depth	1620 mm	1620 mm
Trench width	1400 mm	2000 mm
Length	6675 m	1420 m
Joint bays (No.)	18	2
Joint bay chamber depth	1.65 m	1.65 m
Joint bay chamber width	2 m	3 m
Joint bay chamber length	12.5 m	5 m
Draw pits (to be fully reinstated following works) (No.)	35	7
Draw pit depth	1.65 m	1.65 m
Draw pit width	3 m	5 m
Draw pit length	8 m	8 m

180. Where road width is insufficient, the road verge and adjacent field areas may be utilised, within a maximum work corridor width of 30 m.

181. Approximately 20 m x 7 m of hardstanding will be required around each joint bay to provide enough space for the cable pulling works. This area may require use of field areas adjacent to the road.

182. A length of cable installation by HDD will be required to cross the railway line and A55 at the Grid End location. The transition pits will be located either side of the A55 and railway line and in line with the proposed Grid Connection Substation. The two transition pits (exit and entry pits) will be 80 m x 15 m x 1.5 m deep. The final location will be determined within detailed design.

4.4.4. Switchgear Building

183. The infrastructure at Parc Cybi will consist of a 33 kV switchboard room and metering room. The existing road will be used to access this location, during both construction and operation of the switch. The Switchgear Building would comprise a single building up to 9.4 m x 5 m, with a maximum height of 4 m. It would be positioned to the north east of the existing substation within the Parc Cybi employment site (as described in Isle of Anglesey Local Development Plan, 2017), separated from this existing infrastructure by part of the internal road layout. The footprint of the Switchgear Building is 38 m^2, with a temporary construction compound of up to 30 m x 20 m. An indicative site layout for the Switchgear Building is provided in **Plate 4-8**, which may be subject to further refinement.

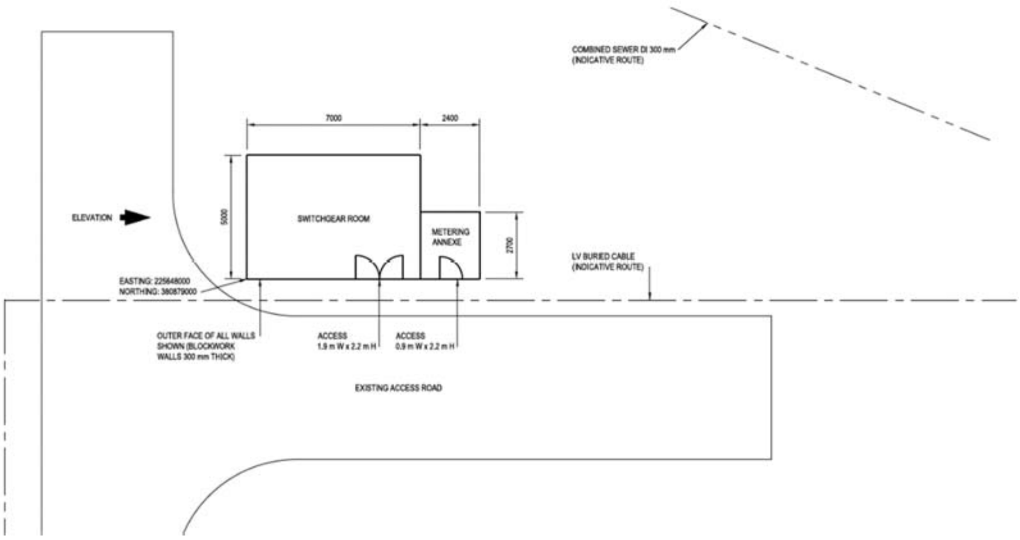


Plate 4-8 Indicative Site Layout – Switchgear Building

4.4.5. Grid Connection Substation

184. A substation will be required to achieve connection at the grid connection point. The Grid Connection Substation will be located within the land that forms part of the former Anglesey Aluminium works to the north east of Holy Island, south east of Holyhead, now known as Orthios. Connection to existing electricity network will be through existing infrastructure.

185. The existing road to the Orthios site will be used to access this location, during both construction and operation.

186. The Grid Connection Substation will contain up to seven energy storage systems each with two sets of inverters, HVAC units and transformers. There will be up to three substation buildings, (two 132 kV substations and one 33 kV) and one static synchronous compensator (STATCOM) building. The compound will also contain external air-cooled reactors and cooling units.

187. The Grid Connection Substation will have an overall footprint of up to 104 m x 62 m. It would contain external plant and equipment, together with four buildings. The maximum height of the proposed structures within the Grid Connection Substation will be 9 m. An indicative site layout for the Grid Connection Substation is provided in **Plate 4-9**, which may be subject to further refinement. An indicative location for the Grid Connection Substation is shown in **Figure 1-2**

(**Volume II**) and throughout supporting figures to the technical chapters. However, note that this is indicatively only and will be refined upon detailed design.

188. A temporary construction compound and laydown area will also be created, up to 50 m x 100 m, or equivalent area.

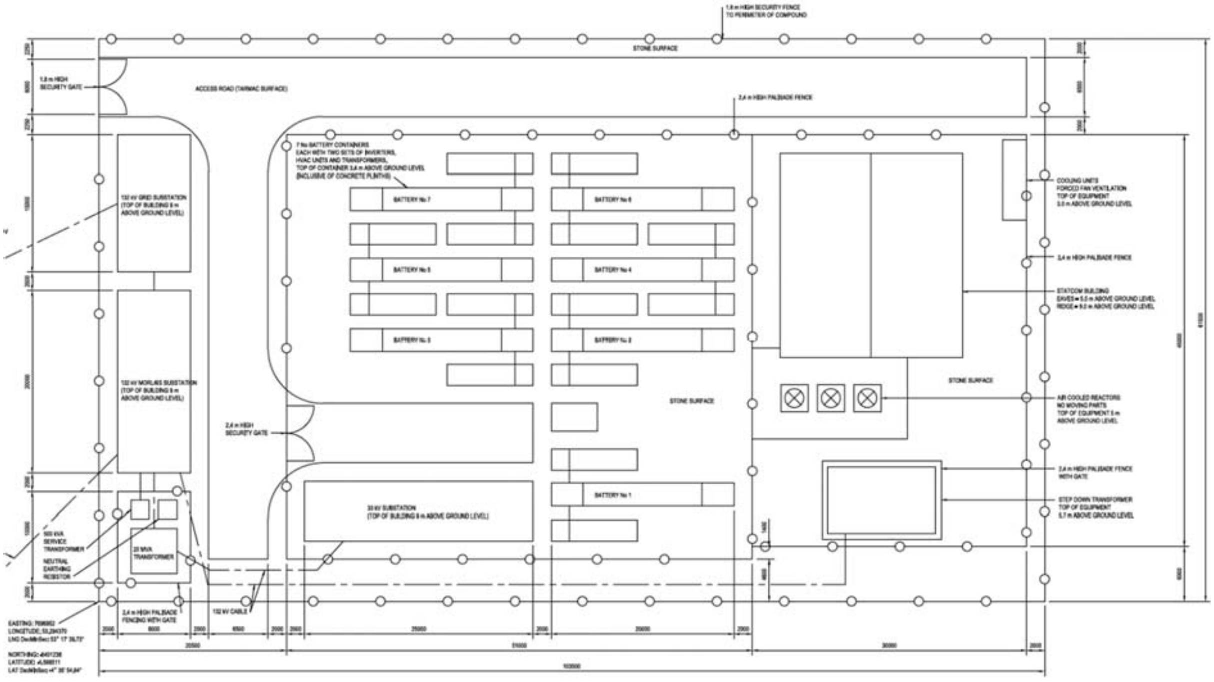


Plate 4-9 Indicative Site Layout – Grid Connection Substation

4.4.6. General Building Parameters

189. The parameters bulleted below are relevant to the infrastructure within the ODA, including the Landfall Substation, Switchgear Building and Grid Connection Substation:

- Appearance of the buildings;
- Lighting;
- Screening structures;
- Access;
- Foundations;
- Building materials; and
- Drainage.

4.4.6.1. Appearance

190. The preferred appearance of the Landfall Substation is for agricultural (shed-like) buildings (which will house indoor equipment), which will allow at least partial mitigation of noise and visual impacts of outdoor equipment. The buildings will be steel portal frame structures with pitched roofs and can be clad in timber or a profiled metal cladding. Differently, the Grid Connection Substation and Switchgear Building are located within the context of buildings that are comparable in form and function. It is anticipated that the proposed the buildings would be

constructed using materials that are similar to those located in the immediate surroundings i.e. within the Orthios and Parc Cybi sites.

191. The buildings may feature low level ventilation louvers to bring in cooler outdoor air, and high-level exhaust cowls with ducted axial fans. These ventilation features would be visible from outside the building.

192. Distinct cooler compounds are to be steel structures with ventilation louver cladding to bring in cooler outdoor air. The cooler compounds are anticipated to abut with the buildings and will be visible from outside the building.

193. The perimeter will be protected by a weld steel fence. The design of the fence shall be such that it blends in with the local environment as far as possible. The perimeter fencing would be a minimum of 1.8 m tall.

194. Outdoor equipment may be placed outside in the external compound at the Landfall Substation and the Grid Connection Substation. Reinforced concrete blast walls will provide a protective barrier between adjacent transformers and enclosure whilst palisade fencing can be installed around the perimeter of the external compound to provide security. The palisade fencing will be installed hidden from view within the substation perimeter fence. The palisade fencing would be at minimum 2.4 m tall.

4.4.6.2. Lighting

195. A minimum of 110 lux (lx) directed lighting will be required around the entry to the Landfall Substation and Grid Connection Substation, which will be turned on when needed, and may be equipped with motion sensors. Adequate lighting will be provided for any outdoor electrical plant areas in the form of compound floodlighting to facilitate any inspection or maintenance of electrical equipment at night. This would normally provide 10 lx along access paths and around major items of electrical plant. This may require columns to fix lighting to although electrical clearances will be followed to eliminate the possibility of a column falling across electrical equipment.

4.4.6.3. Access

196. Access and egress to each site will be on a 24 hour and seven days per week basis. It is anticipated that access will be via secure key pad and automatic gate.

197. Specific areas of the road network may need works to assist with turning radius or weight distribution for transport of low loader vehicles.

4.4.6.4. Foundations

198. Each item of outdoor and indoor electrical and non-electrical equipment will have a concrete slab foundation. Strip and pad foundations will be utilised if possible.

199. It may be necessary to utilise a piled foundation solution, using pre-cast concrete piles or similar, if warranted, depending on the underlying geological conditions (to be determined by the civils contractor) and the outcome of post-consent, pre-construction archaeological evaluations. The

transformer foundations will be bunded to contain any risk of oil leakage from the transformer or any other oil-filled plant.

4.4.6.5. Building Materials

200. The interior of the Landfall Substation building, an agricultural shed type structure, will have fire barrier walls made of dry wall cladding. The main transformer room for the agricultural shed will have firewalls constructed out of concrete or concrete blocks. Other rooms may similarly utilise blockwork construction including the switchgear, battery and auxiliary power rooms.

201. It is anticipated that the proposed Grid Connection Substation and Switchgear Building would be constructed using materials that are similar to those located in the immediate surroundings i.e. within the Orthios and Parc Cybi sites.

4.4.6.6. Surfaces

202. Hard standing will be in the form of hard core or tarmac surfaces on the access roads within the Landfall Substation and the Grid Connection Substation. This pertains to the 5 m to 7 m wide perimeter access road, additional access areas around transformers and reactors, building entrances, and the main substation entrance and car park.

203. Footpaths or pavement in and out of the grid connection substation building and areas commonly accessed may be of poured concrete instead of hard core or tarmac.

204. Outdoor areas within the Landfall Substation and Grid Connection Substation compounds will have a layer of crushed rock or gravel approximately 80 mm to 150 mm thick. This will be everywhere inside of the substations' perimeters with the exception of the access roads, protruding equipment foundations, and buildings.

4.4.6.7. Drainage Systems

205. Generally, the aim will be to discharge surface water runoff as high up the following hierarchy of drainage options as reasonably practicable:

- Priority Level 1: Surface water runoff is collected for use;
- Priority Level 2: Surface water runoff is infiltrated to ground;
- Priority Level 3: Surface water runoff is discharged to a surface water body;
- Priority Level 4: Surface water runoff is discharged to a surface water sewer, highway drain or another drainage system; or
- Priority Level 5: Surface water runoff is discharged to a combined sewer.

206. Guidance indicates that Priority Level 1 is the preferred (highest priority) and 4 and 5 should only be used in exceptional circumstances.

207. A Surface Water Drainage Strategy will be developed according to the principles of the Sustainable Drainage Systems (SuDS) hierarchy and in line with S1 Surface water runoff destination, as set out in the Statutory Standards for sustainable drainage systems.

208. The foul drainage system is to take wastewater from personnel areas and connect into a local septic tank with an overflow into a local infiltration trench. The surface water system collects run off from buildings and roads run through oil interceptors and discharged using bund pumps, so all contaminants are removed from the water. The drainage system will be designed to handle the worst-case water situation and with consideration of flood risk. The surface water may connect into a sewer system, discharge into a local watercourse if possible, septic tank, or be discharged into a soakaway system constructed nearby.

209. An oil interceptor may be required to be installed to protect the surface water system from pollution. Such an interceptor capacity should be adequate to the area intercepted by the substation surface water drainage system.

4.5 CONSTRUCTION METHODOLOGY

4.5.1. Offshore

4.5.1.1. Device Installation

210. Due to the wide range of possible device types that may be installed within the MDZ, it is not possible to specify the exact installation methodology that will be adopted. The consultation process with potential developers has been used to inform the likely foundation and device installation methods that may be used at the site.

211. A number of installation methods could be adopted, including those below:

- Installation of foundations and support structures, then lower, ballast or pull the TEC(s) down onto the foundation;
- Installation of foundation, support structures and TEC as a complete unit from a heavy lift (dynamic positioning or moored barge) or bespoke vessel;
- Installation of foundation, support structures and TEC as a complete unit towed to site and then ballasted into position (seabed or mid water column or surface emergent seabed mounted); and
- Floating and mid water buoyant systems will be towed to site and while on the surface attached to pre-installed anchors and mooring lines / cables. Mid water buoyant devices will then be winched below the surface via mooring / anchor lines.

212. Drilled socket pile foundations would mainly be installed by a moored barge or Dynamic Positioning (DP) vessel with sufficient cranage (250 t to 400 t). Monopile and pin-piles will be installed through remote drilling using a subsea rig controlled from a DP vessel (up to three days per large pile socket drilled, or 1.5 days for pin-piles).

213. TECs and supporting structures would then be installed separately using a DP vessel (potentially the same as for the foundation installation) or a multicat vessel.

214. A moored barge may be suitable for some installations. Such a barge would be approximately 100 m x 30 m and have four to eight 100 tonne gravity blocks (5 m by 5 m) or drag anchors (3 m x 5 m) with some anchor chain catenary, estimated at 400 m to 500 m length on seabed and 1 m diameter. A typical mooring spread would consist of moorings on a ‘radius’ from the vessel

centre of between 500 m and 800 m. Overall 'footprint' of mooring spread would be a

rectangle of approximately 500 m to 1,400 m x 850 m to 1,600 m. This type of vessel will require one or two small support vessels (30 m x 22 m) to assist with positioning and anchor deployment.

215. A DP vessel would be of a similar size to the barge (155 m x 30 m) but would not disturb the seabed and may not require any tugs.

4.5.1.2. Cable Installation

216. After HDD drilling, diver operations will be required to fit a seal/cap to the offshore end of each of the ducts. This would be carried out by a small dive support vessel/multicat and will take approximately five days to complete.

217. Before export cable laying, diver operations will again be required to open the ducts and install pick-up lines for the cable laying vessel. If the HDD end is in an area of sediment, it may need to be exposed which will require diver excavation. This would also be carried out by a small dive support vessel/multicat and take approximately five days.

218. Export cables will be installed using specialist cable installation vessel, barge or multi-cat. Where a cable tail is used, the vessel will pick-up the cable ends, connect the cables, and lay towards the tidal array. Where cable tail is not used, then the cable will be continuous from HDD to the array. Connection to device arrays could include daisy-chained devices as well as connection via single and multiple hubs (submerged and surface emergent).

219. Post cable installation, if the HDD is to be bentonite filled then the offshore end will need to be vented which will require further diver operations. This would also be carried out by a small dive support vessel / multicat and take approximately five days.

220. Following surface cable laying, cable protection systems, either concrete mattress or rock bags will be installed. Sediment within the MDZ is limited, however, burial of the cable in the first 1 km to 2 km may be attempted with multiple passes of a jet trenching Remotely Operated Vehicle (ROV), or possibly diver burial techniques over shorter lengths in the shallow water.

221. Installation of export and array cables could require a medium sized cable installation vessel (up to 140 m long and 6 m draft), plus barge (could be up to 130 m long x 30 m wide) for installation of rock bags / mattresses (30 m long x 12 m wide), with a small additional support vessel for each.

222. It is anticipated that there will be a safety zone of 500 m around all installation vessels.

223. The cable vessels will be mobilised directly from the manufacturing / supply port; likely to be Hartlepool, Norway, Italy or Germany for cables. Installation support ports are likely to be Holyhead, Mostyn, Liverpool or Birkenhead; although ports further afield may be used by some developers.

4.5.1.3. Cable Tail Installation

224. If cable tails are installed this will be undertaken by a cable vessel, barge or multicat (up to 140 m long and 6 m draft), plus small support vessel(s). The cable installation vessel is likely to be on site up to ten days; cable protection installation vessels may be on site for up to two days.

4.5.2. Onshore

4.5.2.1. Onshore Cable Route

225. Trenching for the onshore cables will be undertaken using a large excavator to dig up the ground along the route. Rock breakers will also be required along some sections.

226. Where the route goes through fields the trench will be backfilled with sand and/or stabilised material to a depth of approximately 150 mm above the top of the cables. The material originally removed from the trench will be replaced on top of the stabilised material. Finally, the trench will be topped up with a minimum of 150 mm of topsoil and the land restored as close as possible to its original condition. The cable will be buried to a depth of approximately 1 m, from the surface to the top of the ducts. Up to 30 m working width will be required for plant access, lay down of equipment, top soil, spoil and trench shoring along the cable route.

227. Cable installation within a road or a verge will follow the methodology of cable installation in a field. However, due to the restricted environment, installation activities will need to be sequenced and material will need to be removed from the site or kept off site until required. A trench will be cut through the road surface and excavated. Once the trench is prepared, the cables or ducts will be laid, and the road reinstated. A working area of approximately 6m width would suffice for installation in a single lane road.

228. The onshore cables will cross the A55 and the railway line within an area opposite the Grid Connection Substation. The HDD rig will either be positioned within the footprint of the Grid Connection Substation or on the opposite side of the A55/railway. The route will be perpendicular to the A55 but the exact location of the entry/exit pits will be refined during detailed design. Up to two crossings, each involving six drills, will be required with a drill length of approximately 150 m. Two site areas will be prepared for each HDD crossing; the drill rig site where the HDD enters the ground, and the exit point on the other side of the crossing.

229. When crossing underground services, it is likely that the cable trenches will pass underneath existing services, unless the service is extremely deep. This will be determined through further surveys.

4.6 CONSTRUCTION SCHEDULE

230. An overview of the indicative Project construction schedule is shown in **Table 4-16**. This is based on the assumption of project consent in March 2021 and on the preferred option of HDD construction methods at the landfall. Further detail on the offshore and onshore timescales are provided in **Section 4.6.1** and **Section 4.6.2**, respectively.

Table 4-16 Indicative Morlais Construction Programme

Task Name	Start	Finish
Grid Connection Substation		
Construction	January 2022	October 2022
Onshore Cable Route		
Transition Pit installation	September 2022	December 2022
HDD works mobilisation and preparation	November 2021	June 2022
Onshore Cable Construction	March 2022	April 2023
Landfall Substation and Switchgear Building		
Preparation works	November 2021	December 2021
Construction works	February 2022	October 2022
Electrical Installation	July 2022	December 2022
Cable Connection	November 2022	January 2023
Offshore Infrastructure		
Installation of infrastructure within the MDZ and ECC	January 2023	December 2023

4.6.1. Offshore

231. Offshore works (for installation of tidal devices and associated cabling and infrastructure) would be phased over a period of several years, taking up to 15 days per device or hub and up to 1.5 day for each inter-array cable, and up to 20 days for each export cable plus up to 12 days each for cable protection. For the main installation phase of tidal devices and associated electrical hub infrastructure, the typical time for complete installations is between three and 15 days per device, including foundation.

232. For the full 240 MW capacity scenario, the worst-case scenario in terms of installation period would involve all devices using drilled socket pin-piled anchors requiring multiple drilling operations. These could take between 4 and 15 days per device. Therefore, total time on site installing developer devices (and hubs) could be up to 4,306 days.

233. For the export cable installation, it is anticipated that each of the nine export cables would take up to 20 days installation (total of 180 days). For array cable installation, installation could take up to 1.5 days per cable. For the maximum number of 740 array cables, this amounts to 1,110 days of array cable installation. Cable tail installation may take up to 20 days in total for 9 tails.

234. Durations for key elements of offshore construction are provided in **Table 4-17** below. It is important to note that many of the activities detailed may occur concurrently.

Table 4-17 Morlais Installation Durations

Activity	Predicted number of vessels on site	Indicative number of days vessels on site			Proportion of time vessels on site per year
		Over 10 year construction	Per year	Per year per sub-zone	
Cable tail installation	3 vessels (1 x cable tail installation vessel; 1 x cable tail installation support vessel; and 1 x dive support vessel)	200 days (assumes single operation of up to 15 days with 5 days extra for protection)	20 days	N/A (works in nearshore area not sub-zones)	5.48 %
Export cable installation	2 vessels (1 x cable installation vessel; and 1 x support vessel)	180 days (assumes 9 blocks of 20 days over 10yr period)	20 days (worst-case assumes that one 20 day block of activity occurs per year, for 9yrs of the 10yr build-out period)	Each 20 day block of export cable installation per year predicted to be spread across each of the 8 sub-zones	5.48 %
Export cable protection installation	3 vessels (1 x cable tail installation vessel; 1 x cable tail installation support vessel; and 1 x dive support vessel)	108 days (assumes 9 x blocks of 12 days following each block of export cable installation)	12 days (worst-case assumes that one 12 day block of activity occurs per year, for 9 yrs. of the 10yr build-out period)	Each 12 day block of export cable protection installation per year predicted to be spread across each of the 8 sub-zones	3.29 %
Inter-array cable Installation	2 vessels (1 x cable installation vessel; and 1 x support vessel)	1,110 days (assumes a 10 year period build out of all 8 arrays, and no more than 2 arrays built in parallel at any time)	111 days	Up to 13.75 days	30.14 %
Hub installation	2 vessels (1 x hub installation vessel; and 1 x support vessel)	1,800 days (assumes 15 days per hub for 120 hubs)	180 days	22.5 days (assumes total hub installation vessel days will be spread equally across the 8 sub-zones)	49.32 %

Activity	Predicted number of vessels on site	Indicative number of days vessels on site			Proportion of time vessels on site per year
		Over 10 year construction	Per year	Per year per sub-zone	
Tidal device installation	2 vessels (1 x construction vessel; plus 1 support vessel) Or 4 vessels (2 x construction vessel; plus 2 support vessel)	4,306 days	431 days	54 days (assumes total tidal device installation vessel days will be spread across the 8 sub-zones)	100 % & 18 % (assumes 1 x construction vessel plus 1 support vessel on sites every day; plus for 18 % of year assumes 2 x construction vessel plus 2 support vessels on site)

4.6.2. Onshore

235. A build out schedule for the onshore and landfall infrastructure of 24 months is planned (assuming all works can be carried out in parallel, not sequentially). The schedule would consist of the following:

- HDD at landfall lasting up to ten months;
- Substations (Landfall Substation and Grid Connection Substation) and Switchgear Building totalling 24 months duration. The work would mainly be running in parallel, with some activities staggered or phased. This includes:
  - Year 1: enabling works and civils
  - Year 2: electrical fit out and commissioning;
- Onshore cable circuit installation (including HDD for any crossings) lasting up to 18 months.

236. Working hours are expected to be:

- 24 hours per day and seven days per week for HDD and offshore cable tail installation; and
- Daylight only and six days per week for all other works.

237. This is summarised below in **Table 4-18**.

Table 4-18 Summary Table for Onshore Construction Schedule Parameters

Parameter	Value
HDD Schedule	10 months Working 24 hours per day and seven days per week
Substations schedule (Landfall and Grid Connection Substation)	24 months Daylight only / six days per week
Offshore cable tail schedule	Three months Working 24 hours per day and seven days per week
Onshore cable circuit schedule	Up to 18 months Daylight only / six days per week

4.6.2.1. Summary of Installation Works

238. Enabling works at the Grid Connection Substation, the Switchgear Building and the Landfall Substation may include:

- Surveying and measurement of sites, including pre-construction archaeology and ecological surveys and mitigation;
- Reinforcement or alteration of access roads;
- Creation of construction compounds (temporary laydown/construction areas and site office);
- Provision of electricity supply and other services to site;
- Construction of temporary security and site fencing;

- Tree and scrub clearance; and
- Foundation excavation.

239. Works at the Landfall Substation site may entail

- HDD between the transition pits and offshore HDD 'break out';
- Possible alternative method if HDD not feasible consisting of cutting of trenches with excavator / rock cutter and installation of marine cables from transition pit to shallow subtidal, including installation and pinning of ducting and cable to cliff face using split-pipe;
- Construction of transition pits to joint marine and non-marine cables;
- Installation (pulling in) of subsea cable tails; and
- Cable installation via trenching between transition pits and the Landfall Substation;

240. The following ancillary works may be undertaken in association with construction of the Landfall Substation and Grid Connection Substation building and outdoor compounds and the construction of the Switchgear Building;

- Creation of parking areas;
- Construction of foundations for buildings and plant;
- Construction of cable basements or cable pits;
- Possible construction / installation of screening and/or landscaping measures, including embankments and/or stone walls;
- Installation of transformers, switchgear and other electrical infrastructure within both substations;
- Termination of cables and wiring of electrical systems;
- Installation and termination of communications;
- Testing and commissioning activity; and
- Reinstate access roads/public rights of way and affected ground.

241. The following activities may be associated with the cable route trenching works;

- Construction of joint pits every 200 m to 900 m;
- HDD to enable crossings of watercourses and roads; and
- Reinstatement of access roads, public rights of way and affected ground.

4.6.2.2. Traffic and Staff

242. To understand the likely numbers of employees and Heavy Goods Vehicles (HGVs) that would be required for the onshore construction works, B&V have been commissioned to provide industry expertise and to develop the methodologies and quantities that underpin the traffic demand assumptions for the Project.

243. The construction workforce would consist primarily of specialist workers who travel to work on similar projects throughout the UK. To supplement this, local workers would be used where

possible, subject to required skills being available. The peak number of construction employees required has been estimated at up to 70 per day, further details regarding the likely split between the various construction activities is provided within **Table 4-19**.

244. **Table 4-19** also provides a summary of the forecast HGV movements for the respective construction activities. The numbers presented represent the peak periods for each construction activity. Further details of the traffic demand and derivation are provided within **Chapter 23, Traffic and Transport**.

Table 4-19 Vehicle Trips and Staffing Requirements for Onshore Construction Works

Activities	Peak two-way * daily HGV movements	Peak two-way * LGV ** movements	Peak all vehicle movements (two-way *)
Cable installation	6	24	30
Landfall substation and HDD	20	64	84
Inland substation and HDD	20	52	72
Total	**46**	**140**	**186**
Notes			
*	*A two-way movement represents the inbound (laden trip from source/home) and the outbound trip (back to source/home). For example, 20 two-way HGV movements comprise 10 laden trips from source and 10 outbound unladen trips back to source.*		
**	*LGV (Light Goods Vehicles) includes a range of vehicles, such as cars, vans, pickups, etc.*		

245. It is proposed that vehicles associated with the Landfall Substation, landfall HDD works and cable installation activities would first travel to the site compound at the Landfall Substation. From this point, vehicles associated with the cable installation would then travel onwards to their respective work fronts. Vehicles associated with the Grid Connection Substation and HDD works across the A55 would travel direct to these sites.

246. Upon completion of the construction there would additional vehicle movements to the Landfall Substation associated with installation of tenant equipment and periodic maintenance.

247. B&V have identified that during installation of tenant equipment within the landfall substation up to 30 employees would be required to travel to the Landfall Substation (60 two-way movements). In addition, up to four HGV deliveries per day (eight two-way movements) would be required.

248. Upon completion of the construction and developer equipment installation, there will be a requirement for periodic maintenance at the Landfall Substation and Grid Connection Substation. This is likely to result in a peak of 10 employees (20 two-way movements) per day.

249. To facilitate the safe access and egress from the public highways to the Landfall Substation and landfall HDD, a new access would be provided from South Stack Road. This access would be constructed prior to the commencement of construction and remain in place post construction for maintenance traffic.

250. The Grid Connection Substation would be accessed from existing accesses from the A5 London Road. Full details of the access requirements are contained within **Chapter 23, Traffic and Transport**.

4.6.2.3. Noise Emissions

251. A non-exhaustive list is included below in **Table 4-20** for plant creating notable noise in relation to the onshore works. All plant listed is relevant to construction.

Table 4-20 Noise Emission Figures for Onshore Construction Plant

Vehicle / plant	BS5228 Reference	LwA dB(A)	On time Correction	Comments
Tracked Excavator	C2.17	103.9	75 %	Will be used at all points of the works
Backhoe Loader	C2.8	95.8	75 %	Used at substations
Bulldozer	C2.11	106.9	75 %	Will be used at all points of the works
Dumper	C2.32	101.9	75 %	Will be used at all points of the works
Mobile Crane	C4.38	106.2	75 %	Used at substations
Cement Mixer Truck (Discharging)	C4.18	103.1	50 %	May be used at transition pits and substations
Truck Mounted Concrete Pump and Boom Arm	C4.32	105.8	50 %	Used along cable route and at substations
Dump Truck	C2.30	107.0	75 %	May be used along cable routes and at substations
Generator	89.4	89.4	100 %	May be used at all points of the works
Water Pump	C2.45	93.1	75 %	May be needed at various locations depending on ground water conditions
Lorry	C4.53	104.9	20 %	Will be used at all points of the works
Asphalt spreader and road roller*	C5.33	103.6	75 %	Used along cable route and at substations
Backhoe Loader	95.8	96	50 %	May be used along cable routes and at substations
HDD Drilling Rig	105.0	105.0	75 %	Likely needed at landfall and the A55/Railway crossing along at the Grid Connection Substation
Conveyor Drive Unit	C10.22	97.2	100 %	May be used along cable routes and at substations
Field Conveyor (Rollers)	C10.23	80.5	100 %	May be used along cable routes and at substations

4.7 OPERATION AND MAINTENANCE

4.7.1. Tidal Devices

252. Developers are expected to visit each tidal device up to 15 times annually for both planned and unplanned maintenance activities. Many developers plan to undertake at least monthly routine inspection / maintenance using small vessels. A worst-case scenario of one five-hour visit to each device on site per month may be foreseeable.

253. During maintenance activities a safety zone will apply around the O&M vessels. Offshore maintenance activities should be made available through Notices to Mariners.

254. Typical maintenance jobs may include: diagnostic tests, oil changes and lubrication, replacement of control cards and sensors, removal of biofouling, overhaul or replacement of systems (gearboxes, generators, switchgear etc.). Major operations such as retrieval and repair following structural failures would require similar vessels and procedures as installation works.

255. Maintenance procedures vary with device types with some tidal technologies having built in mechanisms to raise the devices to the water surface minimising the requirement for large maintenance vessels. Examples are as follows:

- TEC buoyant nacelle (remotely) released to surface and towed by a multicat or workboat to maintenance port. All work will be carried out onshore;
- Device designed for minimal interventions and high reliability (most critical systems are off the device), no gearbox or lubrication systems. TEC nacelle lifted with bespoke lifting frame via guide chains or similar. TEC disconnected from cable and taken to shore for work;
- Each TEC nacelle can be independently lifted from / lowered onto a seabed frame using a DP vessel or crane barge with moderate lifting capacity. Work on TECs will be carried out onshore. Lifting operations would typically take only a few hours each;
- Floating devices are designed so that it can be accessed at sea so that a large proportion of the maintenance can be carried out without removing the TEC from its moorings. These devices can, however, be towed by a small vessel to a nearby port for any major maintenance works; and
- Surface emergent, floating platforms are designed to be stable enough to carry out all but the largest of maintenance operations at sea. Access can be gained for some operations through surface emergent elements (transformers, control equipment etc.). Platform is raised (through variable buoyancy) for access to TEC. These can then be separately removed to shore for major work as necessary. Vessels for O&M would mainly be a workboat or multicat. For removal of tidal devices, a large multicat or possibly offshore DP vessel may be required.

256. Seabed mounted surface emergent devices are designed so that all equipment requiring regular maintenance is accessible above water and can be carried out from small maintenance vessels. For electrical hubs, requirements will vary depending on supplier and nature of the hub. Likely to require access several times a year. For fully submerged systems, the hub and foundation would either be lifted in its entirety or a buoyant hub may be remotely released and accessed by a much smaller vessel on the surface. Surface emergent hubs could be access using smaller

vessels on site and/ or be towed to shore for more major operations. A wide variety of DP vessels, heavy lift vessel, multicat, workboats and ROVs may be used.

4.7.2. Export Cables

257. It is expected that once installed, the ongoing offshore operations for the export cables will be limited to inspection (through survey) and maintenance of the cables and ancillaries.

258. The inspection regime for the offshore cables is expected to consist of annual inspections for the first two or three years reducing to every two years thereafter depending on the results of the initial surveys.

259. The inspections will be performed by an offshore survey vessel (including the use of an ROV) to assess the cables for any signs of damage or movement that has resulted in/from a free span. In the event of any cable movement to a position of concern, corrective action will either involve a (larger) work-class ROV to move that portion of the cable to a more stable location and/or the use of additional rock bags to lay over / under the cable in its new position.

260. As well as the scheduled maintenance operations it may be necessary to repair a subsea cable in the event of a failure or break. The most common cause of damage to a cable in offshore projects is from fishing trawl gear or anchor impact.

261. Repair of a cable will necessitate a vessel with suitable lifting and cable jointing equipment. The following process will be undertaken in this event:

- Isolation of the requisite cable(s);
- Location of the fault from onshore using suitable electrical techniques;
- Location and assessment of the fault offshore using an offshore survey vessel (including the use of an ROV);
- Cutting the cable subsea adjacent to the break on an area of ‘good cable’;
- Lift the good end of the cable, check this part of the cable is undamaged;
- Once check is satisfactory, buoy off good end and return to water;
- Lift the damaged section of the cable, cut out any damaged length;
- Splice on spare cable length;
- Return to previously buoyed off end and joint to spare cable;
- Return cable to the seabed;
- Complete testing from onshore; and
- Re-energise system.

262. It is anticipated that up to ten major cable repairs (five days each) may be required throughout the project life. It is assumed that up to 750 m of cable will be subject to repair works per event (From a total of 7,500 m). These will involve the same type of seabed disturbance and potential exclusion of other marine users due to the presence of cable repair vessel, as experienced via

the main cable installation phase. However, any such disturbance will be much more temporally and spatially limited.

263. Annual maintenance of navigational buoys and any environmental monitoring equipment will also be required. These works will be undertaken using a workboat with small crane. The buoys or ADCP frames will be lifted onto the vessel from which appropriate maintenance can be carried out, this will include cleaning to remove marine growth, bulb replacement for buoys; diagnostic tests and battery replacement for ADCPs.

4.8 REPOWERING

264. The Project is a tidal technology demonstration project and it is anticipated that the tidal devices/arrays may be replaced several times within the 37-year project life.

265. A repowering of a device/array is defined as the end of a berth/array demonstration cycle, at which time the TECs, device foundations, support structures, electrical hubs, tenant monitoring equipment, and inter-array cabling may be removed, in line with procedures adopted during decommissioning (see Section 4.9). Once the developer owned assets listed above have been removed, the Project will then have capacity for 'repowering' when tidal devices within existing arrays may be replaced at the same berth, or full arrays may be replaced with new arrays deployed at a new location.

266. Once all the tenant's infrastructure has been removed, the specifications of any new array would be reviewed by regulators against the consented PDE following an agreed consent management regime. Construction of new devices will be undertaken in accordance with the construction procedures for device foundations, support structures, TECs, electrical hubs, tenant monitoring equipment, and inter-array cabling outlined in **Section 4.5**.

267. Export cables, export cable protection, navigational markers and onshore infrastructure will remain in place for the life of the Project.

268. The repowering process differs from O&M activities where, for example, the TEC may be removed for maintenance, whilst the other infrastructure (e.g. foundations) would remain in situ.

269. The quantified values for repowering are presented in **Table 4-27** Worst case parameters for drilled socket foundations

Parameter	Worst case (240MW)	Potential repowering value
Drilled pin pile foundations	5,889 m2 *	2,944.5 m2
Drilled socket arisings	117,780 m3 *	58,890 m3
Drilling footprint	5,889 m2 *	2,944.5 m2
Drilling time	3,990 days	1,995 days
* Note that drilled foundations, footprints and arisings do not contribute to the worst case for permanent or temporary loss of seabed habitat. Permanent and temporary seabed habitat loss worst case values are based on the large footprint of gravity foundations and other project infrastructure, are shown in Tables 4-26 and 4-28 respectively.		

270. Table 4-28 Worst-Case Parameters for Temporary Seabed Habitat Disturbance during Construction, Operation (including repowering) and Decommissioning.

271. An assumption has been made that 50% of the tenants will undertake repowering, i.e. for 50% of the tenants, their infrastructure will be removed and replaced (potentially with different infrastructure by a different tenant). For the other 50% of tenants, their infrastructure will remain over the lifetime of the project. The repowering process has been defined as per below:

- Initial temporary seabed disturbance via deployment of barge anchors to remove foundations, TEC's, hubs, inter-array cables and monitoring equipment for 50% of the Tenants (berths);
- Further temporary seabed disturbance via re-installation (repowering) of foundations, TEC's, hubs, inter-array cables and monitoring equipment for the same 50% of Tenants (berths); and
- Additional permanent habitat loss (over and above that via initial construction phase), due to placement of re-installed (repowered) foundations/TECs in different areas to where originally installed.

272. The operational phase values also include the temporary seabed disturbance that would arise from up to ten cable repair events.

4.9 DECOMMISSIONING

273. Although contractual details have not been finalised, decommissioning of individual devices and arrays will be the responsibility of the individual tenants. However, Menter Môn holds ultimate responsibility for decommissioning of the Project, and the decommissioning of general infrastructure will be the direct responsibility of Menter Môn.

274. Offshore decommissioning methodologies would vary considerably between devices but would be expected to be similar to the construction phase in reverse. For the purpose of this ES, it is assumed that offshore cables are required to be removed as this represents the worst-case scenario in terms of impacts.

275. At the end of the intended Project lifetime of 37 years, the Project is likely to be decommissioned or re-powered. The decommissioning phase is expected to be as below, for the purposes of the ES:

- Cables will be re-used, preserved *in situ* or removed. Removal is considered as the worst-case scenario;
- Cable protection material will be left *in situ* on the sea bed, assuming that it causes no unacceptable impacts or hazards;
- Gravity base foundations (including gravity anchors) may be left *in situ* while drilled socket piles would be cut to an acceptable seabed level;
- All other components of the tidal devices (i.e. TECs, superstructure and support structure) will be removed;
- Any electrical hubs will be removed; and
- Navigation buoys and site monitoring equipment and their foundations / moorings will be removed for re-use.

276. At this stage, decommissioning of onshore electrical infrastructure is expected to consist primarily of removal of the onshore substation. Any cables that might be laid on the surface within the onshore Development Area would be terminated and it left in situ. All structures laid upon the cliff face and foreshore will be removed upon decommissioning, any buried cables will remain in situ.

277. For the purposes of the EIA, the PDE will include a worst-case scenario for the decommissioning against which the assessment of impacts will be undertaken.

4.10 PROJECT DESIGN ENVELOPE SUMMARY

278. This section provides the key parameters that define the PDE for which consent is sought and the worst-case scenarios of the key components of the project description which are taken forward in impact assessments.

279. Table 4-21 to Table 4-30 summarise the PDE.

Table 4-21 Generic Project Parameters

Parameter	Maximum value
MDZ area	35 km^2
ECC area	4.75 km^2
ODA area	1 km^2
OfDA area (MDZ plus ECC)	39.75 km^2
Intertidal area	0.0151 km^2
Project life	37 years
Project installed capacity	240 MW
Tidal Energy Converters	1,648
Number of Export cables	9
Total length export cables	40.5 km
Number of Inter-array cables	740
Total length inter-array cables	204.5 km
HDD ducts	9
Transition pits or bays	9
Export cables and export cable tails	9
Landfall substation	1
Switchgear building	1
Grid Substation	1

Table 4-22 Worst-Case Number of Tidal Devices for Each Device Type

Tidal Device Type	Number of devices
Floating / Surface emergent and/or Surface Emergent Seabed Mounted	Up to 130*
Buoyant mid-water and/or seabed mounted fully submerged	Up to 490
TOTAL	**Up to 620 ****
* Worst case scenario for surface emergent devices detailed in paragraphs 104 and 117, as well as Chapter 25 SLVIA. There will be no more than 130 floating or surface emergent devices deployed at one time within the MDZ.	

** See paragraphs 36 and 60. There will be no more than 620 tidal devices deployed within the MDZ, comprised of no more than 130 floating / surface emergent devices, and no more than 490 buoyant mid-water and / or seabed mounted tidal devices.

Table 4-23 Tidal devices and TECs worst-case parameters[12]

Parameter	Maximum value
TEC output	4 MW [13]
TEC diameter	27 m
TEC average speed	22 rpm
Height above sea level (for floating device)	6.5 m
Height above sea level LAT (for Surface Emergent Seabed Mounted device) within the green hatched area as shown in Figure 4-5	18 m
Length	72 m
Width	30 m

Table 4-24 Worst case parameters for device spacings within arrays

Device Category	Spacing between tidal device centres		Maximum extent of surface movement	
	Perpendicular to flow	Parallel to flow	Perpendicular to flow	Parallel to flow
Fully submerged seabed mounted device	50 to 100 m	100 to 250 m	NA	NA
Surface emergent and buoyant mid water device	50 to 200 m	120 to 500 m	60 (±30 m)	80 (±40 m)
Surface Emergent Seabed Mounted (SESM) device	50 to 200 m	120 to 500 m	NA	NA

Table 4-25 Hubs and buoys, navigation and monitoring equipment worst case parameters[14]

Parameter	Maximum value
Number of hubs	120[15]
Height of hubs above LAT	18 m [16]
Navigation (including IALA Cardinal marks) and marker buoys, marking location and extent of arrays and groupings of tidal devices within arrays as required.	60
Dimensions of navigation buoys	Up to 3 m, with a focal plane height (position of light) of 6 m
IALA Cardinal Marks	4

[12] This table is drawn from review of parameters of multiple tidal devices and TECS, to identify the worst case or maximum value for each parameter. It does not refer to one single device example.
[13] 4 MW anticipates improvements of design and efficiency of tidal technologies over the time of the project to allow for a greater installed capacity per device, with all other maximum PDE values unchanged, and up to the maximum installed capacity of the Project of 240MW.
[14] This table is drawn from review of parameters of monopile, floating and seabed hubs to identify the worst case or maximum value for each parameter. It does not refer to one single hub type example.
[15] Fully submerged seabed mounted hubs.
[16] Up to eight surface piercing pile hubs.

Parameter	Maximum value
Dimensions of IALA cardinal marks	Up to 3 m, with a focal plane height of 6 m
ADCPs	40
Footprint of individual ADCP (and total across MDZ)	7 m^2 (378m^2)
Monitoring buoys or platforms (in addition to navigation and marker buoys	5
Dimensions of environmental monitoring buoys or platforms	Up to 3.6 m above sea level
Seabed footprint of anchors (each)	Concrete weight up to 2 m in diameter, with a chain catenary in contact with the seabed of up to 30 m
Visibility of fully emergent/floating devices	Coloured yellow above water and with navigation lights

Table 4-26 Worst-Case Parameters for Permanent Seabed Habitat Disturbance including Repowering

Parameter	Worst case (240 MW)	Comment
Main installation		
Maximum seabed footprint of devices	74,790 $m^{2\,*}$	Max value across entire project. Based on scales of anchor mooring systems for floating devices. Includes hubs.
Swept Area of Catenary Cables	2,055,000m^2	Based on: 30 devices having swept area of 9,500 m^2 140 devices having swept area of 7,500 m^2 floating devices 240 devices having swept area of 3,000 m^2 small floating devices
Export Cable Footprint (cables and protection systems + rock bags)	11,745 m^2	Up to 40.5 km of export cables (with split-pipe protection/shells and rock bags)
Array Cable Footprint (cables and protection systems + rock bags)	30,040 m^2	Up to 204.5 km of array cables (with split-pipe protection/shells and rock bags)
Landfall trench for nine landfall cables	7,400 m^2	740 m long trench x 10 m width in intertidal region
Maximum footprint cable tails	120 m^2	Based on 9 x tails of 620 m length
Maximum footprint of 40 ADCPs	280 m^2	7 m^2 per ADCP mooring x 40 units
Footprint of eight seabed mounted environmental monitoring units	112 m^2	14 m^2 per env monitoring unit x 8 units
Footprint of 60 Navigation and Marker Buoy moorings	540 m^2	3 m diameter square gravity anchor (9 m^2) per anchor x 60 anchors/buoys
Footprint of five sea level environmental monitoring buoy moorings	45 m^2	22.5 m^2
Permanent habitat loss (initial operational phase: 2,180,072m^2 (2.18 km^2)		

Parameter	Worst case (240 MW)	Comment
Repowering		
New tenant infrastructure in 50% of berths	52,504 m^2	Includes device, array cable and supporting equipment footprint.
Permanent habitat loss (repowering of 50% of berths) 52,504m^2		
Permanent Habitat Loss: Total of 2,232,576 m^2 (2.23 km^2)		
* A maximum total footprint for devices within the MDZ is sought rather than a potential maximum footprint for individual devices. This approach allows for evolution of technologies over time, within the maximum footprint.		

Table 4-27 Worst case parameters for drilled socket foundations

Parameter	Worst case (240MW)	Potential repowering value
Drilled pin pile foundations	5,889 m^2 *	2,944.5 m^2
Drilled socket arisings	117,780 m^3 *	58,890 m^3
Drilling footprint	5,889 m^2 *	2,944.5 m^2
Drilling time	3,990 days	1,995 days
* Note that drilled foundations, footprints and arisings do not contribute to the worst case for permanent or temporary loss of seabed habitat. Permanent and temporary seabed habitat loss worst case values are based on the large footprint of gravity foundations and other project infrastructure, are shown in Tables 4-26 and 4-28 respectively.		

Table 4-28 Worst-Case Parameters for Temporary Seabed Habitat Disturbance during Construction, Operation (including repowering) and Decommissioning

Parameter	Entire Site	Comment
Construction Phase:		
Post-lay cable management	27,259 m^2	Area of sand wave field where post-lay works with Mass-Flow Excavator (MFE) may be required if surface laid cable shows areas of suspended cable.
Deployment of anchor blocks by barges during cable installation	100,240 m^2	Temporary disturbance arising from mooring footprints. Up to eight 25 m^2 (5 m by 5 m) anchor blocks for a single barge equal to a total footprint per anchor deployment of 200 m^2. Assumed that these types of anchor barges generally deploy a spread every 500 m. So, for every 500 m of cable installation a footprint of 200 m^2 of temp seabed disturbance occurs (via the anchor blocks). Total cable length = 250.6 km (Exports: 40.5 km Inter-Arrays: 203.5 km Cable Tails: 5.6 km) Assuming a footprint of 200 m^2 every 0.5 km, or 400 m^2 every 1 km, and assuming all cables are installed using anchor barges,

Parameter	Entire Site	Comment
		temporary disturbance impact equal to 100,240 m^2 (0.10 km^2).
Deployment of anchor blocks by barges during tidal device installation	248,000 m^2	Max. no of devices set at 620 x small (0.2 kW devices) Assumed that deployment of each device requires 2 x anchor deployments from barge (2 x 200 m^2 = 400 m^2) Therefore, total temporary seabed disturbance = 620 x 400 m^2 = 248,000 m^2
Deployment of anchor blocks by barges during hub installation	48,000 m^2	Maximum number of seabed mounted hubs is set at 120. Assumed that deployment of each hub requires two anchor deployments from barge (equal to 400 m^2). Therefore, total temporary seabed disturbance is equal to 48,000 m^2.
Construction Phase TOTAL	**423,499 m^2 (0.42 km^2)**	
Operational Phase:		
Repowering 50 % of tenants' infrastructure (foundations; TEC's; hubs' array cables; monitoring equipment) removed and replaced with new (different) tenant infrastructure	377,400 m^2	Initial removal of tenant infrastructure from 50 % of berths • 50 % of anchor block value (above) for inter-array cables only (203.5/2 * 0.4) = 40,700 m^2 • 50 % of anchor block value of tidal device installation = 124,000 m^2 • 50 % of anchor block value for hub installation = 24,000 m^2 Sub-Total = 188,700 m^2 Subsequent re-installation (re-powering) of tenant infrastructure from 50 % of berths • 50 % of anchor block value (above) for inter-array cables only (203.5/2 * 0.4) = 40,700 m^2 • 50 % of anchor block value of tidal device installation = 124,000 m^2 • 50 % of anchor block value for hub installation = 24,000 m^2 Sub-Total = 188,700 m^2

Parameter	Entire Site	Comment
Cable repairs	3,000 m^2	Up to 10 major cable repairs (five days each) may be required throughout the project life (assumed that cables will be surface-laid). It is assumed that up to 750 m of cable will be subject to repair works per event (7,500 m in total). Anchor deployments at of 400 m^2 temp seabed disturbance per 1 km of cable works is equal to 3,000 m^2.
Operational Phase TOTAL	**380,400 m^2 (0.38 km^2)**	
Decommissioning Phase:		
Decommissioning Phase	Same worst-case as per construction phase due to same activities needed to remove infrastructure.	
Decommissioning Phase TOTAL	**423,499 m^2 (0.42 km^2)**	

Table 4-29 Maximum Weight of Offshore Infrastructure Deployed

Infrastructure	Weight
Steel	193,333 tonnes
Concrete	466,667 tonnes
TOTAL	**660,000 tonnes**

Table 4-30 Worst-Case Onshore Infrastructure

Parameter	Value
Landfall Substation	
Fenced compound	80 m by 80 m or equivalent area.
Buildings	Building A: 62 m by 22.5 m (or equivalent area) x 7 m high Building B: 28 m by 10 m (or equivalent area) x 7 m high Building C: 8 m by 8 m (or equivalent area) x 7 m high Building C is within a plant compound: 28 m x 36 m (or equivalent area) x 7 m high.
Temporary construction compound	50 m x 100 m or equivalent area.
Substation perimeter fencing	Weld steel 1.8 m tall.
Palisade fencing	Hidden within perimeter fence 2.4 m tall.
Access / egress	Via new entrance South Stack Road.
Surfaces	Hard standing 5 m to 7 m wide on access roads and access within substation. Outdoor areas other than hard standing crushed rock 80 mm to 150 mm deep.
Foundations	Concrete slab foundations. Slip and slab if possible. Alternative piled solution if ground conditions require.
Cut and fill volumes	Approximately 13,900 m^3 cut and approximately 130m^3 fill.
Drainage	Foul drainage to septic tank.

Parameter	Value
	Surface water via oil interceptors (as required) to water course, septic tank or soakaway.
Lighting	110 lx directed lighting. Lit only as needed. Motion sensor activated.
Other	Facility for electric vehicle charging.
Switchgear Building	
Fenced compound	N/A
Building	Single building up to 9.4 m x 5 m, with a maximum height of 4 m.
Temporary construction compound	30m x 20 m or equivalent area.
Palisade fencing	N/A
Access / egress	Access via the existing road to Parc Cybi employment site
Surfaces	N/A
Foundations	Concrete slab foundations. Slip and slab if possible. Alternative piled solution if ground conditions require.
Drainage	Surface water via oil interceptors (as required) to water course, local sewerage, or soakaway.
Lighting	110 lx directed lighting. Lit only as needed. Motion sensor activated.
Grid Connection Substation	
Fenced compound	104 m x 62 m or equivalent area.
Buildings	Buildings and plant to maximum height of 9 m.
Temporary construction compound	50 m x 100 m or equivalent area.
Palisade fencing	2.4 m height palisade fencing.
Access / egress	Access via existing road to Orthios site.
Surfaces	Hard standing 5 m to 7 m wide on access roads and access within substation. Outdoor areas other than hard standing crushed rock 80 to 150 mm deep.
Foundations	Concrete slab foundations. Slip and slab if possible. Alternative piled solution if ground conditions require.
Drainage	Foul drainage to local sewerage network, or to septic tank. Surface water via oil interceptors (as required) to water course, local sewerage, or soakaway.
Lighting	110 lx directed lighting. Lit only as needed. Motion sensor activated.
Onshore cables	
Cables from transition pit to Landfall substation	From transition pit to Landfall Substation, each of the 9 onshore cables will require up to 8 ducts depending on the specific requirements of the tidal energy devices. The maximum case of 8 ducts comprises, 3 x HV, 1 x fibre optic, 1 x LV and a spare, 1 x Extra Low Voltage and a spare. The minimum case of 2 comprise a single, multi-core HV cable and a fibre optic. This gives a maximum case of 72 ducts.
Cables from Landfall Substation to Grid Substation	Six power cables and two fibre optic cables. Each to a maximum 110 mm diameter.
Cable route length	Up to 8.1 km, depending on route finalisation

Parameter	Value	
Installation method	Cables will be laid in ducts installed into trenches. Trenches will be laid into the road and adjacent verge / field area areas.	
Trench parameters (per section)	Landfall Substation to Grid Connection Substation	Switchgear Building to Grid Connection Substation
Circuit	132 kV	33 kV
Trench depth	1620 mm	1620 mm
Trench width	1400 mm	2000 mm
Length	6675 m	1420 m
Joint pits (No.)	18	2
Joint pits chamber depth	1.65 m	1.65 m
Joint pits chamber width	2 m	3 m
Joint pits chamber length	12.5 m	5 m
Draw pits (to be fully reinstated following works) (No.)	35	7
Draw pit depth	1.65 m	1.65 m
Draw pit width	3 m	5 m
Draw pit length	8 m	8 m
Hard standing	20 m x 7 m hardstanding at each joint bay.	

4.11 SUMMARY

280. The Project details for the MDZ described in this chapter have been considered by for the parameters relevant to each receptor. Chapters 7 to 26 outline the worst-case scenario for each relevant receptor and this is used as the basis for assessing the impacts. By assessing the worst-case scenario per receptor, it is deemed that this provides the maximum potential impact for assessment.

5. REFERENCES

Isle of Anglesey County Council (2017). Joint Local Development Plan (Anglesey and Gwynedd). https://www.anglesey.gov.uk/en/Residents/Planning-building-control-and-conservation/Planning-policy/Joint-Local-Development-Plan-Anglesey-and-Gwynedd/Joint-Local-Development-Plan-Anglesey-and-Gwynedd.aspx