Offshore Demonstration Site Demand and Feasibility Study

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- ORE Catapults Levenmouth Demonstrator Turbine
- The Offshore Wind Industry Council's Pathways 2 Growth Workstream
- ORE Catapults Robotics and Autonomous Systems (RAS) facilities in Blyth
- The European Marine Energy Centre (EMEC)
- Hywind II Scotland Pilot Project
- Celtic Sea Power, previously supporting delivery of Wave Hub in Cornwall
- HR Wallingford's Marine Testing Facilities
- The ECOWind Programme Team
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- Blackfish Engineering Design Ltd
- BP
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Foreword

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

As the UK aims to further grow its offshore wind capacities, Natural England commissioned consultants, Opergy, to undertake a desk-based study into the demand and feasibility of an offshore demonstration site located in English waters. Natural England along with other bodies have a duty to advise on industrial and infrastructure developments that could have a potential impact on the natural environment. As such, there is a need to develop the evidence base to ensure there is a clear understanding of the potential environmental impacts and mitigation possibilities in relation to construction, operation and decommissioning of infrastructure and associated activities. The project tested the idea that a national demonstration and trial area where new and novel technologies/approaches could be trialled and monitored would add value for industry, researchers, regulators and conservation and government bodies.

Executive summary

In late 2022, Opergy were commissioned by Natural England following a competitive tender process to undertake a desk-based research study into the demand and feasibility of an offshore demonstration site in English waters.

With the UK already home to one of the largest offshore wind capacities in the world and looking to grow this in future, Natural England and other bodies with a responsibility to advise on industrial and infrastructure developments that could have a potential impact on the natural environment will be all the more keen to grow the evidence base and ensure that there is clear understanding of the potential environmental impacts and mitigation possibilities in relation to construction, operation and decommissioning of infrastructure and associated activities.

This study tests the hypothesis that a national demonstration or trial area, or areas, where new and novel technologies or approaches that seek to minimise environmental impacts of the offshore wind sector could be trialled and monitored would add value for industry, researchers, regulators, statutory nature conservation bodies and government bodies, supporting the industry as a whole to drive down its environmental impact and address consenting risks at a precommercial scale.

An initial desk-based research and literature review found that while there are test and demonstration sites that do explore environmental impacts, there is no specific facility focused solely on them. A total of 46 offshore trial and demonstration sites, both in the UK and abroad, were explored, with most covering offshore wind while others catered for wave and tidal energies, with the thinking being that some of this knowledge may well be transferable.

Key initial findings included that facilities tend to have a commercial motivation in their inception, they tended to be financed through multiple sources, featuring both public and private money, have a presence both onshore and offshore, and aim to offer representative conditions of what the technologies being tested would be facing offshore.

Through engagement with key stakeholders, the specific idea at the centre of this project enabled greater exploration, with an appetite discovered among different statutory bodies and industry representatives for a site of this kind. The overriding feedback seemed to be that a test and demonstration site could complement work streams of other organisations and help the UK to meet crucial net zero targets in the years ahead through ensuring the technologies needed to mitigate any environmental impacts are already in place and ready to go.

These discussions also shone a light on potential issues that such a site could target, such as the impacts of cable trenching and laying activities; the impacts of new anchoring systems for floating offshore wind in the construction and installation phase; the prevention or removal of biofouling and solutions for protection of corrosion over time during operations and maintenance; cumulative impacts, such as noise, temperature and seabed disturbances from turbines across a whole wind farm and research into the longer-term, exploring the cumulative anthropogenic impact on populations of fish, birds and marine mammals.

Stakeholders were asked to reflect on potential site locations for the proposed activity, as well as opportunities for new areas of the seabed that could be identified for this trialling and demonstration activity. Furthermore, to consider the potential to use existing

demonstration or commercial project sites as part of a network of locations where this sort of environmental testing could be undertaken.

From this, all stakeholders engaged as part of this study saw value in including existing infrastructure in a network of locations where trialling of equipment, techniques and monitoring of environmental impacts could be encouraged or facilitated. Notably, this would ensure that provisions are not duplicated, something that was raised as a concern during stakeholder discussions, while also saving what could be considerable development costs in the process too.

There was a willingness identified among test and demonstration sites to work with a future network of test and demonstration facilities, with many drawing on the productive relationships they already share with other research organisations and universities to share resources and data for the purposes of furthering research topics.

That having been said, there was also a willingness for new sites to be set up for trialling and monitoring of environmental impacts, which could be selected to meet the demands of specific testing activities, while offering a variety of different seabed environments to potential users. This could potentially be in relatively crowded areas of the seabed, where testing could be undertaken on cumulative impacts on multiple offshore wind developments and other anthropogenic uses on the seabed and environment.

Complementing this engagement, an online survey was undertaken to engage potential users of the trial site(s) to gather information on the nature of their requirements. Many suggested their solution that they would wish to test could be used at multiple stages of the development cycle, though most offered solutions for construction and installation, and operations and maintenance. The presence of existing seabed infrastructure or hardware was considered the main requirement for a potential offshore trial or demonstration site, while many identified that not only was there a gap in the market for an accessible trial facility in the UK, but there was in fact a need – cited by 60% of respondents.

Key conclusions drawn through stakeholder engagement include that there is a definite gap in the existing provision of testing, trialling and demonstration facilities for environmental testing, while there is clearly broad and positive support for bringing forward an environmentally focused demonstration site. Notable supporters included Cefas, the Crown Estate, Defra, the Environment Agency, the Marine Management Organisation and other equivalent agencies in the devolved administrations as well as industry representative bodies too, such as the Offshore Renewable Energy Catapult and OWIC Pathways to Growth Group.

Stakeholder engagement also identified a strong need to strengthen the perception of the importance of considering approaches to monitoring, managing and minimising environmental impacts of offshore wind developments, across all levels of the supply chain, especially given the scale at which it is set to grow in the years ahead.

Therefore, key recommendations and next steps for Natural England and its partners to pursue include for consenting and regulatory bodies to promote the value of evidencing, managing and minimising environmental impacts across the supply chain; pursuing the development of a network of Trial and Demonstration sites across England and potentially the UK; engaging in consultations to identify potential locations; further engagement with potential delivery partners, especially as plans develop and become more specific; consideration of a complementary funding scheme with partners of the network of demonstration sites; establishing governance arrangements, including a Steering Group;

and mandating environmental monitoring and data sharing by all users, with a real consensus uncovered on the need for this, given how this will help with further consenting by allowing issues to be resolved far earlier.

Contents

1 Introduction

In late 2022, Opergy were commissioned by Natural England following a competitive tender process to carry out a desk-based research study into the demand and feasibility of an offshore demonstration site in English waters.

The UK is already home to one of the largest operating offshore wind capacities in the world, with a combination of shallow seabed's, high winds and North Sea oil and gas expertise allowing it to establish itself as a leading nation. It is also showing no signs of slowing down, with the government now targeting 50GW of capacity by 2030 as part of its Energy Security Strategy[1], with at least 5GW coming from floating offshore wind.

The government has also, more recently, unveiled further plans to accelerate offshore wind as part of its "Powering Up Britain" announcements. These included revised energy National Policy Statements (NPS)[2] which are used to support decisions on major energy infrastructure, with a consultation launched and views sought on a new policy presumption known as a "critical national priority" for offshore wind and its supporting onshore and offshore network infrastructure, as well as related network reinforcements.

This means that, subject to any legal requirements, the urgent need for offshore wind to achieve the country's energy objectives, together with the national security, economic, commercial and net zero benefits, will generally outweigh any other residual impacts that are not capable of being addressed by application of the mitigation hierarchy.

The British Energy Security Strategy also introduced the offshore wind environmental improvement package (OWEIP). The OWEIP is focused on helping to accelerate the deployment of offshore wind, while protecting and enhancing the marine environment which, the government says, should speed up deployment by 25%[3]. It is facilitating the consideration of environmental issues earlier in the planning process, which includes the use of strategic compensation measures to address impacts across projects, encouraging collaborative work between developers, as well as with government, all with the aim of reducing delays.

In the context of this significant projected growth in the offshore wind sector in the UK and efforts to accelerate the process, Natural England and other bodies with a responsibility to advise on industrial and infrastructure developments with a potential impact on the natural environment have a particular focus on identifying accurate, evidenced environmental sensitivity information and data to demonstrate the individual and cumulative impacts of the development of offshore wind developments.

There are currently several evidence gaps associated with the construction, operation and maintenance and decommissioning of an offshore wind farm infrastructure on the marine environment, as evidenced on the Offshore Wind Environmental Evidence Register[4]. Natural England wish to better understand the environmental impact pathways and mitigation possibilities of installation, operation and maintenance, and eventual

[1] British energy security strategy – UK government
[2] Planning for new energy infrastructure: revisions to National Policy Statements – UK government
[3] Energy Security Bill factsheet: Offshore wind environmental improvement package – UK government
[4] Offshore Wind Environmental Evidence Register – Marine Data Exchange

decommissioning of infrastructure. This study seeks to test the hypothesis that the provision of a recognised national demonstration or trial area, or areas, where new and novel technologies or approaches seeking to minimise environmental impacts of the offshore wind sector could be trialled and monitored, would add value for industry, researchers, regulators, statutory nature conservation bodies (SNCBs) and government bodies. The site(s) would offer a facility for the trialling and monitoring to establish potential impact pathways, providing greater evidence and confidence on the impacts of a technology or approach at a pre commercial scale, as well as inform suitable mitigation measures, of commercial scale adoption of technologies.

The ambition, if feasibility of the concept is recommended, is to create a facility where users from Small to Medium-sized Enterprises (SMEs), larger commercial companies as part of the supply chain, and/or research bodies can either hook up or install their solutions to monitor its performance over a period of testing time. This would allow the user to identify and evidence the wider impacts on seabed and other local environmental receptors, identifying impact pathways including scale and severity and recoverability. It is not the intention for the proposed demonstration site to cater for those whose sole interest is technical testing and proof of concept. It would also be hoped that the site would offer an area for Natural England, other SNCBs or research bodies to test and monitor the environmental implications of activity on the seabed themselves.

The result of this would be that Natural England and other users have the evidence and can better appreciate the potential environmental impacts and how they can be mitigated, ensuring better, evidence-based environmental impact assessments and better designed projects. Furthermore, it would also offer the potential to provide greater confidence to developers and regulators, streamlining the consenting and examination process.

1.1 Key Objectives of the Research

Through this research, the overall aim has been to build an evidence base of the demand or otherwise, the related requirements for, and potential value of one or more offshore demonstration and test sites, which Natural England could then present to stakeholders and take forwards further.

The study has sought to address 4 key objectives as follows:

Objective 1: Identify lessons learnt from other successful demonstrator sites, including international sites.

Objective 2: Identify potential market demand for the proposed demonstration site(s) in England through engagement with industry, SNCBs, regulators and the Crown Estate.

Objective 3: Identify and articulate the appropriate process for establishment for a demonstration area in English waters.

Objective 4: Identify and recommend suitable governance and operational arrangements for the proposed demonstrator site(s), including likely costs of establishment, management, and monitoring.

The following report details research and findings of this work, outlining clear conclusions, recommendations and proposed next steps to further this idea from initial concept to operational demonstration site(s).

2 Methodology

A thorough methodology was deployed to provide an evidence-based study to establish the demand and feasibility for the proposed offshore demonstration and trial site(s) in English waters. This methodology is described below, including reference lists detailing stakeholders engaged at each stage.

Stage 1 – Desk-Based Research & Literature Review

The first stage of this work involved an extensive and in-depth literature review to establish background to the study and identify the existing provision of testing, trialling and demonstration sites relevant to offshore wind in the UK and internationally. This research is analysed and presented in later chapters to identify gaps in the existing provision, lessons learned, and best practices across existing demonstration areas.

Existing testing, trialling and demonstration sites were identified through internet searches utilising key words such as “offshore wind test site”, “offshore wind demonstration site”, “offshore test site”, “offshore demonstration site”, “offshore wind environmental testing”, and “offshore wind environmental demonstration”. When incorporating “environmental” as a key word, results tended to lean more towards different academic studies, instead of leading to test and demonstration sites that would have been beneficial for the work of this report.

Of the sites identified, those that incorporated environmental considerations and monitoring of environmental impacts across their activities were identified and highlighted. 46 sites were identified in total, and 14 sites were identified as having some consideration of environmental impacts as part of their objectives, though this was a secondary focus. Further details are provided in the subsequent chapters as well as in depth case studies in Appendix 1.

Stage 2 – Engagement of Key Stakeholders

A central source of information to inform this study was the targeted engagement of a range of stakeholders from existing trial and demonstration site operators to key consultees from government, Arm’s Length Bodies and SNCBs. The project team conducted over 15 direct and detailed discussions with statutory bodies, research organisations and industry representatives during the course of this research as listed below.

Firstly, to supplement the evidence gathered through stage 1, several demonstration sites across the UK were engaged and interviewed directly. Demonstration sites and facilities of most interest were selected in collaboration with Natural England and invited for interview. Though some European facilities were identified, the majority were UK-based, due to the likelihood that these may have encountered similar challenges, opportunities and constraints that any potential new UK demonstration site(s) may be likely to experience. Those agreeing to interview in the timeframes available, and whose feedback has been incorporated into the assessment detailed in the following report, are as follows:

- ORE Catapult’s Levenmouth Demonstrator Turbine
- ORE Catapult’s Robotics and Autonomous Systems (RAS) facilities in Blyth
- The European Marine Energy Centre (EMEC)

- Hywind II Scotland Pilot Project
- Celtic Sea Power, previously supporting delivery of Wave Hub in Cornwall
- HR Wallingford's Marine Testing Facilities

In parallel with the engagement with existing trial and demonstration sites, the project team arranged and hosted detailed discussions with the following government departments, Arm's Length Bodies, SNCBs, research, and industry representative bodies to gather their views on the project concept and inform the assessment completed within the study:

- Crown Estate
- Marine Management Organisation (MMO)
- Department for Environment, Food and Rural Affairs (Defra)
- Environmental Agency
- Centre for Environment, Fisheries and Aquaculture Science (Cefas)
- NatureScot
- Offshore Wind Industry Council's Pathways 2 Growth (P2G) Workstream
- Offshore Renewable Energy Catapult
- ECOWind Programme Team

Time restrictions meant it was not possible to have one to one discussions with the Joint Nature Conservation Committee (JNCC), Natural Resources Wales (NRW) and the Department of Agriculture, Environment and Rural Affaires (DAERA) of Northern Ireland among others, as well as international demonstrator sites. Whilst many of these stakeholders were able to participate in the stakeholder workshop later within our methodology, it is recommended that future workstreams look to engage these stakeholders further.

Details of these one-to-one consultations are discussed in the main body of this report, as well as being detailed further in Appendix 3 to this report, indicating where bodies were supportive of the concept overall.

Stage 3 – Online Survey of Potential Users

To further inform the assessment of demand and requirements for the proposed trial or demonstration site(s), a widely distributed, industry focused survey was developed and released to engage potential users in consideration of such a facility. The survey, designed by the project team and approved by Natural England in advance of distribution, sought to gather feedback on previous testing and demonstration activities undertaken in the past, and future requirements for demonstration and testing sites/facilities in the future.

The survey questions, which were made available and completed via the freely accessible online survey platform Microsoft Forms, are provided in Appendix 4. Respondents to the questionnaire were largely from the offshore wind supply chain sector and are included in Table 1.

Table 1. Respondents to the online survey assessing demand and requirements for environmentally focused trial / demonstration site(s) in the future

Contributing Company	Description of their main activities
Armultra Ltd	A leading engineering services company based in the East of England and working across energy and renewables sectors supply chains offering fabrication, offshore construction, decommissioning and rope access services, petrochemical and vessel, resource solutions and personnel training.
Blackfish Engineering Design ltd	Blackfish is one of the UK's leading names for engineering design and development in Tidal, Wave and Offshore Wind sectors; they also have extensive Development & Test capabilities, where they have produced prototype devices, scaled devices, full size test rigs as well as serial production units.
bp	A leading energy provider active across Oil & Gas, Carbon Capture & Storage, Hydrogen, Offshore Wind, Solar and Retail sectors. In partnership with EnBW, bp are developing offshore wind projects in two major UK locations with Morgan and Mona in the Irish Sea and Morven in the North Sea.
DOF Subsea	DOF Subsea offer a range of integrated subsea and marine services to offshore energy and other subsea sectors from construction and installation, inspection, maintenance and repair, decommissioning services, as well as building and managing purpose-built vessels.
Forsyths Ltd	Forsyths Ltd is the fabrication arm of the Forsyth Group based in the North East of Scotland. With six fabrication sheds over two sites which include excellent dockside facilities, Forsyths offer the oil & gas and renewables sectors design and manufacture services in a wide range of equipment in numerous different grades of material. Typical fabrications include structural steelwork, piping, pressure vessels, umbilical/pipe reels and tanks. Together with their E&I and coatings group companies they also provide a complete in-house solution for preassembled skid units.
Glacier Energy	Glacier Energy provides a range of specialist products, services and engineered solutions to support new and existing energy infrastructure from Heat Transfer, Machining, and Welding Solutions to Inspection and NDT Services to maximise performance and prolong life of critical assets in Renewables, Oil & Gas and other Power Generation and Industrial sectors.
Instrument Transformers Limited	Instrument Transformers Limited design and manufacture low voltage current and voltage transformers for a wide range of equipment; GIS Switchgear, Vessel Propulsion, Substation Automation, Power Factor Correction, Tariff Measurement & Power Plant Protection to name but a few, supplying their transformer and sensor technology across renewables sectors both on and offshore.

Contributing Company	Description of their main activities
Offshore Wind Power Systems of Texas LLC	With 30 years of experience in the Offshore Energy Industry, Offshore Wind Power Systems of Texas LLC were created to pursue opportunities in the development of the innovative and patented Titan Mobile Self Installing Platform offering a solution for deep water offshore wind installations across the globe.
Anonymous Respondent (wished to remain anonymous or did not provide consent for their participation to be credited)	An ocean services provider offering oil and gas, offshore renewables, and other non-energy clients a full range of services from surveys, engineering, project management, and installation to maintenance and recycling.
Anonymous Respondent (wished to remain anonymous or did not provide consent for their participation to be credited)	A supply chain company offering a full range of supply and service support packages for all electrical rotating plant and accompanying equipment. With an established track record in the design and supply of both medium and high voltage motors, generators and associated equipment, this provider offers supplies to the power generation sectors, including renewables and oil & gas, as well as process and mining sectors.
Anonymous Respondent (wished to remain anonymous or did not provide consent for their participation to be credited)	Leading suppliers of safety equipment, training and consultancy services this supply chain company supplies trusted life critical safety products to a wide range of industries including the Power Sector, Oil and Gas, Offshore Renewables and Construction.

Stage 4 – Interim Reporting and Stakeholder Workshop

Based on the evidence gathered via the above stages, the project team undertook an initial analysis and compiled an interim report detailing project activities to date, key stakeholders consulted, feedback received, and findings identified.

On review of the interim report and through discussion with Natural England's project team, it was identified that a secondary stakeholder engagement would be beneficial. This offered the opportunity to validate initial analysis, and further build upon emerging conclusions and recommendations of the report through open and candid discussion amongst invited consultees.

This further stakeholder engagement was facilitated in an online workshop (22nd March 2023), with selected key stakeholders and consultees invited. The workshop was arranged and facilitated by Opergy, with key input from Natural England. The agenda included two key elements; firstly, a presentation of interim findings, followed by a facilitated discussion guided by pre-designed discussion questions, to gather further views of the workshop attendees.

The project team were joined in the workshop by the following attending organisations:

- Natural England
- Crown Estate
- Marine Management Organisation (MMO)
- Department for Environment, Food and Rural Affairs (Defra)
- Environment Agency
- Centre for Environment, Fisheries and Aquaculture Science (Cefas)
- Joint Nature Conservation Committee (JNCC)
- Department of Agriculture, Environment and Rural Affairs (DAERA)
- National Resources Wales (NRW)

Stage 5 – Finalised Conclusions, Recommendations and Reporting

In this final stage of this project, building upon insights and analysis throughout the methodology and refined by the stakeholder workshop held in stage 4, the project team refined and finalised the project report, including clear and concise conclusions and recommendations.

3 Existing Provision and Lessons Learned

The first objective of this research has been to identify best practices and lessons learned from successful demonstrator sites. Through a detailed literature review and direct engagement with a selected number of test and demonstration sites, this chapter presents a review of a range of different processes for establishment, design considerations, financing, key stakeholders and governance and management models for existing trial and demonstration sites/facilities across the UK and internationally.

The initial literature review identified and assessed 46 offshore trial and demonstration sites both in the UK and abroad. These facilities primarily covered offshore wind, however some catering more specifically for wave and tidal energies or offering more generalised demonstration and testing infrastructure were also included. Of the 46 assessed, 14 have some form of environmental impact feature within their scope, though it proved a challenge to identify trial or demonstration sites that focus solely on that element. A table detailing all sites identified is provided in Appendix 2.

3.1 Establishing Existing Demonstration Sites

The literature review first considered the motivations and process for establishing existing demonstration sites.

Motivations for establishment were found to be mostly commercial, something Case Study 1 (overleaf) alludes to, with the process for taking sites forward involving multiple stakeholders and organisations across government, industry and academia. It was also found to be a process that can take several years to move from an initial concept into full operation.

In the UK, the Crown Estate has been heavily involved in existing demonstration sites, given it is responsible for granting the lease for the seabed. Other common permissions needed include a section 36 consent[5] from the Secretary of State or MMO under the Electricity Act, referring to proposals for the construction, expansion, extension or operation of any offshore generating station above 1MW in the case of wind, wave or tidal power. Pre application assessments may also be required, such as onshore and offshore surveys and public consultations to inform Environmental Impact Assessments, Habitats Regulation Assessments[6] and Marine Conservation Zone Assessments.

Looking at test and demonstration sites specifically, they may make use of using a Rochdale Envelope approach[7]. The Rochdale Envelope provides flexibility in design options when details of the project are not yet fully available once the application is submitted, though still ensures that the worst-case scenario impacts of the final development are fully assessed during the Environmental Impact Assessment. Consents or Marine Licences are then granted to include conditions on the final details for agreement before construction takes place. Should any projects using the test and

[5] Generating energy offshore – MMO
[6] Marine Licensing: impact assessments - MMO
[7] Using the Rochdale Envelope - IEMA

demonstration area have components or impacts that fall outside of the parameters of the design envelope, further assessments are likely to be required prior to deployment at the site. Examples of the Rochdale envelope licensing process considerations are explored further in section 5.3.

Case Study 1: ORE Catapult's Levenmouth Demonstration Turbine

7MW Levenmouth Demonstration Turbine. Image credit: ORE Catapult Picture Library – free-to-use for publications with registration.

The Levenmouth Demonstration Turbine is a good example of how a demonstration site can grow from an existing facility. Located at the Fife Energy Park, it was developed by Samsung Heavy Industries for use to prove the technical capabilities of its turbine designs. The facility was built in 2013, but Samsung Heavy Industries came to the decision to withdraw from Fife, leading to the sale of the facility to the Offshore Renewable Energy Catapult for research purposes. It was awarded a section 36 consent from the Scottish government to operate the turbine until 2029 and has since attracted 98 Small Medium-sized Enterprises for technology development, testing or demonstrations, with the facility becoming a core asset in its research and development programme.

A key feature of the 7MW Levenmouth Demonstrator Turbine is its location just meters off the coast allowing access via a short platform which supports efficient access for research, development and testing.

3.2 Design Elements

When exploring the design and development of existing facilities available, it was concluded that there is no standard template for test and demonstration sites, although there are some common elements that many seem to share, including:

- A presence onshore and offshore
- An ability to offer representative conditions of what the technologies being tested would be facing offshore, such as water depth; weather conditions; and seabed conditions.
- Complementary infrastructure to maximise the benefits of the research and development activities being carried out.

Of the sites open to multiple users – as covered in Appendix 1 – demonstration areas vary widely in size. Smaller facilities include SEM-REV off the French coast, which is the smallest identified within the literature review, with just a 1km^2 test area which is grid connected. The Offshore Test Site run by the North Sea Farmers in the Netherlands, which is explored in greater depth in Case Study 2, covers a total area of 6km^2, split into six different 1km^2 areas. In contrast, other sites such as the German National Test Field for Offshore Wind Energy (NaT-Off[8]), offer much larger trial zones, this one being one of the biggest research sites identified spans 13km^2.

The size of the facility is dependent on what it is looking to accomplish. The North Sea Farmers' Offshore Test Site has a fairly specific aim to test new innovations in line with its mission to "make positive climate impact with seaweed". The NaT-Off site is substantially larger than many others identified reflecting its aspiration to test new technologies and innovations to support Germany's climate objectives. Further examples of large scale projects aiming to demonstrate next generation technologies such as floating offshore wind innovations at scale include the 100MW proposed Erebus test and demonstration project, which is set to cover 32km^2 and the Llyr Project, which is to comprise of two 100MW demonstration projects using different floating offshore wind platform technologies, and consist of two 50km^2 areas of search – though the eventual extent of the area will be reduced once appropriate site investigation and detailed design work is complete.

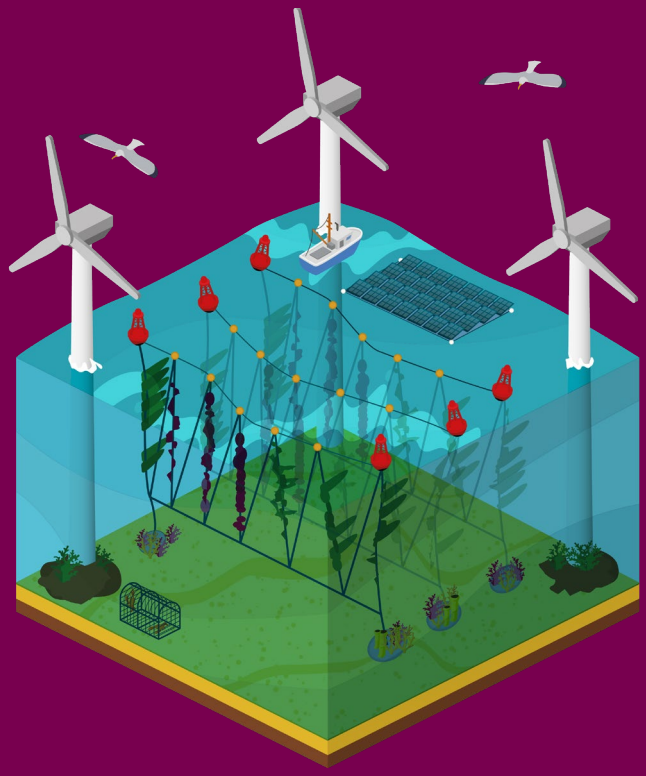
Those sites with associated infrastructure, such as multiple turbine arrays and cables, tend to be situated further from the shore. The Offshore Test Site and SEM-REV are 12km and 20km from shore respectively, whereas the Research at Alpha Ventus (RAVE) initiative in Germany, which features 12 wind turbines and a 100m high measuring mast is around 60km from the shore. Water depths also vary, sometimes under one testing umbrella – take the European Marine Energy Centre (EMEC) as an example with its sites. The Billia Croo wave energy test site has five cabled test berths at 70m depth, while the Fall of Wareness grid-connected tidal test site has seven cabled test berths at depths that range between 12m to 50m. The Shapinsay Sound scale tidal test site and Scapa Flow scale wave test site both have depths of 21-25m.

[8] Site Conditions – Nat-Off

Of the existing trial and demonstration sites highlighted here, a wide variety of sites are identified offering a diverse range of characteristics from size of facilities, water depths, distance from shore and infrastructure installed on site. As noted above, these overall design elements must be determined by the aims of that particular site and the anticipated research topics that are likely to be explored on site. Some of the smaller existing sites identified, such as the Offshore Test Site in the Netherlands, are looking to test specific innovations and as such do not demand a huge area. Whereas demonstration projects such as Erebus and Llyr are striving to show how floating offshore wind technologies can work and how viable they are, therefore they must be larger in order to demonstrate the full impact these technologies can have on the net zero agenda.

It is worth noting that the Llyr project's size has not yet been determined, with site investigation and detailed design work to determine its eventual area, indicating the

Case Study 2: North Sea Farmers' Offshore Test Site



Visual of a seaweed farm in between a wind park. Image credit: "North Sea Farmers" – North Sea Farmers Press Kit.

The Offshore Test Site, devised by the North Sea Farmers to support its mission to "make positive climate impact" with seaweed, is situated 12km off the coast of Scheveningen in the Netherlands and is considered a "breeding ground for start-ups and scale-ups that want to test their innovations in demanding offshore conditions". It secured a 6km^2 area of the North Sea, offering a "safe environment to test new innovations", which it has split into six plots, all covering 1km^2, with no fishing permitted in the area. It is guarded 24/7 and offers users the ability to dive and investigate the pilot underwater, knowledge and experience sharing with other Offshore Test Site users, weather forecast modelling, real-time data measurement of offshore conditions and a whole host of other sensors and equipment.

importance of keeping an open mind throughout development. Continued discussions with stakeholders will of course be paramount throughout this.

3.3 Financing Methods

The facilities explored through the literature review were financed through multiple sources including both public and private investment, with the latter coming from developers and the supply chain companies.

Considering the scope of this study, the focus is on sites in the UK, where the European Regional Development Fund[9] was commonly featured as a funding source. Since the UK's exit from the European Union, the European Regional Development Fund will no longer be an avenue future sites can explore, it is since replaced by a UK Shared Prosperity Fund[10].

The UK Shared Prosperity Fund is being described as a "successor" to some EU Structural Funds and the European Regional Development Fund is cited specifically in that context, as is the European Social Fund.

Section 5.4 explores potential funding requirements and sources of investment for any future development in greater depth.

3.4 Partners and Stakeholders

While each site will have specific partners and stakeholders depending on the region and commercial interests, exploring this question did help to get an idea of some of the key players in this field, such as the Offshore Renewable Energy (ORE) Catapult[11], which is perhaps hardly a surprise given that research and testing and validation are among the key areas of its work.

A primary takeaway here, though, is perhaps the make-up of the partners and organisations involved, going site by site. Commonly, it was found that stakeholders span multiple sectors. Take the European Marine Energy Centre[12] (EMEC) for example, which lists the Carbon Trust, Orkney Islands Council, Highlands and Islands Enterprise, HIE Orkney, the Scottish government, UK government, Scottish Enterprise and the EU as partners. In Germany, Research at Alpha Ventus (RAVE)[13] lists the universities of Hannover, Oldenburg and Stuttgart as its largest research partners, along with Siemens Gamesa Renewable Energy, DNV-GL, UL International and OFFIS e.V. Institute for Information Technology.

From this, it can be seen how the sites bring together partners and organisations from industry, academia and government, showing how test and demonstration sites can be of relevance to a range of different parties, also perhaps showing how important it is to

[9] European Regional Development Fund – European Commission
[10] UK Shared Prosperity Fund: prospectus – UK government
[11] Offshore Renewable Energy Catapult – ORE Catapult
[12] "Funders" - European Marine Energy Centre (EMEC)
[13] About RAVE - RAVE

involve a broad range of stakeholders in a management unit or advisory board when setting up a site. Further recommendations related to this have been made later in this report.

3.5 Management Methods

While not offshore wind related, the Tidal Thames Test Site[14] and Falmouth Bay Test Site[15], both of which focus on wave and tidal energy, offered detailed pictures on how each site is managed and operated, which may be transferable to this project.

The Tidal Thames Test Site requires[16] an operator to provide sufficient information to reassure the Port of London Authority of the dimensions and mechanisms of the system proposed, to facilitate the use of appropriate lights and radar reflection in the design, and that the operator will undertake regular inspections of mooring lines and maintain ropes and securing points to prevent breakout from the mooring.

The operator also has to notify the Port of London Authority (PLA) of how long it is planning to use the site at least two months in advance, while also having the relevant agreements and consents in place as available for inspection by the PLA. The operator must also be responsible and suitably insured for any damage that must be put right to the infrastructure and river assets in the vicinity of the mooring as a result of its activity. It will be expected to collect and share relevant data during the full-scale trial to satisfy requirements from the PLA, as well as any additional requirements from the Environment Agency.

The Falmouth Bay Test Site (FaBTest) is overseen[17] by a regulatory body that has two permanent members – Falmouth Harbour Commissioners (FHC) and the University of Exeter. There is a steering group that supports the FHC, with representatives from industry, academia, agencies and others.

The regulatory body, meanwhile, has a specific focus on implementing a diligence process to establish that each FaBTest installation proposal meets with the requirements as set out by marine FHC regulations, the Crown Estate lease and good practice in accordance with stakeholder expectations. The regulatory body will then advise and inform decisions to approve or decline an application for berth at the Falmouth Bay Test Site.

3.6 Site Offerings

The services and facilities provided by existing test and demonstration projects vary, depending on the aims and objectives they are pursuing. From the literature review, as detailed through appendices 1 and 2, a set of commonly offered infrastructure, capabilities, and support interventions for site users can be identified. Examples of these

[14] Tidal Thames Test Site - Tethys
[15] FaBTest – Falmouth Bay Test Site
[16] Tidal energy and its importance – Port of London Authority
[17] Guide to Deployments and Application Process Requirements – Falmouth Bay Test Site

which could potentially be considered as part of a suite of measures available at any new test and demonstration site(s) are provided in table 2.

Table 2. Infrastructure and project support site offerings commonly made available at existing test and demonstration sites

Infrastructure	Project Support
• **No energy production** • **Energy dumped on site** • **Energy storage on site** • **Cables to connect to the grid network** • **An onshore/offshore substation** • **An onshore/offshore met mast** • **Wave rider buoys** • **DCP profiler measuring conditions such as turbidity, conductivity and temperature** • **Passive acoustic monitoring systems** • **An onshore research centre, analysing data** • **Fibre optic cables for data transmission** • **Floating Lidar system** • **Floating platform**	• Supporting SME to access funding streams, including grants and loans • Supporting developers in relation to access, vessels, divers • Support in relation to transport and logistics, as well as wet storage areas and harbour access

To explore some specific examples, the North Sea Farmers' Offshore Test Site in the Netherlands offers the opportunity to dive and investigate the pilot areas underwater, an ability to share logistics costs, essential vessels that can transport materials from the mainland to the test area, as well as some of the aforementioned measurement tools – real-time data measurement of the offshore conditions of Turbidity, Chlorophyll-A and conductivity and temperature, as well as a DCP Nortek profiler and DAS module.

SEM-REV in France is clearly marked out by cardinal buoys, features a hub that enables the simultaneous operation of three machines, as well as a research centre back at Penn-Avel that receives and analyses data, controls the test devices and is staffed by a dozen researchers and engineers. Looking to Spain, the Biscay Marine Energy Platform (BiMEP) has a seabed that is mostly sandy, though does feature some rocky areas. It provides historical data from a metocean buoy that has been installed in the area since 2008, has four subsea cables (13.2kV/5MW) filled with optic fibre, an onshore substation and resource management that uses an oceanographic buoy and floating Lidar System.

Certain centres also have multiple sites, catering to different research needs, such as the European Marine Energy Centre's test sites[18]. The EMEC has two grid-connected test

[18] Facilities – European Marine Energy Centre

sites, one for wave energy, another for tidal, which feature coastal 11kV control and switching stations, 13 subsea cables across the pair connected to the UK grid, data transfer through fibre optic cables which allows for remote access, metered power output from the test devices, comprehensive supervisory control and data acquisition systems that enable real-time monitoring, wave, tidal and environmental baseline data collection, full confidentiality of data and CCTV monitoring.

The EMEC scale-testing sites are designed for smaller scale devices in less challenging conditions. Each site offers berths with mooring points, specifically designed test support buoys for electricity dissipation and remote communications with the device, areas of seabed for rehearsal of deployment techniques and a simplified consenting process, given that EMEC holds an overall license.

Another example is the Marine Energy Test Area in Wales (Case Study 3), which is explored in greater depth below.

Case Study 3: Marine Energy Test Area (META)

The Marine Energy Test Area has eight pre-consented test sites split into two phases – META quayside (*pictured, credit: META Wales*) which supports testing activities such as component testing; operational testing; research and innovation; deployment and retrieval methods; and health and safety procedures. It has five sheltered easily accessible sites. The META Open Water phase, which has three sites further offshore with far greater resource exposure.

The META Open Water sites are able to support open water testing activities, such as scaled tidal devices, micro tidal devices, instruments, components and subassemblies, ROV (remotely operated underwater vehicle) or other monitoring equipment, site preparation methodologies, decommissioning methodologies, salvage methodologies, research and innovation, full-scale wave energy converter device testing, scaled wave energy converter device testing, component testing for floating offshore wind technology, and support structures, moorings and foundations.

The main services META can offer developers are consenting, mobilisation, supply chain, project management, data support, operational management, site permitting and risk management services, technical support and marine energy hub office facilities. Alongside Marine Energy Wales, it is also able to offer grant funding bid support, market and building brand awareness, business development, a springboard to demonstrate technologies at Welsh demonstration zones, and stakeholder and community engagement.

3.7 Observing Environmental Impacts

Through the literature review, a range of different environmental monitoring options provided from various test and demonstration areas have been identified, such as in the case of the Marine Energy Engineering Centre of Excellence in Wales, which allows access to the expertise of its university partners, including Swansea University's Energy and Environment Research Group, who offer environmental impact identification. In France, developers and other users at SEM-REV can also benefit from support with environmental impact assessments through the industrial and research network which is a part of services provided by the site.

EMEC's grid connected test sites[19] [20], meanwhile, set a number of monitoring measures for deployment at the site with environmental impacts in mind, such as site-wide monitoring of wildlife abundance and density, something EMEC itself will deliver but if unable to fund or conduct itself, will call on developers to contribute accordingly. It also includes focal studies on animal behaviour in the vicinity of the devices and marine works, including use of underwater lighting and monitoring for fish or bird attraction and collision risk for predators.

Notably, the environment also appears to be a focus for projects devoted to commercial testing too, such as the Llŷr Project and CADEMO projects, both coming from Floventis Energy[21], the former seeking to accelerate the adoption of floating offshore wind technology through meaningfully addressing any short or long-term impacts to sensitive ecosystems, commercial fisheries or other maritime users, while the latter wants to validate fish and wildlife impact and mitigation measures.

From the literature review it appears there is a range of environmental monitoring provisions made available at existing and established sites. In many cases, the operators of demonstration areas can support developers / users to develop their monitoring plans, providing guidance, best practice and contacts to appropriate subcontractors to support the monitoring activity. This is the case at the Marine Energy Engineering Centre of Excellence in Wales, which calls on the universities it is associated with to support users in this area. Other sites offer a complete suite of on-site monitoring equipment which can then be accessed by users, or deployed by site operators, to monitor impact on behalf of those demonstrating technology on site. as seen with the European Marine Energy Centre, as discussed above.

For future offshore demonstration sites, the monitoring program should be determined by the evidence priorities as well as any requirements or restrictions made through the funding on offer. Engagement with the right organisations, including research bodies, will be key in ensuring monitoring programs are scientifically robust and contribute to evidence gaps and the reduction of consenting risk.

[19] Grid-Connected Wave Test Site – European Marine Energy Centre
[20] Grid-connected Tidal Test Site – European Marine Energy Centre
[21] Green Energy out of the Blue – Floventis Energy

4 Establishing Market Demand

The second objective of this research study has been to assess the market demand and support for the proposed demonstration site(s) in English waters through engagement with industry, SNCBs, regulators and the Crown Estate.

Through a broad engagement and consultation exercise with a number of statutory bodies, regulators, research bodies and industry representative groups, as well as through a targeted survey with potential future users of the proposed demonstration facility, this research has sought to identify the types of technology or approaches industry have a need to test, what industries main requirements for a test site would be, and to identify perceived barriers to the development of a demonstrator site(s). This chapter outlines findings from this research and summarises what considerations this indicates for the development of a demonstrator site(s) in the future.

4.1 Direct Engagement with Key Stakeholders

In compiling this report the project team engaged with a wide range of key stakeholders, holding over 15 direct and detailed discussions with statutory bodies, research organisations and industry representatives, followed by a focused workshop session to validate initial findings and receive further stakeholder views. All stakeholders consulted during initial one-to-one interviews, and the workshop event are detailed in Chapter 2 – Methodology.

Stakeholder feedback received during interviews and workshop sessions related to the demand for, and key requirements of, the proposed trial / demonstration site(s) are detailed below. Further detailed information on the comments of stakeholders interviewed, particularly on their support for the concept of new trial and/or demonstration sites with a focus on environmental issues, are provided in Appendix 3.

Is there an appetite for this sort of site?

The stakeholder consultations, both one to one and workshop sessions, revealed a real enthusiasm and active interest in the concept of environmentally focused trial or demonstration site(s) amongst statutory bodies, research organisations and industry representative bodies alike.

The Crown Estate told Opergy that the site could link to a lot of things they are currently trying to do or wider workstreams they are involved in with offshore wind, describing it as a "*really helpful piece of the puzzle*".

Defra could also see the benefit of such a testbed, indicating it could offer a valuable location for research and development activity in both offshore wind and other marine sectors. Defra also identified many areas of ongoing work including the development of Environmental Design Standards and strategic mitigation measures for offshore wind which could be supported by information gathered on minimising the environmental impacts of such a site.

The MMO similarly identified their support for a demonstration site(s) with a focus on addressing environmental impacts, indicating that research on such a site(s) could fill gaps

in information and provide valuable evidence to support offshore wind Environmental Impact Assessments submitted by developers as part of their licence applications.

The OWIC Pathways to Growth Group also indicated that they would be "*very interested*" with a test area potentially offering a platform to ensure mitigation technologies are fully tested in the field, looking to 2030, and can then be used by developers going out to 2050 to meet net zero targets.

The concept was welcomed by Cefas, who acknowledged it could help to address questions over how fishery species respond to different technologies and would give them an opportunity to build on work that could have a conservation focus but link it to the ecosystem as a whole.

As Scotland's Nature agency, NatureScot were also supportive of the concept for environmentally focused trial and demonstration site(s), indicating they would be open to further discussions around suitable locations in Scotland. They highlighted the already quite extensive existing provision of demonstration facilities in Scottish waters, particularly citing the European Marine Energy Centre and Offshore Renewable Energy Catapult facilities which may offer related provisions but recognised that their *"…focus has been around demonstration of wind turbine technology as opposed to the environmental aspects*".

The Offshore Renewable Energy Catapult indicated that, through their experience of working with multiple organisations across the offshore wind industry, many companies, particularly SMEs, have reported significant difficulties in receiving permissions for access to the seabed for short-term research and demonstration projects. This has been due to concerns from regulators around potential impacts of the activity, and crucially of responsibility for returning the seabed to its original state on completion of the works. Representatives of OREC therefore considered that a purposefully defined and designated area of the seabed for this purpose could complement existing Test and Demonstration facility provision and offer a valuable resource for those seeking to monitor real life environmental impacts of their technologies and/or solutions.

Celtic Sea Power adopted something of a more cautious tone, however, explaining companies are probably more interested in commercial opportunities than test and demonstration projects. Celtic Sea Power suggested focusing on sites that have already been leased could be a better way of establishing evidence and building a data bank on environmental issues, rather than a new site.

Whilst the initial brief for this work concerned establishing a site in English waters, during one-to-one discussions and the workshop session, there was also an openness to further consider the concept of a network of trial /demonstration site(s) across devolved administrations. Organisations including NatureScot, National Resources Wales, The Joint Nature Conservation Committee (JNCC), and Department of Agriculture, Environment and Rural Affairs (DAERA) all indicated their interest and willingness to continue discussions on the suitability and added value their regional sites and existing demonstration facilities may offer as a location for a single or network of environmentally focused test and demonstration sites.

Which areas of research should be targeted?

During engagement with stakeholders, the project team asked stakeholders what areas of research would be valuable to explore, or where gaps in knowledge exist, in terms of the

potential environmental impacts across the offshore wind project lifecycle. Within the summary table provided (Table 2), suggested areas of research have been divided into categories depending on the phase of the offshore wind farm life cycle:

- Construction / Installation
- Operations and Maintenance (O&M)
- Decommissioning
- Impacts occurring across Multiple Lifecycle Stages
- Cumulative Impacts of Increasing Levels of Offshore Wind

Table 3. Valuable Areas of Research for any new Demonstration Site(s) with a Focus on Environmental Impact, as Suggested by Stakeholders Consulted

Lifecycle Phase	Area of Research
Construction / Installation	• Impacts of cable trenching / laying activities, on installation and over time as the cables lay in situ • Trialling of noise mitigation technologies for use during particularly noisy installation activities such as foundation installation • Impacts of new anchoring systems for floating offshore wind on benthic habitats • Impacts of new catenary mooring lines for floating offshore wind on benthic habitats
Operations & Maintenance	• Prevention or removal of biofouling along with solutions to prevent marine growth on turbine structures and ladders • Solutions for protection of corrosion over time • Impacts of cable electro-magnetic fields (EMF) over a windfarm's lifetime • Research topics around scour impacts and scour protection over a windfarm's operational life, including artificial reef creation • Testing of access systems
Decommissioning	• Approaches to decommissioning • Demonstrating that scour protection can be removed successfully at end of life with minimal impacts • Impacts of leaving cable infrastructure in place as opposed to removal, requiring further disturbance related to trenching and seabed restoration activities
Impacts occurring across multiple lifecycle phases	• Monitoring and mitigation of noise levels particularly during construction / installation and O&M • Trialling different approaches to impact monitoring and data gathering • Demonstration of offshore refuelling of alternative fuels or electrification of vehicles

Lifecycle Phase	Area of Research
	• Trialling of measures that encourage biodiversity to recolonise / biodiversity enhancement in and around foundation structures or cable routes. • Demonstrating environmental design standards • Trialling of measures to achieve Biodiversity Net Gain/ Marine Net Gain at offshore wind farms • Approaches to digital transmission of data from offshore wind farm sites
Cumulative impacts of development of multiple offshore windfarms	• Cumulative and in combination impacts such as noise, temperature change, seabed disturbance from turbines across a whole wind farm. • Cumulative impact/cumulative effects in the context of marine spatial planning – how do you manage multiple conflicting, or overlapping impacts? • Research into the longer-term, cumulative anthropogenic impact on populations of fish, birds, marine mammals and benthic habitats. • Opportunities and impacts around co-location and coexistence with offshore wind and other marine industries and sectors • Demonstrating strategic mitigation and compensation methodologies

An impact pathway requiring further investigation that was raised by multiple stakeholders concerned the potential impacts of elevated noise levels, particularly during construction / installation and O&M activities, on marine life and the seabed ecosystem. It was noted that there have been uncertainties around what is an acceptable level of noise, over what durations elevated noise levels may become harmful, and acceptable distance limits between the site of noise generation and key environmental receptor groups for example fish or marine mammal populations. Defra, Cefas, and The Crown Estate highlighted this area as a "*big issue*" with the opportunity to test different types of foundations and noise mitigation technologies prior to commercial scale role out definitely of value.

The Offshore Renewable Energy Catapult's (OREC) Levenmouth Demonstrator Turbine operations team cited an example of a project they were unable to pursue due to uncertainties around the potential noise impacts. The project aim was to trial and demonstrate the effectiveness of a new solution to remove and prevent biofouling on the transition piece and turbine access points involving regular pulses of noise vibration at the turbine itself. The research team involved found it hard to get access to an area to test the methodology to prove that it was not too noisy without putting it into an environment where it was a danger to sensitive receptors. A specified area where they could test this, therefore, would be useful. However, this throws into focus an issue worth deeper exploration – how to find a trial site location where the impacts of the trials will not be a negative or, at least, finding ways to mitigate and manage for this.

A further particularly contentious research area, and one where it has proven particularly challenging to successfully licence, is activity requiring any sort of seabed intervention,

such as foundation installation, ploughs or cable laying which result in significant seabed disturbance. OREC Blyth Facilities explained that a designated trial or demonstration area where this could be facilitated safely would be valuable and should be considered a particular research topic for any new site. Similar to these areas of work, HR Wallingford suggested replacement technologies for scour protection or rock armour and concrete blocks for break waters is a further area of valuable research that could be trialled at an offshore test / demonstration site(s).

Cefas specifically raised the potential impacts of the Electro Magnetic Field (EMF) created by cables on certain sensitive fish and elasmobranch species over the lifetime of the windfarm. There have been concerns raised in the past that these may impact natural movements, behaviour, feeding and breeding among other things. A number of studies were carried out in the early 2000's on the impact of EMF but were largely inconclusive and mostly based on in-lab experiments rather than in the field. While impacts from EMF have not stopped the consenting of wind farms, it still hasn't been put to bed and with the emergence of floating offshore windfarms, it could bring it back up the agenda.

Further research areas exploring the wider impacts on fish, bird and mammal species were also suggested by multiple stakeholders, particularly considering and exploring the long-term and cumulative impacts of multiple offshore wind developments, alongside other energy and infrastructure projects in crowded areas of the seabed. A deeper understanding of the long-term impacts on fish population, spawning areas, nursery grounds, as well as impacts on bird life, and marine mammals including behaviour change and potential impacts on migration pathways was considered valuable.

Some consultees also suggested trialling of different data gathering and site monitoring approaches, testing both methodologies and equipment, may be an area of value.

During the workshop session, Cefas highlighted that, during the Deemed Marine Licencing process and within the Development Consent Order (DCO) issued by the Secretary of State, offshore wind developers may receive instructions or conditions to undertake additional research, trials, or monitoring of particular elements of their project development proposal. A recent example includes a requirement issued to one developer to undertake further trials of a Conditional Flow Device proposed to dredge offshore cable routes into the seabed. It was suggested that research areas spinning out of the licencing and DCO process should be captured centrally and could be tested at a demonstration site such as that suggested here, rather than owned and delivered by the developer independently.

A final research area of particular note, suggested by stakeholders including Crown Estate, Defra, MMO, Natural England and the P2G working Group, were the identification of cumulative impact of multiple offshore wind farms and other marine industries and the opportunity to test approaches to, and impacts of, co-location and co-existence with offshore wind and other neighbouring marine industries. This was considered particularly important by Defra who highlighted that a greater understanding of the impacts and opportunities in this area could inform future marine spatial planning / marine spatial prioritisation.

Research conducted within a test and demonstration site(s) could facilitate filling priority evidence gaps as identified on the Offshore Wind Environmental Evidence Register (OWEER). Led by Defra, the OWEER was created by JNCC with input from several contributing organisations, for The Crown Estate's Offshore Wind Evidence and Change (OWEC) programme. This Register draws together the key evidence gaps around offshore wind environmental impacts as well as documenting research projects recently completed,

in progress and in planning, that are relevant to reducing these evidence gaps. The OWEER is available from the Marine Data Exchange.

Site and Locational Considerations

Throughout consultations, stakeholders were asked to reflect on potential site locations for the proposed activity, which may include opportunities for new areas of the seabed identified for this trialling and demonstration activity as well as for utilising existing demonstration and/or commercial project sites as part of a 'network' of locations made accessible for this activity.

All consultees saw the value of incorporating existing infrastructure, including existing testing and demonstration sites as well as commercial offshore wind projects where appropriate in a designated 'network' of locations where trialling or monitoring of environmental impacts could be encouraged and facilitated. It was recognised that this could enable informative and valuable trialling where infrastructure is already in place, thus saving some considerable development costs and ensuring research projects can get off the ground quickly. This would also ensure that provisions are not duplicated which was raised as an area of caution by Celtic Sea Power.

Equinor, the operators of the Hywind Pilot Floating Offshore Wind Park in Scotland, highlighted that they, like many other commercial developers and operators, have previous experience of working with selected partners to trial new technologies and approaches within their offshore wind farm areas. Equinor indicated that in these cases, whilst they have had a high degree of cooperation with the companies seeking to deliver demonstration projects, they do not own the portion of seabed in which their project lies and could not on their own prohibit offshore trialling activities in these locations with the exception in cases where direct interactions with their infrastructure is required. They indicated an openness to supporting future trialling and demonstration activities on their site where appropriate and mutually beneficial and highlighted numerous other stakeholders that should be considered and consulted including but not limited to regulatory and licencing bodies the Crown Estate and MMO, local and regional authorities, and other users of the sea including fishing and tourism users.

All other consultees identified a willingness to work with a future network of test and demonstration sites. Many highlighted productive relationships they already hold with other research organisations and universities to share resources and data for the purposes of furthering research topics investigated on behalf of themselves and their clients or users.

During the course of this research the Opergy project team identified and engaged with the delivery partners of the ECOWind Project[22], which at the time of this research was exploring best practices in the use of commercial offshore wind sites for research purposes, encouraging developer/operator and research communities to interact with one another in a cooperative and mutually beneficial manner. Given the findings of this work, suggesting it may be beneficial for any new trial and/or demonstration site provision to include a network of possible locations that may include existing demonstration sites and/or offshore wind farms themselves, reference is made, in the case study provided, to

[22] ecowind.uk

insights gained through attending a consultation workshop hosted and facilitated by the ECOWind Project. With representatives of the offshore wind developer and academic research communities participating, the workshop highlighted best practice in facilitating effective and productive research activity at operational commercial scale offshore wind farms, further details of which are provided in Case Study 4.

In addition to utilising existing demonstration and/or commercial project sites for the trialling of environmental impacts, the consultation indicated strong support for the identification and leasing of new sites for this purpose. Anecdotal feedback from consultees suggested that any network of trial / demonstration sites should seek to offer a variety of different seabed environments to potential users, including different water depths, current speeds and flows, seabed environments, habitats, and species present.

The selection of a trial and demonstration site in relatively crowded areas of the seabed where cumulative impacts of multiple offshore wind developments, as well as other anthropogenic uses impact the seabed and environment, could be monitored in addition to smaller scale projects was considered valuable by some. Southern North Sea locations off the East and South-East coasts of the UK may offer this characteristic where the environment is impacted by multiple offshore wind and Oil and Gas developments as well as major shipping routes and historic fishing and tourist industries.

Consultees also considered links with the developing regional expertise in the Celtic Sea around floating offshore wind and wave and tidal sectors, suggesting the location as suitable for future demonstrations to understand environmental impacts in this location would be valuable. Site selection and activity here would need to be sensitive to, and complement, provisions at the Pembrokeshire Demonstration Zone, the proposed Erebus Floating Offshore Wind demonstration project, the Llyr projects and Fab test and other commercial and/or testing and demonstration projects within the region.

In selection of a new, open seabed trial or demonstration area, Defra highlighted the need to avoid the locations of new Highly Protected Marine Areas (HPMAs) as championed by the Secretary of State with an aspiration to monitor their condition and maintain their integrity over time. For reference, Allonby Bay in the North-West of England, Dolphin Head in the English Channel, and Farnes Deep in the North-East have all been designated pilot HPMAs.

Cefas indicated that in selecting a site for the purposes of environmental monitoring, it may also be advisable, if practical, to select a site where there is already monitoring underway providing an understanding of the existing status of seabed, habitats, and/or environmental receptors present. This would be hugely valuable when identifying changes and impacts as a result of the installation and use of a new technologies or interventions in an environment. The Clean and Safe Seas Evidence Group (CSSEG) monitoring program was referenced as a key source of monitoring data and information for some 20 offshore sites around the UK including monitoring physical, chemical and biological characteristics of sites within scope[23].

During the one-to-one stakeholder interviews and via the Opergy-led workshop, there were limited specific recommendations on potential sites offered by stakeholders

[23] Updated UK Marine Strategy Part Two, 2022 (publishing.service.gov.uk) - Defra

consulted beyond the commentary provided above. However, a key suggestion offered by some stakeholders during their one-to-one interview and raised again in the workshop with widespread agreement was that any trial location should be selected first and foremost for its suitability to provide a representative testing environment for the specific environmental impact and technology / process being trialled.

It has not been possible within the timeframes and budget of this project to develop a more detailed and visual geographical picture of the key characteristics of the subsea locations around the UK. However, recommendations for next steps for this work include producing maps indicating locations of the MPA network including HPMAs, key historic CSSEG monitoring sites, as well as existing infrastructure including existing offshore wind projects, test and demonstration sites, other marine industries to support the further discussion and identification of suitable locations for a network of environmentally focused trial and demonstration sites.

In summary, no specific sites for future development of a trial and/or demonstration zone were recommended through the stakeholder engagement. Whilst research highlighted that a ‘network’ of multiple sites offering a variety of characteristics through both existing demonstration and/or commercially operating sites, and potential new demonstration zones would be advantageous, it was suggested that suitable site location(s) should be explored and selected based upon the characteristics required to effectively fill evidence gaps, with key research hypotheses dictating the suitable locations in terms of:

- Seabed characteristics
- Water depth
- Meteorological conditions
- Representativeness/Rarity of habitats and species in the area
- Proximity to / presence of existing infrastructure
- And proximity to shore and/or portside access.

Case Study 4: Lessons Learned from the ECOWind Programme Workshop

The ECOWind Programme has funding of around £7.5 million, provided by The Crown Estate's Offshore Wind Evidence and Change Programme (OWEC) and by the Natural Environment Research Council (NERC), with support from Defra. The purpose of the programme is to address three challenging topics: How will offshore wind expansion, combined with other anthropogenic pressures, impact species interactions and marine ecosystems? How can enhanced marine observations, through innovative technologies, better inform our understanding of the effects of offshore wind on marine life? And how can understanding these first two challenges better inform marine policy and management, including marine environmental restoration and net environmental gain?

Following engagement with the ECOWind team, Opergy attended a workshop titled Understanding needs and requirements for site access at Offshore Wind Farms, where ECOWind brought together offshore wind developers and academic researchers to build an understanding of site access needs and requirements for research purposes at offshore windfarms in the UK. Discussions at the workshop were wide-ranging and identified key areas to develop towards brokering effective and productive relationships going forward. The following were the most prominent:

1. **CLARITY OF PURPOSE** - researchers being clear about their research goals, including why they are beneficial for industry, and ensuring this is communicated to the relevant decision makers and amongst OW developers. Simultaneously, clarity regarding access regulations versus recommendations, and on liabilities and responsibilities when on site is important to establish.

2. **EARLY DISCUSSIONS** - to effectively integrate into wind farm operations and overcome any obstacles, beginning discussions and relationship-building significantly in advance of intended rollout.

3. **BEST PRACTICE PRINCIPLES** - establishing a set of principles, for use by both researchers and OW developers, which define optimal inter-stakeholder relationships.

4. **GUIDE TO PROCESS** - a set of guidelines for researchers regarding how to communicate and collaborate to gain access to offshore wind sites, noting that much of the process will be site-specific.

The ECOWind Project Team are undertaking follow-on work to build upon the workshop findings and develop a guidance document highlighting key principles and recommendations to ensure effective engagement between academic researchers and offshore wind developers to facilitate increased research activity at commercially operating offshore wind farms. This is an important reference for the future development of any network of trial / demonstration sites incorporating this provision into the future.

4.2 Potential Users – Requirements Survey

To complement the targeted stakeholder engagement elaborated upon above, the process to establish market demand for this study included a widely distributed industry focused survey to engage potential users of the trial site and gather information on their specific requirements from an offshore demonstration site(s).

A total of 16 responses had been received by the industry demand survey, with 11 responses providing complete and meaningful feedback to the questions posed. Whilst providing some useful feedback as outlined below, it is noted that this is a lower-than-expected level of engagement with the survey. A full list of respondents who were willing to be credited for providing feedback to the survey is provided in the methodology set out in Chapter 2.

The survey questions posed are provided in the Appendix 3 to this report.

Survey Respondents

Responses provided were all from companies currently operating within, or looking to grow their services and operations across, the UK offshore wind sector. It is noted that with the exception of 1 respondent; bp, all other companies contributing feedback were representatives of supply chain companies supplying products and services across lower tiers of the supply chain. This may suggest that few developer / operators require the use of open access trial and demonstration sites. This is supported by feedback from existing demonstration site operators such as the Offshore Renewable Energy Catapult, as well as discussions held at the stakeholder workshop session, where it was identified that the likely user profile for any new test and demonstration site is anticipated to be dominated by innovative small and medium sized supply chain companies seeking to prove their concepts for sale to major projects or higher tier companies.

When asked to indicate in which UK regions they were operating, respondents indicated activity across the UK. The majority (64%) indicated they operate across the UK, as shown in Figure 1 (overleaf). A lesser number of responses stated operating in either the East of England or Scotland (18% each).

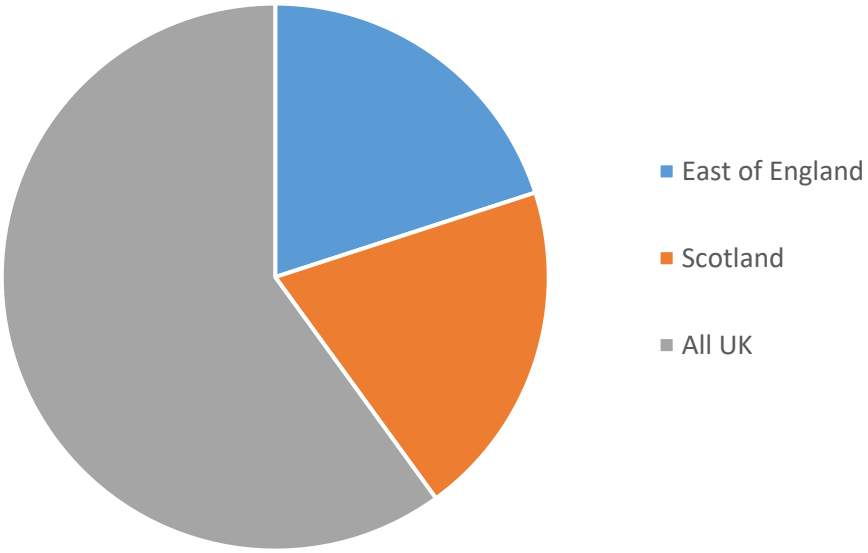


Figure 1. UK Region in which Survey Respondents Operate (includes 'All UK', 'East of England' and 'Scotland' with 'All UK' being the largest section)

Previous Experience in testing and trialling

Survey respondents were asked to elaborate on their previous experience in testing and trialling offshore wind technologies and approaches. Of the responses, just over half (55%) indicated they had completed previous testing or trialling activities either on and/or offshore.

Trialling activities previously undertaken by survey respondents included the development and demonstration of new component technologies such as generators, mooring systems, and an offshore crew transfer vessel (CTV) charging system with associated vessel electrical connection technology. One response indicated trialling new equipment for decommissioning campaigns, whilst others mentioned trialling technology for monitoring and inspection including a novel export cable monitoring technology as well as other inspection technologies and approaches.

A number of respondents indicated that they had previously undertaken monitoring of environmental aspects as part of their trial:

- One response mentioned environmental compensation measures including offshore nesting structures for endangered bird species.
- One respondent indicated specifically monitoring or measuring environmental impacts of their technologies as part of previous trials; undertaking an acoustic marine mammal baseline monitoring and data collection programme to help improve knowledge and understanding of the seasonal presence and movement of marine mammals, as well as conducting a sound measurement study for an offshore drilling activity to improve understanding of underwater sound characteristics for a typical Mobile Offshore Drilling Unit (MODU).
- Two smaller companies responding indicated that their customers had looked into the environmental impacts of their solutions more specifically, including monitoring of bird species interactions with a new bird house for offshore wind assets which was built and supplied by the respondent.

In terms of locations where previous testing was undertaken, one respondent indicated testing onshore at their own premises before moving offshore. Others indicated offshore or

open water testing in locations including Vobster Quay in Somerset and in the Faeroe Islands north of Scotland, or at offshore locations internationally. Three indicated utilising existing test and demonstration facilities as listed below, and one mentioned testing at multiple commercial UK offshore wind farms:

- Fort William Under Water Trials Centre (UTC)
- Blyth Offshore Demonstrator, Northumberland
- European Offshore Wind Development Centre at Aberdeen Bay

When asked if they had experienced any challenges or barriers to accessing trial / demonstration sites in the past, those who stated utilising existing test and demonstration site facilities indicated that they had found limited barriers. One mentioned they were able to specifically find trial sites that were suited to their testing requirements. Another indicated that installation being carried out by a third-party contractor significantly reduced their barriers to offshore trialling. For the respondent who indicated trialling at existing UK offshore wind farms, they did experience significant challenges in a reluctance of operators to trial new solutions offering potential improvements in current practice on commercially operating offshore wind sites.

One respondent indicated they had previously wanted to undertake environmental trials/demonstrate activities but had so far been unable to find a site with the right conditions/access.

Therefore, of the 11 meaningful responses from supply chain 2 reported difficulties in finding appropriate trial and demonstration areas for their service indicating a lack of access through existing provisions at commercial wind farms and testing sites.

Current and Future Requirement for Trial or Demonstration Offshore

The survey asked respondents to comment on their future requirements for technology trialling and demonstration, particularly looking at environmental impacts of their technologies and solutions.

Survey respondents indicated a variety of product, service, and technology innovations which may require offshore trials in the next 5 - 10 years. Examples included:

- The continued development of offshore CTV charging system solutions and vessel adaptions for offshore charging,
- Mobile, self-installing, 'Jack Up' turbine platform solutions including adaptions and full equipment for offshore desalinated/deionized water production and onshore green hydrogen production at high volume,
- To trial remote installation solutions for dynamic submarine cables for floating foundations,
- Installation techniques and tools utilising Unmanned Surface Vehicles (USVs), particularly during challenging met ocean conditions to establish operational windows and likely seasonal working patterns.

One respondent indicated they are supporting the Marine Resilience Initiative (MARIN) project[24] on seagrass restoration and coral rehabilitation. Part of the project is to test seagrass replanting techniques and monitoring of coral spawning, to assess the health of the seagrass beds and to assess carbon stock. This respondent also indicated their contribution to the innovative ECOWind project (as detailed above), the SERPENT Project[25] undertaking deep sea research using Remotely Operated Vehicles and the INSITE project[26], which is exploring the impacts of anthropogenic structures on the ecology of the North Sea.

When asked what stage of the project development process their product/service/technology is suitable for, many respondents indicated their solution was utilised at multiple stages of the development lifecycle, but most offered solutions for Construction and Installation and Operations and Maintenance. Figure 2 offers a full breakdown of the responses received.

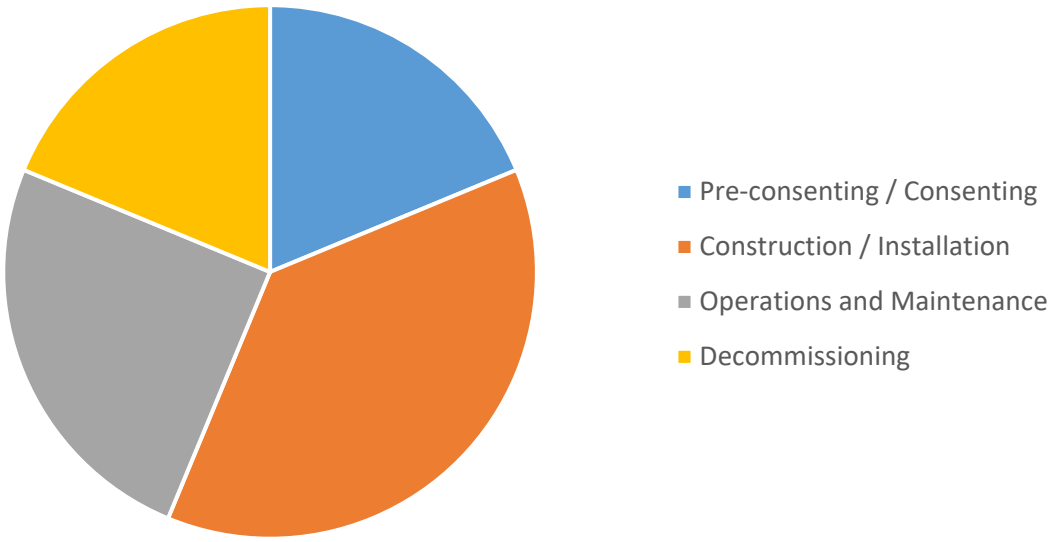


Figure 2. Phase in the OWF development lifecycle within which the respondents' products / services / technologies apply (includes 'Pre-consenting/Consenting', 'Construction/Installation', 'Operations and Maintenance' and 'Decommissioning'. 'Construction/Installation' has the largest pie followed by 'Operations and Maintenance' then 'Decomissioning' and 'Pre-consenting/Consenting')

It is notable that only two respondents to the survey indicated that they had previously undertaken any assessment into the environmental impacts of their new technology or solution; one undertaking noise and marine mammal monitoring, a second examining the CO_2 emissions of the solution. Whilst CO_2 emissions foot printing indicates a recognition that minimising and reducing carbon emissions is important, it does not indicate any recognition of the potential wider impacts such as on other environmental receptors that may be impacted by the deployment and use of their solution. Beyond the one respondent indicating a recognition of their potential impacts across marine mammals, benthic habitats

[24] The Marine Resilience Initiative, Tobago (Pilot Project) - IMA
[25] https://serpentproject.com/
[26] https://insitenorthsea.org/research-projects

and species, the survey appeared to reveal a limited recognition amongst most respondents about the importance of demonstrating, understanding and communicating the environmental impacts of their solutions, or even of the environmental receptors that may be impacted by the adoption of their solution. No other survey respondents discussed any potential impact of their solution that they believed would require measurement and monitoring in the future, and most did not articulate which environmental receptors may be impacted. Even respondents with a high level of confidence that their solution minimised environmental impacts compared to the state-of-the-art installation techniques on offer did not indicate that they planned to undertake any specific activities to measure or monitor environmental aspects or impacts of their solution.

This may indicate that whilst increasing understanding of potential environmental impacts of new offshore installations is of increasing importance to regulatory stakeholders, and to an extent project developers, the importance of addressing this area may not be being effectively promoted to lower tiers of the supply chain. To date, the survey suggests many supply chain companies have not yet fully considered quantifying the environmental implications of their products and services. When asked if having environmental data which they could submit to developers or projects to support and demonstrate environmental impacts of their new product/service/technology would streamline its continued development and adoption, three responses indicated this would be the case, two indicated they were unsure and four indicated this would not make an impact.

The awareness of supply chain to environmental impacts as indicated from the survey was discussed at the stakeholder workshop. Many attendees suggested that the provision of a network of trial / demonstration sites with a mandatory requirement to monitor environmental impacts may increase the profile of this important topic across the supply chain. Many other contributors also agreed work like Defra's ongoing work to develop Environmental Design Standards for offshore wind could offer an additional driver for offshore wind developers themselves to communicate the requirements to measure and minimise environmental impacts wider through their supply chains.

Survey respondents were asked about their principal requirements for an offshore trial or demonstration site – broken down in Figure 3 below – with the presence of existing subsea infrastructure or hardware cited as being among the most crucial requirements. This was followed by proximity to offshore wind project locations and grid connection availability. This may indicate that the supply chain companies responding wish to test innovations on existing or future infrastructure.

One responder indicated they had found a potentially suitable location for offshore demonstration and rollout of their solution in the Irish Sea off the coast of Anglesey in North West Wales, which had been abandoned by original developers.

Responders who offered an answer to the timescales over which it would be suitable to trial their technology or service innovation to sufficiently monitor its environmental effects, two respondents indicated 1 - 2 years would be required, with a further respondent indicating up to 5 years. It is of note here that during the workshop with key stakeholders, it was recommended that monitoring timelines should be defined by the particular research questions and should be dictated by the time required to observe the full environmental impacts of the product or technology i.e., time taken for habitats and species to determine impacts and recovery.

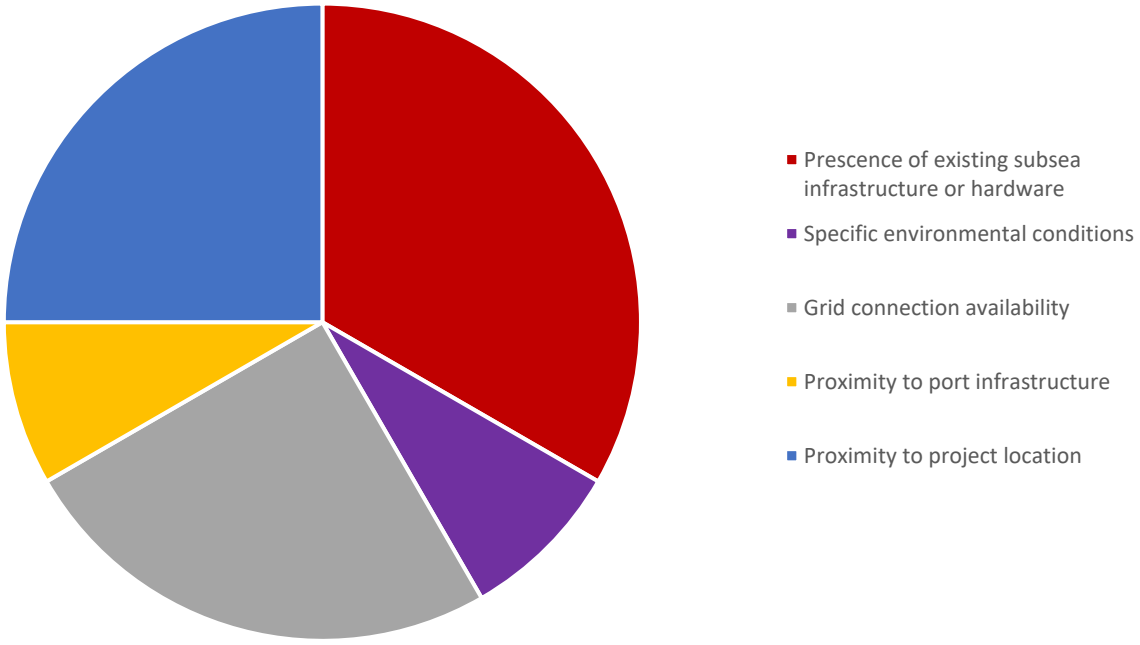


Figure 3. UK shows respondents answers to their principal requirements to an offshore trial or demonstration site (includes 'Prescence of existing subsea infrastructure or hardware', 'Specific environmental conditions', 'Grid connection availability', 'Proximity to port infrastructure' and 'Proximity to project location'. 'Prescence of existing subsea infrastructure or hardware' is the largest pie followed by 'Proximity to project location', 'Grid connection availability' then ''Proximity to port infrastructure' and 'Specific environmental conditions')

When respondents were asked about if there were any gaps in the market for an accessible trial facility in the UK, the majority (60%) indicated that there was in fact a need. One responder indicated "*a wider field of renewable energy demonstration sites would help us potentially expand the products scope of operation*," whilst another commented "*Yes, the UK needs facilities to be able to keep up with the rest of the markets*". Another indicated that in their experience, the offshore wind industry favoured a "*closed club*" of accepted suppliers able to gain access to turbines for their solutions, with newcomers prohibited from test and demonstration activities offshore.

5 Offshore Trial Site Development Process

In the UK, the seabed, out to 12 nautical miles within the UK territorial waters, is owned and governed by The Crown Estate, or Crown Estate Scotland in Scottish territorial waters. Typically, in England, energy infrastructure developments offshore will require at a minimum, two forms of consent:

1. A seabed lease[27] from The Crown Estate granting permission to utilise an area of the seabed for a defined period of time for commercial, farming or energy production purposes
2. A Marine Licence[28] assessed and awarded by the Marine Management Organisation (MMO)

Through this research, the project team have consulted with regulators and SNCBs responsible for advising on and awarding of these permissions, to identify key elements of the process. The research has also sought to understand key considerations in the case of offshore trial and demonstration areas. These discussions and initial findings are outlined below.

5.1 Seabed rights

Through consultation the Crown Estate outlined what their role would be in the delivery, development and establishment of a trial site of this kind. Discussions revealed this would be dependent on what the activity in question is that seabed rights would be sought for.

For renewable energy project developments, an agreement for lease is awarded, the developer then goes through the consenting process and once all the key consents and/or licenses are in place, then the developer can move forward with construction. In relation to a potential demonstration site(s), as explored through this feasibility study, it was suggested that it would likely be a different sort of agreement with Crown Estates would be required suitable for the way in which the site may be accessed by numerous individual developers, supply chain companies, and researchers coming forward to use it for trial and demonstration of varied technologies, processes and approaches.

The details of a suitable seabed lease agreement would be discussed and agreed with Crown Estate based on a number of practical issues including the body who takes ultimate responsibility for insurance, and liability and the risk of infrastructure being left on the seabed. Through these negotiations, Crown Estate would need to understand who is responsible for removing equipment and returning the seabed to its original state, with clarity on this point considered crucial. Though there was an expectation expressed that there is likely some form of agreement or approach to licensing and leasing for an area of seabed that would fit the purposes of the test site, or sites, as proposed here.

[27] Seabed lease (England and Wales) – UK government
[28] Make a marine license application - MMO

It was recommended that there are two conversations that probably need to be happening with The Crown Estate in parallel:

- How can we enter into the right form of seabed lease for this proposal?
- How do we choose the right location? It was highlighted that, as a practical step, conversations could take place with The Crown Estate's Geographic Information System (GIS) colleagues to run a proximity check, looking at proposed or indicative locations and see what other interests or assets are in that area. Is there a spatial overlap with any existing customers or tenants? Are there any potential interests – for example, potential marine energy projects – nearby that have not yet progressed forwards?

5.2 The marine licence application – an overview

The Marine and Coastal Access Act 2009[29] dictates that a marine licence is required for certain activities carried out within the UK marine area. This applies to any construction activity in/over the sea and on/under the seabed including maintenance, alteration, or improvement activity, or in the case of any deposit or removal of any substance or object either in the sea or on/under the seabed.

The purpose of a marine licence application[30] is for the Marine Management Organisation (MMO) to understand the likely impacts of the proposed activities that may be undertaken within a demonstration area. Part of the application will be a Marine Plan Policy Assessment[31] – this was highlighted to Opergy as part of the process, regardless of whether an Environmental Impact Assessment is needed or not.

The purpose of the Marine Plan is to set out the priorities and directions for future development within the plan area, inform sustainable use of marine resources and to help marine users to understand the best locations for their activities, including whether new developments could be appropriate. The level of information needed from an applicant here is said to be proportionate to the level of risk presented by the proposal.

Turning to an Environmental Impact Assessment[32], the need for this is dependent on whether the project would fall under the Marine Works Regulations (MWR)[33]. During conversations with the MMO, it was suggested that a demonstration area would not be anticipated to fall under the MWR, however should this be the case, an Environmental Impact Assessment screening would be required, with the MMO recommending allowing at least 8 weeks to go through screening.

The Marine Works Regulations requires certain types of projects with the potential to significantly impact the environmental to conduct an Environmental Impact Assessment (EIA) before a marine licence is then granted. Under the MWR, there are two schedules – A1 and A2. Schedule A1 of the MWR includes projects such as nuclear power stations,

[29] Marine and Coastal Access Act 2009 – UKSI
[30] Marine Licensing: impact assessments - MMO
[31] Marine Plan Policy Assessment - MMO
[32] Environmental Impact Assessment - MMO
[33] The Marine Works (Environmental Impact Assessment) Regulations 2007 – UKSI

trading ports, or piers that can take vessels over 1,350 tonnes. These projects require an Environmental Impact Assessment (EIA). Schedule A2, projects will require an EIA if they are likely to have significant effects on the environment. According to the schedule, these include projects such as wind farms and installations producing electricity – both of which could potentially be relevant under this project.

There are two options for Environmental Impact Assessment screening, the first of which is screening by determination where the MMO assesses the project and determines whether an EIA is necessary. This is something that can be requested by an applicant, or the MMO itself will direct the applicant to request. The MMO is unable to deal with the marine licence application until the screening option has been given. For reference, under the MWR, a request for screening opinion needs to include:

- A chart and/or map of the location of the project and the regulated activity.
- A description of the project, including:
    - A description of the physical characteristics of the whole project and, where relevant, demolition works;
    - A description of the location in relation to environmental sensitivity of areas that are likely to be impacted;
    - A description of aspects of the environment likely to be significantly affected;
    - And a description of likely significant effects of the project on the environment from expected residues, emissions, and waste use of natural resources, in particular soil, land, water and biodiversity.
- Any other information or representations that the applicant wants to make, including a description of any features of the project or measures envisaged as helping to avoid what would otherwise be significant adverse impacts on the environment.

Screening by agreement, meanwhile, would bypass this whole process. This happens when there is little ambiguity of the project having significant impacts on the environment and falling under Schedule A2 of the MWR. There is also the opportunity for a scoping opinion which is optional, where the MMO will carry out a 4-week consultation with primary advisors and technical advisors to ensure all aspects of the Environmental Impact Assessment have been sufficiently covered. This is targeted as being issued within 13 weeks from validation of a submitted request.

If the project is screened, either by agreement or determination, then the marine licence application should be submitted with an Environmental Statement, which should be accompanied with a statement of professional expertise, with additional consideration provided with regards to population and human health, risk of major accident, disaster and climate change.

Another key part of this application process is that of technical assessments, which can include a Marine Conservation Zone (MCZ) assessment[34] and a Habitats Regulations Assessment[35]. Through the MCZ assessment, the MMO will consider if there is a significant risk that the activity seeking a marine licence will hinder the conservation objectives of an MCZ. If this is found to be the case, then consideration must be given to

[34] Marine conservation zone assessment - MMO
[35] Habitat Regulations assessment - MMO

whether there are alternative ways of moving forwards. This could include changing methods or a new location. If all options are exhausted, things move forward to a second stage.

Through the MCZ assessment, the onus is on the applicant to demonstrate that the benefit to the public of granting the licence will outweigh the risk of damage to the environment, as well as showing that they will carry out measures of equivalent environmental benefit to mitigate the damage.

The Habitats Regulation Assessment (HRA), meanwhile, is where the MMO assesses licence applications for impacts on the conservation objectives of Special Areas of Conservation (SACs) and Special Protection Areas (SPAs).

Specifically, the MMO looks to ensure there are no negative consequences on European and Ramsar sites, taking decisions under the Conservation of Habitats and Species Regulations 2017 or the Conservation of Offshore Marine Habitats and Special Regulations 2017[36].

This stage requires the applicant to provide sufficient information to the MMO that will then allow it to undertake the necessary HRA. This includes the location of the project in relation to any European site; the interest features and conservation objectives of the European site; an indication of the means by which the plan or project could impact the conservation objectives and designated features of the site and a description of any such effects; and any proposed mitigation measures.

The HRA then consists of four steps. The first involves the MMO assessing whether the proposed project with have a likely significant effect on a European site and should it deem this to be the case, then it will move to the Appropriate Assessment stage. Here, the MMO will assess the plan or project in greater detail and its potential impact on the integrity of the protected site features, with the overriding aim here to determine whether an adverse effect on site integrity (AEOI) can be ruled out.

Through this step, the MMO will grant the licence if concluding the proposed works would not have an AEOI. If the inverse is true and an AEOI cannot be ruled out, then the licence can only be awarded if there are no feasible alternative solutions, imperative reasons of overriding public interest, and compensation for any impact is secured, which is the focus of steps three and four, otherwise known as derogation provisions.

These provisions will only be applied if the MMO deems it appropriate to do so. It is not automatic and the MMO will need to be satisfied there are no feasible alternative solutions to the plan or project; take a decision as to whether the plan or project must be carried out for imperative reasons of overriding public interest; and be satisfied that the necessary compensatory measures which ensure that the overall ecological coherence of the protected site network have been secured.

[36] Habitats Regulations assessment - MMO

Water Framework Directive (WFD) regulations[37] and Waste Regulations[38] are also important considerations for the MMO, though given the nature of this proposal, unlikely to be a factor if and when this proceeds to seek a marine licence.

5.3 The Rochdale Envelope

The research for this project has highlighted some particular considerations that may apply in the development of any new test or demonstration site(s).

This includes support for a network of sites, instead of a single location, given that this would have the benefits of being able to cover different geographies with different features, environments and locations across the UK. A network of sites would be in a strong position to include a mixture of provisions through new open water sites that are developed specifically for the purposes of accommodating trial and demonstration projects that focus on environmental impacts, as well as, where feasible, focused research activity at existing trial and demonstration sites and commercial scale offshore wind farms.

As alluded to earlier in this report, a design envelope, or Rochdale Envelope approach[39] is used when some of details of the whole project have not yet been confirmed when the application is submitted, and flexibility is sought to help address that uncertainty.

According to the planning inspectorate, if developers are seeking flexibility within their application for development consent, then they must ensure:

- That the approach is explained clearly for the purpose of consultation and publicity at the pre-application stage
- That the Environmental Statement explains fully how the flexibility sought has been taken into account in the assessments and why it is required
- That there is consistency across the application documents including any other relevant environmental assessments.

Consents that are granted on the basis of the Rochdale Envelope are conditional on providing the final details for agreement before construction. What will be important is once the envelope for the site is determined, if any device operators come forward and fall outside it, they may have to conduct their own assessments and apply for a sperate licence for those activities that lie outside the worst-case scenario Rochdale envelope for the site licence,

For example, FabTest[40] – as covered in the literature review – is a pre-consented site, albeit for marine energy converters, but assures that as long as the design being put forward by an operator fits within the defined “Rochdale envelope” of permitted devices, then they can offer certainty of deployment permission. Within the Rochdale envelope the following types of devices can be deployed, subject to permits issued by Falmouth Harbour Commissioners:

[37] The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 – UKSI
[38] The Waste (England and Wales) Regulations 2011 - USKI
[39] Advice Note Nine: Rochdale Envelope | National Infrastructure Planning (planninginspectorate.gov.uk)
[40] FaBTest

- Substantially buoy-shaped device with a maximum diameter of 30m;
- Substantially box-shaped device with a maximum dimension of 30m x 30m or equivalent area;
- Substantially tubular-shaped device with a maximum length of 180m;
- Floating platform type device with maximum dimensions of 35m x 35m or equivalent area; and Subsystem connectors and umbilical's;
- Mooring systems are restricted to gravity and drag embedment anchors.
- Guarded underwater turbines are also permitted.
- Consent for a defined range of floating wind devices is underway.
- Consent for the demonstration of Autonomous marine devices is also underway.

The European Marine Energy Centre (EMEC) is another that has site-wide consents for a deployment of an "envelope" of device types and operations at each of its grid connected sites: the Fall of Warness tidal test site and Billia Croo wave test site.

In the case of Billia Croo[41], for example, activities and deployments included within the envelope are:

- Testing activities associated with single devices and arrays deployments, including installation, maintenance and decommissioning works
- Installation, maintenance, and testing of subsea cables
- Testing of device components including mooring/foundation systems
- Buoys and scientific instrument/equipment deployments and surveys
- Marine works including site preparation and simultaneous operations
- Decommissioning of infrastructure

Projects that are not included within the envelope and would therefore need further consultation and an appraisal or assessment to fully understand the potential positive and negative environmental and navigational impacts include:

- Onshore works
- Percussive piling
- Additional cable
- Beach excavation
- Seabed clearance, such as kelp clearance and rock grinding/blasting

Considering the design envelope of other demonstration sites as presented within the literature review, it is anticipated that a similar envelope would need to be determined for any newly developed test and demonstration site(s) as proposed through this work. The envelope would need to be broad enough to incorporate potentially diverse requirements of future users addressing Research Priorities as laid out in Chapter 4 of this report.

[41] Consents : EMEC: European Marine Energy Centre

What happens if the project generates electricity?

The MMO highlighted that generating electricity through a test or demonstration site, would need a section 36 consent[42].

A section 36 consent is needed under the Electricity Act 1989 for projects generating under 100MW of power. In the unlikely event that a demonstration project was to be generating over 100MW then it would be classified as a Nationally Significant Infrastructure Project and require a development consent order (DCO).

The characteristics of the licence

During conversations with the MMO, Opergy learned that summary licenses under the Marine and Coastal Access Act (MACAA) have been given out for up to 10 years, but that MMO do not tend to issue them for longer than that, and that it would be possible to have multiple sites under one licence.

5.4 Financing Future Development

When discussing with The Crown Estate, they spoke of how they would be interested in helping to facilitate this kind of facility through other relevant work streams and programs that are ongoing. It was suggested that there could be a building block to developing a project proposal that could be submitted into the OWEC programme (Offshore Wind Evidence and Change) for funding, which is jointly run between the Crown Estate, BEIS and Defra. It would be a good step to get wider collaboration, support and funding, while also potentially meeting a number of OWEC's objectives. It was also suggested that there could be scope through ECO Wind, which itself is part funded by OWEC and the Natural Environment Research Council.

While Defra recognised the benefit of a proposed demonstration area, it did warn that getting funding for it could be challenging. The testing work in the short-term was noted as something that could classed as genuine Research and Development funding activities but the longer-term management of the site, or number of sites, would require infrastructure to be maintained, and staff, which are things that would not necessarily be classed as R&D, but more as business funding. The question of how the site would therefore be made economically self-sustainable was raised. Within the stakeholder workshop, Defra also recommended engaging with the Department for Energy Strategy and Net Zero (DESNZ), the Levelling up Department and the Marine Recovery Fund to identify possible funding mechanisms for this future work.

Defra itself does put out various calls for R&D funding, but it was also noted that given the current economic climate, a strong and impactful business case would be important with the prospect of reductions in R&D budgets anticipated in 2025. Defra colleagues also highlighted that UKRI/Innovate UK may offer suitable sources of funding if the site were to enable testing technologies and innovation for the future on top of its primary environmental focus.

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[42] Electricity Act 1989 – Section 36 - UKSI

Looking to existing test and demonstration sites explored throughout the process of compiling this report, a variety of funding sources have been utilised to raise multi-million-pound investment for the development of their facilities. The Marine Energy Engineering Centre of Excellence (MEECE) in Wales, for example, is a “multi-million-pound collaboration” between the Offshore Renewable Energy Catapult and the four Welsh universities of Swansea, Cardiff, Cardiff Metropolitan and Bangor. It forms part of the £60mn Pembroke Dock Marine Project and has been part-funded by the European Regional Development Fund and Swansea Bay City Deal.

Case Study 5: The European Marine Energy Centre (EMEC)

Cardinal buoy at Billia Croo and wildlife observations point at Black Craig. Image credit: EMEC

The European Marine Energy Centre (EMEC) was established in 2003 following a recommendation from the House of Commons Science and Technology Committee to set up a wave and tidal energy test facility to help kickstart a marine energy industry in the UK. Its first wave test site at Billia Croo was opened in 2004, followed by a tidal test site at the Fall of Warness in 2006.

EMEC was set up by a grouping of public sector organisations and saw £42mn of public funding invested into it through the likes of the Scottish government, Highlands and Islands Enterprise, The Carbon Trust, UK Government, Scottish Enterprise, European Union and Orkney Islands Council. In 2011, it became financially self-sufficient, something it credited to “a steady stream of developers using the facilities to prove the commercial potential of their technologies”.

The Research at Alpha Ventus (RAVE) initiative in Germany has had the Federal Ministry for Economic Affairs and Climate Action put in more than €120mn (£102mn) of support to date, while ORE Catapult were recently awarded £3mn by the North East LEP to develop

their new Digital, Autonomous and Robotics Engineering (DARE) centre in Blyth which opened in May 2023. As compared to other test and demonstration sites, much more moderate levels of investment were required as facilities are located onshore at a coastal site. Some of this investment has been used to develop a more robust testing plan incorporating best practice into their operations.

In direct one to one engagement with the Catapult, they highlighted how many of the testing and demonstration projects that they host at their existing facilities are supported by grant funding, with examples discussed including the Maritime Development Challenge Fund, which is co-founded by the Department for Transport.

With reference to existing test and demonstration infrastructure identified through this research, the costs of establishment and management of each site/facility differs widely, depending on the size, location, on and offshore infrastructure provided, monitoring facilities available, management structure and support offered to users. From the case studies highlighted here, development costs may fall anywhere between £3mn for an onshore but coastal testing facility, or in excess of £100mn for a grid connected, offshore demonstration site.

For this reason, it is not possible to suggest a representative cost to develop any new test or demonstration site(s) without further details on location and specific requirements for the particular test site. The costs of developing a site(s) may potentially be reduced if it is either not grid connected or could be closely linked with existing onshore and offshore infrastructure provisions. Investment to support development would likely need to come from multiple sources, however it is noted that demonstration sites can become financially self-sustaining after initial investment and establishment.

Furthermore, the issue of funding is something to really consider in depth in a post-Brexit world, especially when factoring in how many projects have benefited from EU funding. The European Regional Development Fund[43], especially, has helped a host of projects to get off the ground. The government is looking to replace it with the UK Shared Prosperity Fund (UKSPF)[44], which will see £2.6bn allocated across the UK up to the end of the 2024-25 financial year.

[43] European Regional Development Fund – European Commission
[44] UK Shared Prosperity Fund allocations: methodology note – UK Government

5.5 Engagement with other sea users

A final consideration to be made throughout the planning, licencing and development process for any new offshore demonstration site is that of engaging with other marine and seabed users in the vicinity of the project.

During one-to-one consultations with existing site operators, both ORE Catapult and Equinor discussed experiences in the development and operation of their Blyth and Hywind II projects, highlighted some interruptions and constraints they experienced during the development process in engaging with the fishing sector. Also located in close proximity to the ORE Catapults facilities, is the Blyth Offshore Wind Farm, a small scale commercially generating project operated by EDF which ORE Catapult had to consider and engage during development and expansion of their facilities.

There are various models for test and demonstration sites or zones that have been identified as part of this study that require different engagement with sea users, as included in Appendix 3.

At Blyth's ORE Catapult's site, the project team considered carefully how to present their plans to install four test pieces on the seabed to other sea users, with options including cordoning off the entire area – meaning compensation would have to be paid to fishermen – or leaving it open, which could raise the risk of fishermen running over the devices and having their boats damaged. As operators they faced managing a 'balancing act' of protecting their own assets, while causing as little disruption as possible to fishers and other sea users. The eventual decision was to make the whole zone open access and available to all users, managing access with notice to mariners and detailed maps issued, highlighting locations of test pieces and allowing other sea users to determine their own level of access and risk accordingly.

As has been detailed above, the North Sea Farmers demonstration site has taken an approach where the permitted area is closed to fishing creating a safe environment for the pilots, seaweed aquaculture and divers in the water. Similarly, SEMREV in France is managed as a restricted area.

As another example of good practice in engaging with other marine and seabed users, the UMaine Deepwater Offshore Wind Test Site saw extensive public consultation during its inception, with a community forum held on Monhegan Island to discuss issues around a wind energy demonstration area, before fishermen were asked to engage in a mapping exercise to rank blocks within the planning area in a bid to understand if and where a wind energy demonstration area could be located in waters near to the island.

The University of Maine has since been committed to responsible offshore development in a way that includes involvement and guidance from local communities and marine users, with its approach intended to minimise potential risks or adverse effects on both existing industries and the natural environment. Part of its work has been to develop best practices for coexistence with marine users through its two-turbine demonstration project, with a real emphasis placed on local economic development opportunities too.

Early engagement with other seas users will be essential in relation to siting any new demonstration area in the appropriate place. It is clear that the potential different access models as highlighted in appendix 3, that could be adopted by a network of trial and

demonstration zones the engagement will depend on the equipment to be trialled and monitoring techniques.

There is the potential, should a network of demonstration areas be adopted, to have different areas that offer either open of closed access to other sea users, which would afford supply chain and developers a choice of areas in which to undertake their trials depending on the equipment being tested and conditions required for monitoring environmental impacts.

6 Governance and Operational Models

During the consultation, existing test and demonstration site operators were asked to identify lessons learned, including key pitfalls or challenges in operating their trial and demonstration facilities. Other stakeholders participating in direct interviews and the workshop held through the course of the research were also asked to comment on their thoughts regarding the governance and operation of any future trial and demonstration site(s). This chapter details these lessons learned and insights.

Cefas drew on their experiences with similar sites overseas, which are often driven by academic institutions. Cefas advocated for partnership management for any new trial and demonstration site(s), with industry, academic and government interests being involved in their development and operation to ensure that they can deliver on multiple objectives. Cefas suggested a research body or academic partner could help to develop testing scenarios in scope, ensuring they are as far reaching as possible. This would be with a view to maximising the potential depth of environmental research that could be gathered through each trial project.

In terms of specific governance or operational models, Cefas welcomed the idea of a 'Steering Group', or other governance structure, to ensure there is flexibility within the project to allow discussions on different questions. This would ensure that both industry and research interests inform priority project and policy decisions. The aim of this panel would be to determine the overarching objective of the site, or sites, support their operation and ensure good quality research is conducted by users.

For sites where multiple users are competing for access, it is worth noting the European Offshore Wind Deployment Centre as an example. This has seen Vattenfall and the Aberdeen Renewable Energy Group working with the Offshore Renewable Energy Catapult to test new technologies. At one time, €3mn was invested into the facility to learn more about offshore wind and the environment, with a panel of experts responsible for deciding which projects should receive backing.

Celtic Sea Power suggested testing environmental interactions should be a condition on any area for lease provided by the Crown Estate. Utilising existing sites and funding partnerships already established may offer a better alternative than developing a new site entirely. They also explained that in some cases, there have been test and demonstration sites facing funding constraints which has led them to falter.

A key operational consideration for any new trial and demonstration site is the length of time need to trial that a site may need to accommodate. Whilst trialling timeframes for each project using the site should be designed and agreed around the specific demonstration activity and technology/process being examined, it is likely that in order to observe and monitor the likely environmental impacts, individual demonstration projects using the site may require timeframes of no less than 6 – 12 months, as suggested by ORE Catapult, the operators of Levenmouth Turbine. A 6 - 12 month time frame will allow for monitoring of the impacts and interactions for at least a full seasonal weather cycle. As noted in earlier chapters, Supply Chain respondents to the online demand survey suggested timeframes of between 1 – 2 years and commentary from the stakeholder feedback indicated that from a perspective of monitoring of environmental impact, the longer the monitoring activity can be continued the better, with the example that for biodiversity enhancement a minimum of several years in situ would be needed.

Also, learning from previous experiences of operational test and demonstration sites, it is likely that potential users of any new facilities may require external investment, for instance in the form of grant funding, to make their research projects deliverable. The ORE Catapult indicated that much of the research and demonstration activity at their Levenmouth demonstrator turbine and other demonstration facilities is supported by grant or loan funding schemes to smaller commercial organisations who would not be able to fund the activity themselves. Any new trial or demonstration site should consider how they can best accommodate potential users with this consideration. This may include supporting smaller companies designing suitable projects for funding, or providing loan or grant funding directly, or through recognised partners, as is the case for the Marine Energy Test Area (META) in Wales.

Any new trial or demonstration site(s) should also give consideration to the level of maturity required in potential projects undertaken on site. It is noted that the Science and Technology Facilities Council (STFC) uses Technology Readiness Levels (TRLs) to help determine whether a project or proposal is suitable for a specific funding opportunity, where relevant, guidance for that opportunity will state which TLRs are eligible. Across their multiple test and demonstration facilities, the ORE Catapult provide for a range from very low TRL projects, all the way through to TRL 9[45] which means the innovation is already being used offshore. Table 4 shows the complete TRLs definitions, courtesy of UK Research and Innovation (UKRI).

Table 4. Technology Readiness Level definitions

TRL:	Description:
TRL 1	Basic principles observed and reported.
TRL 2	Technology concept or application formulated.
TRL 3	Analytical and experimental critical function or characteristic proof-of-concept.
TRL 4	Technology basic validation in a laboratory environment.
TRL 5	Technology basic validation in a relevant environment.
TRL 6	Technology model or prototype demonstration in a relevant environment.
TRL 7	Technology prototype demonstration in an operational environment.
TRL 8	Actual technology completed and qualified through test and demonstration.
TRL 9	Actual technology qualified through successful mission operations.

[45] Eligibility of technology readiness levels - UKRI

For Blyth, the key is making sure that each piece of technology is tested to the same standard before it then allows them to use its facilities. They have a lot of onshore facilities to do this and once confident in the technology, that is when it will be able to use the offshore demonstration zone without posing risks.

With SME developers coming forwards to test early-stage technologies, they do not tend to have a lot of money themselves. They will have some level of funding, but Blyth does take care to ensure that they do not have to hire expensive vessels and then travel miles offshore, nor create their own test pieces and end up being priced out of things. They explained how they aim to do a lot of things in-house – such as creating universal test pieces – to limit the costs involved as much as possible.

Blyth alluded to a “vigorous process” of testing things before allowing them offshore as particularly good practice. By this, they explained that they do a considerable amount of de-risking during the early stages, as they do not want to put their own assets at risk when allowing developers to test concepts offshore.

The level of dependency of a user for the site has been found to differ depending on the companies as, in the case of early-stage projects that have only been tested a handful of times, users tend to require more of the Catapult’s input on developing a test plan. Whereas some of the more established offshore wind developers, having outgrown their own sites, want to hire the facility out.

Keeping costs down was cited as a challenge, something that any project – regardless of size or developer – will be challenged by. Logistics is another, explained Blyth. This is especially the case for projects they have on-site because of the three very old dry docks they have. These raise issues in terms of access to things such as cranage to lower remote operated vehicles (ROVs) into the dock and move things around.

The problem can also translate offshore too, especially if there is a particularly large piece of technology being tested, then it will not be able to use the university vessel that Blyth uses. This means they then must look at hiring large vessels that feature the right sort of cranage to launch these projects and then recover them.

Then there is the challenge of getting the right team offshore to install things. With completely different technologies, there will always be completely different needs every single time.

6.1 Data sharing

There was real consensus in stakeholder discussions on the importance of data sharing, with Cefas suggesting it should be essential and that data from previous studies should be accessible at the site. Whilst there may be commercial sensitivities of some device testing, there should be some sort of data provision commitment so that learning is cascaded.

Cefas also suggested that as part of the site’s operations, an area of exploration could be different data gathering approaches. The site could have a host of different sensors and monitoring equipment, which would allow the developer to determine the best approach for them. This is something that would not be possible at a commercial site.

The Crown Estate drew on how there are gaps in datasets and suggested a test and demonstration site such as this should be focused on closer to home impacts and localised impacts which could be tested at the site and help to build up the evidence base.

HR Wallingford suggested that to facilitate data sharing would mean part funding projects and having it stipulated as part of the Terms of Reference for use of the area. If projects were fully funded by the developers or teams using the site, for example, it becomes a little harder to get them to share data as there would likely be commercial reasons driving them to want to keep their data private.

The MMO were another to highlight the importance of data sharing as part of the operational model, adding how it would make the evidence base stronger for projects they will be receiving applications for, ensuring less contradiction, or resolving issues prior to the consenting stage.

During the workshop, the Crown Estate's Offshore Wind Evidence and Knowledge Hub (OWEKH) was highlighted as something that could be an ideal signpost for this data sharing from trial and demonstration sites. OWEKH is being funded by the Crown Estate's Offshore Wind Evidence and Change Programme and the ambition is to build a sector-wide open portal that can streamline the consenting process and support wider efforts to develop a digital strategy within the offshore wind industry.

OWEKH recently (16 June) made a call for interested parties to register notice in becoming part of its Community of Practice[46] as it continues its development. Within this it notes that "later this year, the launch of the digital portal will enable developers, regulators, marine specialists, and other professionals working in offshore wind to access and interact with key data and documentation to inform rapid, high-quality consenting around offshore wind development."

[46] https://www.snclavalin.com/en/media/trade-releases/2023/2023-06-16

7 Conclusions and Recommendations

Through this research study, desk-based research and engagement with relevant stakeholders has been completed to examine and evaluate the demand and feasibility of an offshore demonstration site(s) in English waters. The work presented has examined the existing provision of test and demonstration facilities relevant to the offshore wind sector, identified potential market demand for new test and demonstration facilities with a focus on examining and evidencing environmental impact, and explored the future process for establishment of potential new facilities. This final chapter of the report considers the conclusions that can be drawn from this research and presents key recommendations and next steps for Natural England, and relevant partners, to consider in driving forward the concept of an environmentally focused trial or demonstration facility.

7.1 Gap in Existing Provision

The research activities via the literature review, supported by direct feedback from stakeholders consulted both one to one and in a workshop setting, and through the online survey, does suggest that there is a sufficient gap in the existing provision of testing, trialling, and demonstration facilities to accommodate additional provision with a specific focus on measuring and monitoring environmental impacts.

Whilst there are a broad range of existing facilities available, none specifically focus on, or mandate, that users consider the environmental impacts of the technologies or processes being trialled. For example, only 14 of the 46 sites surveyed through the literature review through this study had environmental impacts within their research scope, while direct engagement with stakeholders showed just how much appetite there would be for such a site – a “really helpful piece of the puzzle”, according to the Crown Estate; a valuable location for research and development activity in both offshore wind and the marine sectors, as per Defra; and a chance to correct a lack of information on new technologies right now, said the Marine Management Organisation.

Feedback from supply chain respondents to the online survey also re-iterated this conclusion. 17% of respondents to our survey, which spanned companies operating within, or looking to grow their services and operations across the UK offshore wind sector, reported difficulties in finding appropriate trial and demonstration areas for their service. A further 60% indicated a need for further accessible trial and demonstration facilities in the UK supporting a lack of access through existing provisions at commercial wind farms and testing sites. This further shows the benefit a site such as the one being explored through this study could bring.

7.2 Market Need

The research study has revealed broad and positive support for environmentally focused trial / demonstration site(s) amongst key stakeholders engaged. The concept was supported by the Crown Estate, Defra, the Environment Agency, the Marine Management Organisation, as well as SNCBs across devolved administrations, including Joint Nature Conservation Committee, DAERA, NatureScot and Natural Resources Wales and Cefas. All these bodies indicated their strong interest in exploring the concept further.

Industry representative bodies including the Offshore Renewable Energy Catapult and the Offshore Wind Industry Council P2G working group within RenewableUK also strongly support the concept. Both have offered direct support to future exploration and development of new potential offshore trial and demonstration sites and facilities, recognising the need for greater understanding of environmental impacts of offshore wind and potential mitigation options including habitat restoration and marine biodiversity net gain.

7.3 The Importance of Monitoring and Minimising Environmental Impacts

The research identified a need to strengthen the perception, across the offshore wind industry and its value chain, of the importance of considering approaches to monitoring, managing and minimising environmental impacts of offshore wind developments. Across the government partners and research organisations engaged in this study, there is a clear understanding that environmental impacts must be monitored and mitigated through future projects. Participants from these groups articulated numerous areas for further research to maintain the ecological coherence of marine sites and species, while also de-risking the consenting process as far as possible 58 to addressing and reducing environmental impacts could lead to consent application refusals for future offshore projects, particularly in congested areas of the seabed.

However, whilst capturing the feedback, attitudes, and requirements of a small sample of supply chain companies via the online survey, a low prioritisation of environmental considerations was identified across the majority of the supply chain respondents. Only two businesses had taken any action to measure their environmental impact, through measurement of noise and marine mammal impacts and developing a carbon footprint. Only three respondents thought that having a more detailed understanding of their environmental impact would support continued product or technology development or adoption by project developers. The limited number of potential environmental impacts and receptors noted by respondents, suggests a limited consideration or understanding of wider environmental impacts and challenges amongst respondents.

To rectify this, recommendations – as set out in greater detail in section 7.1 – include promoting the value of evidencing, managing and minimising environmental impact across the supply chain and pursuing the development of a network of trial and demonstration sites.

7.4 Potential Research Topics and Likely Demonstration Site Users

The research identified a broad spread of potential areas of research or topics that could be addressed and examined at a new trial or demonstration site, or sites of the nature proposed. Evidence gaps highlighted as being particularly important by stakeholders consulted include:

- Trialling and demonstration of effective approaches to achieve co-location, co-existence
- Testing Environmental Design Standards and marine biodiversity net gain

- Identifying environmental impacts of new technology types, such as floating offshore wind infrastructure and decommissioning approaches
- Poorly understood areas of potential impact, including noise and electromagnetic field (EMF) impacts

A key conclusion of this study is that development of an increasing provision of trial and demonstration facilities with a particular focus on monitoring and measuring environmental impacts could offer an opportunity for a central body administering or managing these sites to collate and publicise important research topics across the supply chain. Coordination with initiatives such as the Crown Estate's Offshore Wind Evidence and Change Programme and collaborating with industry representative groups such as the Offshore Wind Industry Councils Pathways 2 Growth Workstream, bringing together the proposed network of demonstration sites may support coordination and prioritisation of research activity with the aim to minimise environmental impacts across the supply chain. This can result in a streamlining of the consenting process by demonstrating methodologies and mitigation before application. An important factor of strong industry engagement would be to translate any research results and impacts into actionable industry best practice.

A final consideration highlighted during the consultation was that, for demonstration site(s) of this nature established with the main aspiration to monitor and identify potential environmental impact, licencing bodies and statutory authorities may have to be prepared for representative testing trials resulting in some adverse impacts to receptors, be that in environments that are controlled and monitored to some degree. In all testing to be undertaken at the proposed site(s), a collaborative and transparent approach to monitoring and data collection is recommended, to ensure design of the monitoring programme is suitable to identify all anticipated impacts, and reasonable measures to mitigate or repair sites during and after trialling is complete are planned. Potential marine impacts, alongside anticipated approaches to monitoring, mitigation, and environmental repair should be clearly communicated to regulators, neighbouring seabed users and other stakeholders to ensure that this is understood, and reasonable levels of risk are outlined and accepted.

7.5 Locational Consideration and a Network of Sites

The research has highlighted support for a network of sites rather than one single location. A network of sites would have the advantage of covering a diverse range of geographical areas with different features, environments, and locations across the UK encompassing a broad set of physical, chemical, bathymetric and oceanological characteristics. This network of sites would be well placed to incorporate a mixture of provisions through new open water sites developed specifically for the purposes of accommodating the requirements of trial and demonstration projects with a focus on environmental impacts, complemented where feasible with focused research activity being undertaken at existing trial and demonstration sites and commercial scale offshore wind farms. This approach allows the practical scaling of provisions over time to suit specific trial and demonstration project requirements as they emerge.

Through the consultations, some potential locations for new trial / demonstration sites were highlighted, including the Southern North Sea area off the East and South-East of England where offshore wind and neighbouring industries are closely located with the potential for developing unknown cumulative impacts. The regional hub of expertise in floating offshore wind and wave and tidal stream developing in the Celtic Sea could be

another potential area to locate trials sites. However, no specific sites have been identified and proposed through this work.

It is recommended that any new site or sites should be selected and specified according to direct requirements for research that may take place there. Recommendations 3 and 4, set out in section 7.1, look closer at this process.

7.6 Governance and Operational Considerations

Learning lessons from existing demonstration site operations, as well as through the consultation completed during this project, it is concluded that the likely users of the proposed trial and demonstration sites will be predominantly small and medium sized supply chain companies, developing, proving and refining their technologies and solutions for sale into higher tiers of the supply chain. These users may frequently require some level of support in getting their research, trial, or demonstration project off the ground, from support for their research design, funding to support the research activity, and/or other assistance including access to monitoring equipment, vessels and installation support.

Through the consultation, this report concludes that the proposed network of trial / demonstration sites can be most successful if co-designed and developed through collaboration and input between Industry, Government and Academic Institutions. We suggest that supporting partners assembled through its development may include but not be limited to:

- Department of Energy Security and Net Zero
- Levelling Up Department
- Defra
- The Crown Estate
- Cefas
- Offshore Renewable Energy Catapult
- The Marine Management Organisation
- SNCBs
- Local Planning Authorities
- National Grid
- Renewable UK
- Seabed Users Group

Industry representatives, Academic representatives, and Regulatory Partners could then come together to form a steering group to guide the management and operation of the network of sites

The network of sites should have at its core aim to prioritise monitoring of environmental impacts through all projects that are undertaken on site. Submission of environmental data could be made a condition for use of the area, with data collected by all users of the site made available through established data collection platforms such as The Crown Estate's Marine Data Exchange and sign posted through the Offshore Wind Evidence and Knowledge Hub.

7.7 Recommendations and Next Steps

Based on the conclusions above, this report suggests the following specific recommendations and next steps for Natural England and partners to pursue in order to drive forward the concept of a network of trial and demonstration sites across UK waters:

1. Consenting and regulatory bodies to **promote the value of evidencing, managing, and minimising environmental impact across the supply chain:** This may be achieved through initiatives such as the forthcoming Environmental Design Standards for Offshore Wind being developed by Defra, as well as through market signals such as the inclusion of marine biodiversity net gain targets, and/or minimising environmental impacts alongside skills and innovation and social value considerations within offshore wind supply chain plans. Natural England and partners are encouraged to collaborate with consenting and regulatory bodies, and government departments, through official consultation processes as well as individually to drive this agenda forward.

2. Building on the feedback provided through this report, Natural England and partners are recommended to **pursue development of a network of trial and demonstration sites** including nodes across the UK, working in partnership with devolved administrations and their respective marine and environmental agencies. This will crucially include engagement with government departments including the Department for Energy Security and Net Zero, leasing and licencing bodies The Crown Estate and MMO, and equivalent bodies across devolved administrations to further develop action plans and next steps.

3. **Consultations with key stakeholders to identify potential locations:** At this stage of research, it was not possible to highlight clear recommendations of potentially suitable locations for any new offshore trial and/or demonstration facilities. It is recommended that discussions with key stakeholders, research organisations, and regulators continue to scope potential locations. This may be supported by the development of accessible, visual graphics and maps highlighting key characteristics of the subsea locations around the UK overlaid with locations of the agreed HPMAs, key historic CSSEG monitoring sites, as well as existing infrastructure including existing offshore wind projects, test and demonstration sites, and other neighbouring industries, to support the further discussion and examination of suitable locations for a network of environmentally focussed trial and demonstration sites.

4. **Further engagement with potential delivery partners** should continue in parallel with the above. This may include an open call to existing testing and demonstration sites to establish their interest in becoming initial members of the network, as well as discussions with developers and operators regarding trial and testing options on their sites within their existing marine licence conditions and DCO design Rochdale envelope, in order to determine if there is any headroom and whether there is potential to build out within the current phase of their licence.

5. Engage with partners including the Department of Energy Security and Net Zero, Levelling Up Department, ORE Catapult, UKRI and Innovate UK as well industry groups such as the Offshore Wind Industry Council to **consider the options to establish complementary funding scheme(s)** with partners of the network of

demonstration sites to support research activities developed and trialled through the sites.

6. **Establish governance arrangements including establishment of a Steering Group** invited to participate from now to support development and shaping of the network of sites from an early stage. The Steering Group should include members from research (Cefas and Offshore Renewable Energy Catapult), industry (Renewable UK and/or the Offshore Wind Industry Council) and government communities (Defra, DESNZ, Levelling Up Department, The Crown Estate and Marine Management Organisation).

7. **Require environmental monitoring and data sharing** by all users of the network of trial and demonstration sites as a condition of use.

8 Glossary

Autonomous Underwater Vehicles (AUVs): A robot that travels underwater without requiring continuous input from an operator.

Cefas: The Centre for Environment, Fisheries and Aquaculture Science, Cefas is the government's marine and freshwater science experts, working for healthy and productive oceans, seas and rivers, as well as safe and sustainable seafood.

Crew Transfer Vessel (CTV): Vessels that are used to transport wind farm technicians, as well as other personnel, to and from sites on a daily basis.

Crown Estate Scotland: Responsible for the management of land and property in Scotland, including the seabed.

Defra: The Department for Environment, Food and Rural Affairs is a department of His Majesty's Government responsible for environmental protection, food production and standards, agriculture, fisheries and rural communities in the United Kingdom.

Development Consent Order (DCO): The means of obtaining permission to construct and maintain developments that are categorised as Nationally Significant Infrastructure Projects (NSIPs).

Environmental Impact Assessment: This is a process used to explore the significant effects of a project or development proposal on the environment.

Geographic Information System (GIS): A computer system for capturing, storing, checking and displaying data related to positions on the earth’s surface.

Habitats Regulation Assessment: This is a process which determines whether development plans could negatively impact local plans on a recognised protected European site beyond reasonable scientific doubt.

Highly Protected Marine Areas (HPMAs): Areas of the sea, including the shoreline, which allow the protection and full recovery of marine ecosystems.

Marine and Coastal Access Act 2009: An act which created a new system of marine management and saw the launch of the MMO.

Marine Conservation Zone (MCZ): Areas that protect a range of nationally important, rare or threatened habitats and species.

Marine Licence: Required to carry out certain activities within the UK marine area. The MMO is responsible for marine licensing in English waters and for Northern Ireland offshore waters. There are seven categories that may need a marine licence: construction; dredging; deposit of any substance or object; removal of any substance or object; incineration of any substance or object; scuttling (sinking) of any vessel or floating container; and use of explosives.

Marine Management Organisation (MMO): The Marine Management Organisation aims to protect and enhance the UK's marine environment, while supporting economic growth through enabling sustainable marine activities and development.

Marine Works Regulation (MWR): Requires that certain types of projects with the potential to significantly have an environmental impact assessment before a marine licence decision is made.

Mitigation Hierarchy: The mitigation hierarchy is a set of guidelines with the aim of limiting as far as possible the negative impacts on biodiversity from development projects.

National Policy Statements (NPS): These are produced by government and set out objectives for the development of nationally significant infrastructure in a particular sector and state.

Nationally Significant Infrastructure Project (NSIP): Large-scale developments, relating to energy, transport, water or waste, which go beyond local planning and require “development consent”.

Offshore Renewable Energy (ORE) Catapult: The UK's leading technology innovation and research centre for offshore renewable energy.

Offshore Wind Evidence and Change (OWEC) Programme: Devised with the aim of helping industry and stakeholders to better understand and overcome the cumulative environmental impacts of offshore wind, and its effects on users of the sea and onshore communities.

Remotely operated vehicles (ROV): An unoccupied underwater robot, operated by a crew either abroad a vessel or floating platform, or on land.

Science and Technology Facilities Council (STFC): Coordinates research on some of the most significant challenges facing society, such as future energy needs, monitoring and understanding climate change, and global security. It offers grants and support in particle physics, astronomy and nuclear physics. STFC works with the UK Research and Innovation.

Section 36 consent: This is a section under the Electricity Act 1989 and something the Marine Management Organisation is responsible for considering and determining applications for, for offshore generating stations with a generating capacity of more than 1MW, but less than or equal to 100MW.

Technology Readiness Levels (TRLs): A type of measurement system used to assess the maturity level of a particular technology – TRL 1 (basic principles observed and reported” is the lowest, with TRL 9 (actual technology qualified through successful mission operations) is the highest.

The Crown Estate: One of the UK's largest landowners, both on land and at sea, with its portfolio including the seabed around England, Wales and Northern Ireland.

Unmanned Surface Vehicles (USVs): A boat or ship operating on the surface of the water without a crew.

9 Appendices

9.1 Appendix 1: Literature Review Case Studies

Through an initial literature review, 46 offshore trial and demonstration sites, both in the UK and abroad, were explored. These facilities primarily covered offshore wind, though some catered more to wave and tidal energies, whereas others offered more generalised demonstration and testing infrastructure. Of this number, 14 were identified as having some form of environmental impact feature in their work. It did prove a challenge to identify trial or demonstration sites focusing solely on that element.

To offer greater depth, in this Appendix, case studies will be explored across a range of different areas for:

Project Name	Acronym	Country
The Marine Energy Engineering Centre of Excellence	MEECE	Wales
The Offshore Test Site; North Sea Farmers	OTS	Netherlands
The Levenmouth Demonstration Turbine	LDT	Scotland
SEM-REV Offshore Test Site	SEM-REV	France
UMaine Deepwater Offshore Wind Test Site	UMaine	USA
European Marine Energy Centre	EMEC	Scotland
Research at Alpha Ventus	RAVE	Germany
Biscay Marine Energy Platform	BiMEP	Spain
Marine Energy Test Centre	METCentre	Norway
Llŷr Projects	Llŷr	Wales
The Tidal Thames Test Site	Thames Test Site	England
Falmouth Bay Test Site	FaBTest	England
Marine Energy Test Area	META	Wales
CADEMO Project	CADEMO	USA

A full list of all the sites explored through the literature review can be found after this section, along with links to information sources. These 14 sites have been chosen as they allow for an exploration of different models, both in the UK and overseas, which offer potentially transferable models and lessons learned which may inform the development of any new offshore trial and demonstration site(s) in the future.

The Marine Energy Engineering Centre of Excellence (MEECE) - Wales[47]

The Marine Energy Engineering Centre of Excellence is referred to as the Offshore Renewable Energy (ORE) Catapult's "flagship hub" for advancing the Welsh marine and offshore renewable energy sectors. It wants to be a catalyst for research, technology innovation and testing and demonstration to accelerate the commercialisation of the wave, tidal and offshore wind sectors.

In terms of how it was established, it was a multi-million-pound collaboration between the Catapult and four Welsh universities: Swansea University, Cardiff University, Cardiff Metropolitan University and Bangor University. In early 2022, collaboration agreements were signed between MEECE and the four universities to work together to fulfil the main MEECE objective of providing support to innovative companies in Wales to develop new products, processes and services for the offshore renewable energy sector. This will be done across three support package categories of research, development and innovation; commercialisation support; and company growth support.

MEECE has been part-funded by the European Regional Development Fund (ERDF) and Swansea Bay City Deal and forms part of the £60mn Pembroke Dock Marine Project.

Its key partners include the Marine Energy Test Area (META), Port of Milford Haven, Pembrokeshire Demonstration Zone, local universities and the local supply chain. Bangor University's School of Ocean Science offers a range of laboratory facilities, as well as sea-going capabilities and numerical modelling. Swansea University's Energy and Environment Research Group works with two main research standards of "Engineering from Clouds to Coasts" and "Ocean Energy" with this including environmental impact identification. Cardiff University's School of Engineering Marine Energy Research Group is devoted to making key contributions to the emerging UK tidal stream industry. Finally, Cardiff Metropolitan University undertakes research focused on primarily mapping supply chain capabilities and working with companies to develop their operational capacity and engineering capabilities to enter the renewable sector.

In terms of how MEECE is operated and managed, it is delivered by ORE Catapult and for users to be eligible, they must be a business that is based in the West Wales and Valleys region. It will support businesses that are based elsewhere, should they be wishing to establish an office in the region. It can also connect people with a company in the eligibility area. In cases where the project in question, even if not local, will have a clear benefit for the West Wales and Valleys region, then support will be offered as well.

[47] https://www.meece.org.uk/

When it comes to the facilities and capabilities that MEECE offers to marine energy developers, these include:

- Desk-based research projects to establish feasibility and impact.
- Free Technology Assessment audits.
- Access to world-leading research expertise at both the Catapult and its University partners, as well as access to academic research hubs in Blades, Powertrains and Electrical Infrastructure.
- Collaborative innovation projects to support technology developments at no (or minimal) cost to the company, which could include building prototypes of new technologies and coordinating test campaigns to provide ground truth data on performance and reliability.
- Launching innovation challenges to industry in an effort to find cross-sector solutions.
- Access to expertise through the Catapult's other Centres of Excellence in Operations and Maintenance and Floating Offshore Wind, as well as wider regional expertise across the UK and the Catapult Network.
- Access to a range of unique testing facilities and offshore sites to demonstrate innovations without the costs and risks faced by technology developers – this includes the Marine Energy Test Area, facilities at the partner universities, such as flume tanks and wind tunnels, and the Catapult's own facilities at the National Renewable Energy Centre, Blyth and Levenmouth Demonstration Turbine.
- Provision of market entry information on market size, opportunity, key players and competitors.
- Support in advancing technologies through to commercialisation through access to industry-leading programmes, including its National and Regional Launch Academies.
- Development of detailed business cases specific to the user's technology, including possible exploitation strategies and financial modelling and analysis of new technology adoption.
- Access to private investment through sector-specific investor introduction and pitching/executive summary preparation support.
- Supporting Welsh companies to capitalise on supply chain opportunities through accessing industry and ORE Catapult support programmes, including the Offshore Wind Growth Partnership and the Fit 4 Offshore Renewables Programmes.
- Advice and guidance in seeking export opportunities in emerging markets.

MEECE wants to hear from innovative SMEs that have "ground-breaking technologies and concepts" it can support through to commercialisation. It is clear it can work across all Technology Readiness Levels, from basic concepts to pre-production prototypes.

The Offshore Test Site; North Sea Farmers - Netherlands[48]

The Offshore Test Site was established by the North Sea Farmers, supporting its mission to "make positive climate impact" with seaweed.

[48] https://www.northseafarmers.org/offshore-test-site

For background, the North Sea Farmers is a “hands-on seaweed sector organisation” that works with the belief that seaweed has great potential to make a positive impact on global challenges. Specifically, it works to support and accelerate the development of a sustainable and nature-inclusive seaweed sector that is based on cultivation in the Greater North Sea region.

Therefore, as part of this, the North Sea Farmers wanted to create a space where businesses would be able to test their newest innovations.

The site is situated 12km off the coast of Scheveningen in the Netherlands and is regarded as a “breeding ground for start-ups and scale-ups that want to test their innovations in demanding offshore conditions”. In terms of how it was established, a permit was secured to use 6km^2 of the North Sea for a test site. This was then divided into six plots, all covering 1km^2. It is only available for their users, meaning a “safe environment to test new innovations”.

When it comes to the facilities and capabilities that the Offshore Test Site offers users:

- A permit to perform a pilot in the North Sea
- A 24/7 guarded area by Royal Dirkzwager
- An ability to dive and investigate the pilot underwater
- An ability to work with the North Sea Farmers, who have more than seven years of experience with the Offshore Test Site.
- Connections with other users, sharing knowledges and experiences with other Offshore Test Site users.
- No fishing is allowed in the Offshore Test Site area, meaning a safe environment for the pilots.
- An ability to share logistic costs.
- Essential vessels to transport materials from the mainland to the Offshore Test Site.
- Access to weather forecast model of Svasek.
- Publicity through the North Sea Farmers network.
- Real-time data measurement of the offshore conditions of Turbidity, Chlorophyll-A, and Conductivity and temperature.
- Additional equipment, including DCP Nortek profiler: vertical flow profile, and DAS module: LoraWan gateway.
- Other equipment that can be placed, including Automatic Identification System; GPS-sensor; and Compact Weather Station.

The Levenmouth Demonstration Turbine – Scotland[49]

Plans for test turbines to be installed off the coast of Methil at the Fife Energy Park in Scotland first were afoot in the early 2010s. It was eventually revealed that Samsung would be the first company to build a demonstrator turbine on the site, with a 7MW wind turbine then constructed in October 2013. It is connected to shore by a short ramp.

[49] https://ore.catapult.org.uk/what-we-do/testing-validation/levenmouth/

With Samsung Heavy Industries later announcing plans to withdraw from Fife, the Offshore Renewable Energy (ORE) Catapult entered into discussions with Samsung to acquire the turbine for research purposes in 2015. The deal would go through, with the Catapult awarded a Section 36 Consent variation by the Scottish government in 2018 to operate the turbine until 2029. *The Catapult does offer the opportunity to request a copy of the Decision Notice, Marine Licence or Section 36 Variation for the Turbine by contacting them*.

Details on the arrangement between the Catapult and Samsung are scarce, but it is on record that Samsung invested £70mn into the demonstrator project.

When it comes to the facilities and capabilities offered by the Levenmouth Demonstration Turbine:

- Robotics and Automation: With the Catapult believing that the offshore wind sector could cut its inspection costs by almost 40% by integrating robotics and automated systems into its operations, the Levenmouth Demonstration Turbine has been a "test-bed for both SMEs and academic developers working in this area". It has hosted demonstrations of:
    - Crawling robots
    - Climbing robots
    - Aerial robots
    - Sub-sea robots
    - The next two-years are expected to see trials of the Multi-Platform Inspection, Maintenance and Repair in Extreme Environments (MIMRee) robotic inspect-and-repair mission, which will see drones, blade crawlers and autonomous vessels brought together in fully automated missions.
- Training and Personnel Transfer Systems: With the turbine's proximity to shore, it is an accessible facility for conducting technician training and testing innovative crew transfer systems.
- Data and Digitalisation: The Catapult's Data and Digitalisation team, together with technology developers, has led the turbine in being a test-bed for experimentation with a variety of new digital applications.
    - The turbine has more than 120 packages of instrumentation, including:
        - Lidar installations
        - Novel lightning strike detection systems
        - Sensors that monitor the conditions within nuts and bolts
    - The turbine led to an ORE Catapult competition, funded by the Scottish government, to develop sensor technology and data systems that can help with product development, as well as the operation and maintenance of windfarms.
    - An onshore met mast at the site helps with the testing, calibration and verification of onshore lidar systems.
- STEM, Skills and Local Opportunities: The Catapult has funded a STEM ambassador at Levenmouth Academy since 2016, which has since become a full-time STEM Principal Teacher position, delivering extensive programmes throughout the school in areas which include robotics, drones and programming. It has also been a beneficiary of the Catapult's STEM Club Start-Up programme, which uses funding from the Royal College of Engineering to spark local children's interest in offshore renewable energy as a future career. The Catapult has also worked to create opportunity for young people in the area through:

- Providing a hands-on experience and training for Fife College turbine technicians.
- Collaborative development of a next-generation Immersive Hybrid reality offshore wind turbine for education and training for use in local schools and training centres.
- Contributing to the development of a renewable energy curriculum across the Scottish College Network.

Levenmouth has since attracted 98 SMEs for technology development, testing or demonstration and forms a key asset in the Catapult's core research and development programme, with 45 projects either having been completed or under contract at the facility.

SEM-REV Offshore Test Site - France[50]

The SEM-REV offshore test site in France was launched in 2007, following the signature of a government/regional planning arrangement – 2007-2013 CPER – and is referred to as the first European site for multi-technology offshore testing connected to the grid. It was developed to respond to a major challenge of developing a new industrial sector for marine renewable energies in France.

In the years since, the site has steadily ramped up with environmental and resource monitoring commencing in 2009, the first authorisation to deploy wave energy converters coming in 2011, export cables being installed and buried in 2012, a second authorisation to deploy floating wind turbines coming in 2013, and the installation of a hub and pre-installation of a dynamic cable in 2015.

While specific figures do not seem to be readily available when it comes to costs, a host of organisations came together to fund the site: Centrale Nantes, the European Regional Development Fund, the Pays de la Loire region, Investments for the future from the French State, the Ministry of higher education, research and innovation, the National Centre for Scientific Research and Loire Atlantique. Mairie du Croisic, Conservatoire du littoral and Nantes Metropole are also all credited with support.

Centrale Nantes – the Research Laboratory in Hydrodynamics, Energetics and Atmospheric Environment – operates the site, striving to help industrialists to develop new energy production capacities. There are a multitude of partners spread out across different areas: "project partners", which include the European Marine Energy Centre (EMEC), EDF and SmartBay Ireland; "academic partners", such as the Universitie de Nantes and Institut de Recherche en Energie Electrique de Nantes Atlantique; and "main operation partners" which it notes are subcontractors, such as Enedis, Orange and Bourbon.

When it comes to the facilities, capabilities and characteristics that the SEM-REV offshore test site offers, they include:

- A 1km^2 marine test area that is situated 20km off the coast from LeCroisic, which was chosen following field studies on the basis of environmental and regulatory

[50] https://sem-rev.ec-nantes.fr/

technical constraints and respect of use of maritime spaces by offshore professionals.
- Fully equipped to measure sea and weather conditions.
- Clearly marked out by cardinal buoys. It is a marine restricted area and in the case of intrusion, the SEM-REV team is warned in real time and then refers it to the maritime authorities.
- Electrical infrastructure to connect the system to the Enedis medium-voltage network through an 8MW, 25km long cable.
- A hub, which enables the simultaneous operation of three machines.
- A research centre, located at Penn-Avel, which receives and analyses data and controls the test devices, which is staffed by a dozen researchers and engineers.

As part of a large regional industrial and research network, it also enables:

- Provision of an offshore area fully dedicated to the installation and operation of technologies through permits and authorisation obtained:
    - Approval under the French Water Act, with preliminary consultation with sea users and environmental impact studies.
    - The temporary concession for the occupation of a restricted sea zone, with conditions of use, markings, maritime security with preliminary notice and recommendations to the maritime authorities.
    - A power exploitation permit granted by the Ministry of Energy.
    - Provision of access to meteorological data, oceanographic data and to control means, as well as offices for test surveillance.
- Maintenance of monitoring tools in operational conditions
- Environmental impact assessment for the marine environment and other usages
- Respect of rules regarding maritime safety
- Support for developers in terms of marine operations, such as through booking of naval means, divers, and sub-contracting to qualified staff.
- Support for transport and logistics activities, such as storage in harbour in the area, handling and booking of handling zones.

UMaine Deepwater Offshore Wind Test Site - USA[51]

Over the Atlantic, back in 2008, Governor John Baldacci established the Maine Ocean Energy Task Force to recommend a strategy to develop the renewable ocean energy resources in the Gulf of Maine, which came back with a report setting a goal for 5GW of offshore wind energy by 2030.

This led to the Maine Department of Conservation designating a site off Mohegan Island as one of three wind energy test areas off the Maine coast. Extensive public consultation followed, including a community form on Monhegan Island to discuss issues around a wind energy demonstration area. This saw fishers asked to engage in a mapping exercise to rank blocks within the planning area to understand if and where a wind energy demonstration project could be located in waters near to the island.

[51] http://www.monheganenergy.info/wp-content/uploads/2014/01/UMaine_MonheganTestSite-0422717.pdf

This led to the Maine Department of Conservation designating Monhegan as the Maine Deepwater Offshore Wind Test Site to support the University of Maine (UMaine)'s ongoing research and development efforts. It was chosen due to its distance from the mainland, strong and consistent winds, a limited number of fishers and close proximity to an island with high energy costs.

When it comes to funding, the University of Maine, State of Maine and US Department of Energy funded significant efforts to characterise the baseline physical and ecological environment of the test site.

UMaine oversees the site and says it is committed to responsible offshore development in a manner that includes involvement and guidance by local communities and marine users, with specific pledges including:

- Frequent outreach with communities and existing marine users.
- A single-turbine demonstration project within the University of Maine Deepwater Offshore Wind Test Site for evaluating technology, monitoring the environment, and developing best practices for coexistence with marine users.
- An emphasis on local economic development opportunities.
- Future use of UMaine's VolturnUS floating technology only in commercial projects that are located more than 10 miles from Monhegan, other inhabited Maine islands and the mainland coast.

To use the site, an applicant must apply for a general permit with the State of Maine Department of Environmental Protection that contains:

- Written certification that the offshore wind energy demonstration project will be located within the test site.
- A report prepared in consultation with the Department of Maine Resources, including several specific requirements.
- Acknowledgement that the Maine Department of Environmental Protection may require the applicant to take remedial action at the applicant's expense if adverse impacts to fish and wildlife occur during operation.
- A Fish and Wildlife Monitoring Plan that includes provisions for conducting monitoring throughout the term of the permit.
- Navigation and Safety Plan to protect the public and project facilities.
- Project Removal Plan for the removal of the project within 60 days of termination of a general permit.
- Documentation that each item was created in consultation with several federal and state agencies, including Maine Department of Marine Resources, Department of Inland Fisheries and Wildlife, US Army Corps of Engineers, US Coast Guard and others.
- Proof of Insurance.
- Proof of Financial and Technical Capacity to construct and operate the project as proposed.
- Proof that no applicant has ownership holds or has applied for another permit under this legislation.
- Proof of cooperation with the University of Maine System.

Looking at what the test site allows and caters for, it can be used for offshore wind energy demonstration projects that are conducted by or in cooperation with the University of Maine, and there are no restrictions on fishing or other traditional activities within the test

site, above and beyond current state and federal statutes. Specifically, the activities permitted are:

- A wind energy development project that uses a wind turbine to convert wind energy into electrical energy with no more than two wind energy turbines.
- Up to three meteorological towers per wind turbine.
- One submerged utility line with a maximum capacity of 25MW.
- Up to two wave energy converters, which use the motion of the ocean surface waves to generate electricity.
- An ocean sensor package, which refers to an instrument that would measure met ocean data at the site.

European Marine Energy Centre (EMEC) – Scotland[52]

The European Marine Energy Centre, or EMEC, was established in 2003 as the world's first and leading facility for demonstrating and testing wave and tidal energy converters following a recommendation made by the Commons Science and Technology Committee to set up a wave and tidal energy test facility in 2001, with the hope of kickstarting a marine energy industry in the UK.

It was set up by a grouping of public sector organisations and has seen around £42mn of public funding to date invested by the Scottish government, Highlands and Islands Enterprise, The Carbon Trust, UK Government, Scottish Enterprise, European Union and Orkney Islands Council. It is a not-for-profit, private company and became financially self-sufficient in 2011.

EMEC operates to relevant test laboratory standards (ISO17025) which means it can provide independently verified performance assessments. It is also accredited to ISO/IEC 17020 allowing it to offer technology verification on marine energy converters and sub-systems.

EMEC's operations are spread out over five sites across Orkney:

- Billia Croo grid-connected wave energy test site
    - Placed on the western edge of the Orkney mainland.
    - Area with one of the highest wave energy potentials in Europe – average significant wave height of 2-3 metres, reaching extremes of 18m.
    - Five cabled test berths in up to 70m water depth, located 2km offshore and 0.5km apart. Near shore berth located closer to substation for shallow water projects.
    - Five 11kV subsea cables feeding into EMEC substation, where main switchgear, backup generator and communications room is housed.
    - Three waverider buoys to measure wave height, period and direction.
    - Purpose-built weather station to provide real-time met data for site.
    - Test site berths are monitored by CCTV.
- Fall of Warness grid-connected tidal energy test site

[52] https://www.emec.org.uk/

    - Situated in narrow channel between Westray Firth and Stronsay Firth.
    - Chosen for high velocity marine currents, reaching almost 4m per second at spring tides.
    - Seven cabled test berths at depths ranging from 12m to 50m in an area 2km across and 4km in length.
    - 11kV subsea cables feeding into EMEC's substation at Caldale in Eday, housing main switchgear, backup generator and communications room.
    - Cables contain fibre optics that allow developers to communicate with devices and transmit monitoring data back to EMEC data centre and office facilities.
    - Test site has 4MW export capacity – increasing to 7.2MW in 2023.
    - Has a 670kW hydrogen electrolyser installed adjacent to tidal substation to increase generation capacity further.
    - Developing energy storage onsite with installation of 500kW 1.5MWh vanadium battery flow.
- Scapa Flow scale wave test site
    - Chosen for relatively benign waters, south of Kirkwall, reaching around 0.35m significant wave height.
    - Site has predominantly westerly wave regime 21-25m.
    - Area is 0.4km across, 0.9km in length.
    - Both scale test sites offer use of bespoke test support buoy, device being tested can be connected to it via two umbilical cables, one for power transmission and the other for control and communications.
    - Noted EMEC holds an overarching site licence, which simplifies the consent process within an agreed envelope of activity – each test site has one berth with pre-laid foundation and attachment points, and an adjacent blank test area. Pre-laid foundations are 5m x 5m x 2m gravity-base frames loaded with dense concrete blocks for equipment moorings. An area of seabed is also available for rehearsal or deployment of other tools and techniques.
    - The scale test sites are suitable for, but not limited to:
        - Device testing
        - Component testing
        - New tools, techniques and supply chain solutions
        - Monitoring corrosion, biofouling & acoustic instrument packages
        - Anchoring, cabling, subsea hub & wet-mate connectors
        - Installation tests
        - Rehearsal activities
        - Testing ROV's & vessel activities
        - Operation & maintenance tests
        - Training
        - Health & safety procedures
        - Decommissioning trials
        - Research projects
- Shapinsay Sound scale tidal test site
    - Has fairly benign velocity marine currents with spring tides of 1.1 m/s.
    - Site features water depths of 21-25m.
    - Area is 0.4km across, 0.9km in length.
    - Both scale test sites offer use of bespoke test support buoy, device being tested can be connected to it via two umbilical cables, one for power transmission and the other for control and communications.
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        - Device testing
        - Component testing
        - New tools, techniques and supply chain solutions
        - Monitoring corrosion, biofouling & acoustic instrument packages
        - Anchoring, cabling, subsea hub & wet-mate connectors
        - Installation tests
        - Rehearsal activities
        - Testing ROV's & vessel activities
        - Operation & maintenance tests
        - Training
        - Health & safety procedures
        - Decommissioning trials
        - Research projects
- Caldale Hydrogen Production Plant

Research at Alpha Ventus (RAVE) – Germany[53]

The Alpha Ventus site in Germany entered into being when the Federal Government decided to support offshore wind energy through a research initiative and the construction of an offshore test site. This was in 2006, coming four years after the publication of the strategy of the Federal Government for the use of wind energy at sea. No wind energy plant in Germany had yet "got wet feet", hence the moves that were made.

DOTI – the operating company, standing for German Offshore Test Field and Infrastructure – was founded by EW, E.ON and Vattenfall in 2006, ahead of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety launching the Research at Alpha Ventus (RAVE) initiative, before the first project work followed in 2007. An official launch event came in 2008, before the planning of measurement technology took place, the offshore grid connection was established, and offshore substation erected.

The offshore test field is located 60km from shore, with water depths of 30m. It is made up of 12 turbines in total and has a research platform located in the immediate vicinity of the wind farm to the west, with a 100m high measuring mast. It was funded by the Federal Ministry for Economic Affairs and Climate Action, with the Fraunhofer Institute for Wind Energy Systems coordinating things. To date, financial support has cleared €120mn. The largest research partners involved in the initiative are the universities of Hannover, Oldenburg, and Stuttgart. Siemens Gamesa Renewable Energy, DNV-GL, UL International and OFFIS e.V. Institute for Information Technology are the other partners involved.

[53] Start - RAVE: Research at alpha ventus (rave-offshore.de)

RAVE is focused on reducing the cost of offshore wind and technical risk, bringing new research questions to topics such as optimisation of operation and reliability to the foreground. It has had more than 35 research projects and more than 60 partners from science and industry working on a wide range of research questions since 2008, including ecological questions and further development of plants and foundations to optimisation of operations.

Projects to have used the site with an environmental focus include:

- UFO – Environmental influences on offshore wind turbines, conducted by the Institute of Wind Energy (fk-wind) at the Bremerhaven University of Applied Sciences, together with the Institute for Marine Resources. The aim was the meteorological recording, analysis and evaluation of climatological conditions on platforms and measuring masts, as well as in wind turbines in the offshore and nearshore sector, with the influences of environmental conditions to then be investigated and analysed with regards to the effects on turbine components.
- Ecological Research – between 2008 and 2014, ecological research was conducted at the test site to be used in an evaluation of the BSH's Standards for Environmental Impact Assessments. The aim was to gain better knowledge about the impacts of offshore wind farms on the marine environment during their construction and operational phases.

Biscay Marine Energy Platform (BiMEP) – Spain[54]

The Basque Energy Board set the Biscay Marine Energy Platform (BiMEP) Project in motion back in 2008, after having found the technological development and geographical characteristics of the Basque Country were suitable preconditions for the production of marine energy, including wave and offshore wind. The presence and level of development of the naval industry in the region was also considered a determinant for the wave energy sector to be considered a strategic and promising sector.

The installation for the BiMEP Project was described as "administratively complex" and saw both national and local administrations involved. Several ministries and departments participated in different sectors and steps of the process before it was granted authorisation in 2011. The Basque Government's Energy Agency – Ente Vasco de la Energie (EVE) – obtained the marine-terrestrial public domain as a final step in 2012. Environmental approval for offshore wind testing and demonstration projects at the test site followed a little later in 2018.

The BiMEP has:

- Depths ranging from 50-90m
- A seabed that is mostly sandy with rocky areas
- Historical data from a metocean buoy installed in the area since 2008 which is available for download
- Four 13.2kV/5MW subsea cables fitted with optic fibre
- An onshore substation fitted with 25MVA 13.2/132kV transformers

[54] BiMEP – Biscay Marine Energy Platform

- Resource measurement using an oceanographic buoy and floating Lidar system
- Dry mate subsea connectors
- The possibility to feed in low voltage power
- An area restricted to shipping with perimeter beacons

Interestingly, information was uncovered on some of the environmental factors considered during BiMEP's inception. For example, during the environmental impact study, hydrodynamics, landscape, benthic communities, icthyofauna, marine mammals, fishing activity and archaeological and cultural resources were all considered. The study, developed by AZTI-Tecnalia in 2018 for the use of BiMEP as a floating wind turbine testing facility considered marine bird communities as the major environmental factor that could be most impacted by the resting of offshore wind devices. This led to an ambitious environmental monitoring plan over marine birds being suggested as something to undertake during pre-operational, construction, operational and decommissioning phases.

Marine Energy Test Centre (METCentre) – Norway[55]

The Marine Energy Test Centre (METCentre) in Norway was founded in 2009 and has recently been engaged in work to strengthen the infrastructure it has on site – something to be finalised in 2023. It is owned by local municipalities, Rogaland County Council, Rogaland Resource Centre, Equinor, Haugaland Kraft and the research centre, NORCE. METCentre is also the administrative body of the Norwegian Offshore Wind Cluster, which has more than 370 member companies.

METCentre has two test areas – a deep water one, with water depths of 200m, located 10km from shore, and a shallow water one, with water depths of 20-40m, 1km from shore.

Further characteristics include:

- Concessions already granted
- Critical test infrastructure in place
- A 22kV/15MW export cable, with an additional cable for 66kV being added in 2023
- Fibre for data communication available
- Unique natural conditions for the test of floating technologies, meaning depth, currents and winds
- Geographical location of the test centre close to yards, ports and large markets – meaning the North Sea

Under its plans for extension – which could see its current two test sites grow to six - it noted how a process has been started to look at various measures to ensure safety for both fisheries and shipping, reducing the risk of possible incidents and environmental consequences as a result. An alert and emergency preparedness plan will be established, as well as a separate duty number, staffed around the clock with actors who develop the test centre or test wind turbines having their own contingency plans for their operations.

[55] Marin Energy Test Centre- METCentre

It has also entered into an agreement with leading supplier of optimised monitoring solutions for vessel traffic services, offshore energy and maritime safety, Konsberg Norcontrol, to deliver a safety system for offshore wind and shipping for one of its test areas.

Llyr Projects – Wales[56]

Floventis Energy, a joint venture between SBM Offshore and Cierco, has been involved in developing the Llŷr Project, which is two 100MW projects exploring the potential of two innovative floating offshore wind technologies. These are both still in development, with installation expected in 2025/26.

The projects will be located in the approaches to the Bristol Channel in the Celtic Sea, around 40km offshore, at depths averaging 60-70 metres. Here, they will enjoy windspeeds of more than 10m/s every day. Each 100MW project will be made up of six to eight next generation turbines that are too large to be deployed on land and can be expected to provide power for around 250,000 homes every year.

The sites were carefully selected to enable suitable access to evaluate both the performance of the technology and its environmental interactions. There is a real unique opportunity, according to the developers, to identify issues and test mitigation and monitoring strategies before then having a wider commercial rollout across the Celtic Sea.

In terms of the actual layout of the projects, characteristics include:

- Up to eight turbines with capacities ranging between 12-20MW
- Each project-grouping of turbines will have inter-array cables connecting to a central offshore substation
- Each project will have an offshore substation
- Each project will have up to two offshore export cables to landfall
- Each project will have a minimum operational life of 25 years

The turbines will integrate with a floating platform, which is either semisubmersible or a barge design, using a tension leg or catenary mooring system to secure it to the seabed. The mooring radius will be between 50-800 metres, with this dependent on the mooring arrangement actually used.

Following the issue of a Test and Demonstration Lease from The Crown Estate, further details are set to be provided on the aims of the projects, though what is clear is that they are being set up to generate knowledge and experience that can optimise the design of floating wind arrays and reduce costs for future floating offshore wind developments.

Further motivations include accelerating the adoption of floating offshore wind technology through meaningfully addressing any short or long-term impacts to sensitive ecosystems, commercial fisheries or other maritime users; providing a research platform to understand

[56] Llŷr Floating Wind Farm - Harnessing Welsh Energy (llyrwind.com)

the interactions of floating offshore wind with the natural environment; and identifying and maximising potential supply chain opportunities for the Welsh economy.

The Tidal Thames Test Site – England[57]

After conducting research into potential power supplies available to site operators and pier owners, the Port of London Authority (PLA) found the River Thames could provide local tidal energy opportunities, albeit not through traditional turbine technology due to a lack of space.

Therefore, it set out to encourage the use of microgeneration, recognising that use of any technology must not create issues and impacts for current use of the river, wildlife, and residents on the estuary. With this in mind, it designated a site in the river that could facilitate trials of the types of schemes that could be used in the environment.

With past attempts to deploy untested new technologies having called for significant investment for the applicant and regulators to ensure safe use in the tidal Thames, it has left projects becoming caught in a “no-win discussion” regarding the measurement and demonstration of impact before the equipment could even be evaluated and the power benefit defined.

The test site, therefore, aims to have applicants’ trial both their scale and full-size systems on site, or at least the full-size systems before they can then be deployed elsewhere in the Thames. The site itself is based in Thamesmead on the south side of the river in the Royal Borough of Greenwich. It is just inside the Thames Barrier Control Zone.

To gain an agreement to use the site, an operator needs to:

- Provide information that reassures the PLA of the dimension and mechanism of the system being proposed.
- Reassure that the pull/strain is within the mooring limits with drag calculation.
- Facilitate the use of appropriate lights and radar reflection in the design.
- Undertake regular inspection of mooring lines and maintain ropes and securing points to prevent break out from the mooring.
- Notify the PLA of intended periods of use for at least two months beforehand, while also having the relevant agreements and consents in place and available for inspection by the PLA.
- Be responsible and suitably insured for any damage that must be put right to the infrastructure and river assets in the vicinity of the mooring as a result of its activity.
- Collect and share relevant data during the full-scale trial to satisfy requirements from both the PLA and any additional ones form the Environment Agency.

[57] Tidal Energy on the Thames | Environment | Port of London Authority (pla.co.uk)

Falmouth Bay Test Site (FABTest) – England[58]

The Falmouth Bay Test Site offers a combination of shelter from prevailing wind and swell direction, allowing for high levels of accessibility to deployed devices required for development at Technology Readiness Levels (TRL) 4-8. It does also give exposure to significant sea states from the east and southeast too.

It is a pre-consented site for the development and testing of marine energy converters (MECs). It is also a nursery site, meaning it is not grid connected, so all generated power must be consumed on the site via a dump load. By being pre-consented, the Falmouth Bay Test Site reduces risk, uncertainty, time and cost. It also allows for a crucial step in the device development process between tank testing and demonstration deployment.

It is overseen by a regulatory body that has two permanent members: Falmouth Harbour Commissioners (FHC) and the University of Exeter. It has a steering group that supports FHC and has representatives from industry, academia, agencies and others. The regulatory body, meanwhile, has a specific focus of implementing a diligence process to establish that each specific FaBTest installation proposal meets with the requirements as set out by Marine FHC regulations, the Crown Estate lease and good practice in accordance with stakeholder expectations. The regulatory body then advises and informs decisions to approve or decline an application for berth at the Falmouth Bay Test Site.

The application process itself is relatively straightforward for deployment. It calls for evidence of engineering due diligence, environmental and other risk assessments, as well as deployment and decommissioning plans and evidence of the required insurance and financial bonds. As long as the design fits within the defined "Rochdale envelope"[59] of permitted devices, the site can offer deployment permission.

Marine Energy Test Area (META) – Wales[60]

The Marine Energy Test Area (META) is part of the Marine Energy Wales Program. It is a range of fully licensed and accessible marine energy test sites in and around Milford Haven Waterway in Pembrokeshire which are ideal for marine energy technology developers and researchers to come and test their equipment in a variety of real sea conditions. It was part funded by the European Regional Development Fund, through the Welsh government and Coastal Communities Fund.

Specifically, META Wales includes eight pre-consented test sites which are split across two phases:

- META Quayside, which consists of five sheltered easily accessible sites and supports testing activities including:
    - Component testing

[58] FaBTest

[59] Advice Note Nine: Rochdale Envelope | National Infrastructure Planning (planninginspectorate.gov.uk)

[60] META Wales - META Wales

    - Operational testing
    - Dip testing of devices
    - Support structures, moorings, and foundations
    - Research and innovation
    - Deployment and retrieval methods
    - Vessel approach and recovery
    - Health and safety procedures
- META Open Water, which is made up of three sites further offshore that have greater resource exposure and supports open water testing activities such as:
    - Scaled tidal devices
    - Micro tidal devices
    - Instruments, components and subassemblies
    - ROV or other monitoring equipment
    - Site preparation methodologies
    - Decommissioning methodologies
    - Salvage methodologies
    - Research and innovation
    - Full-scale wave energy converter device testing
    - Scaled wave energy converter device testing
    - Component testing for floating offshore wind technology
    - Support structures, mooring sand foundations

In terms of the services that META as a whole is able to offer, these are:

- Consenting
- Mobilisation
- Supply chain
- Project management
- Data support
- Operational management
- Site permitting and risk management systems
- Technical support
- Marine energy hub facilities

Furthermore, alongside Marine Energy Wales – which helps to administer META alongside the Pembrokeshire Coastal Forum – further services that can be offered include:

- Grant funding bid support
- Marketing and building brand awareness
- Business development
- A springboard to demonstrate technologies at Welsh demonstration zones
- Stakeholder and community engagement

CADEMO Project – USA[61]

Floventis Energy, a joint venture between SBM Offshore and Cierco, has been involved in developing the CADEMO Project, a 60MW offshore wind farm set to be made up of four wind turbines and aim to open up a new path for California's clean energy.

It was a process that kicked off with a detailed, statewide assessment of state waters, evaluating all marine sanctuaries and protected areas in the process, while also looking at water depth, wind levels and electrical interconnectivity.

The project is set to be located 2.8 miles off the Vandenberg Space Force Base on the Central Coast, spanning an area of around six square miles. Notably, it will see two new forms of floating wind foundations introduced that have been especially designed to cater for deep waters off the coast of California. The turbines themselves will be visually similar to conventional onshore wind turbines, albeit taller, featuring larger blades that produce higher generation capabilities. The four turbines will be connected with inter-array cables, with a subsea export cable installed under the seafloor, connecting with an onshore cable landing site at Vandenberg.

It wants to prove next generation technology and environmental best practices, with specific aims including validating fish and wildlife impact and mitigation measures, as well as producing detailed, granular test results about environmental impacts, workforce needs, supply chain options and port facilities needed for offshore wind development in the state.

[61] Home - Cademo

9.2 Appendix 2: Existing Trial & Demonstration Sites

Table 5. Demonstrating all 46 offshore trial and demonstration sites identified through this research study (Note: 'Environmental focus explicitly mentioned?' column includes blank cells where the answer was not recorded as 'Y')

Ref #	Name	Location	Open to all?	Environmental focus explicitly mentioned?	Learn more
Offshore Wind Sites					
1	Levenmouth Demonstration Turbine	UK	Y		https://ore.catapult.org.uk/what-we-do/testing-validation/levenmouth/
2	Viana do Castelo Test Site	Portugal	Y	Y	https://www.wavec.org/en/test-sites/example-test-site-page
3	Aguçadora Test Site	Portugal	Y	Y	https://www.wavec.org/en/test-sites/agucadora-test-sites
4	EMEC 100MW floating wind test site (proposed project)	UK	Y		https://www.emec.org.uk/press-release-emec-concludes-concept-design-on-100-mw-floating-wind-test-site/
5	Erebus Demonstration Project	UK	Demo project		https://www.bluegemwind.com/our-projects/erebus/
6	White Cross Test and Demonstration Project	UK	Demo project		https://whitecrossoffshorewind.com/#:~:text=White%20Cross%20is%20a%20100MW%20project%20being%20developed,Cornwall%20Coast%20and%20covers%20an%20area%20of%2050km2.
7	The Llŷr Project	UK	Demo project	Y	https://www.llyrwind.com/
8	UMaine Deepwater Offshore Wind Test Site	USA	Y		https://umaine.edu/offshorewindtestsite/
9	Maasvlakte 2: test and demo location for offshore wind	Netherlands	Y		https://www.portofrotterdam.com/en/setting/location-

Ref #	Name	Location	Open to all?	Environmental focus explicitly mentioned?	Learn more
					options/offshore/maasvlakte-2-test-and-demo-location-offshore-wind
10	Icebreaker Wind	USA	Demo project	Y	Website undergoing redevelopment (Lake Erie Energy Development Corporation - Offshore Wind Power (leedco.org))
11	CADEMO Project	USA	Demo project	Y	https://cademo.net/
12	National Test Field Offshore Wind Energy (NaT-Off)	Germany	Y	Y	https://testfeld-mv.de/
13	SEM-REV	France	Y	Y	https://sem-rev.ec-nantes.fr/english-version/sem-rev/centrale-nantes-test-site-history
14	Floatgen Project	France	Demo project	Y	https://floatgen.eu/en/demonstration-and-benchmarking-floating-wind-turbine-system-power-generation-atlantic-deep-waters
15	Atlantic Marine Energy Test Site	Ireland	Y		https://www.oceanenergyireland.com/test-facilities/atlantic-marine-energy-test-site/index.xml
16	Biscay Marine Energy Platform	Spain	Y		https://www.bimep.com/en/
17	Pentland Floating Offshore Wind Farm	UK	Demo project		https://pentlandfloatingwind.com/the-project/
18	Alpha Ventus and Research Initiative (RAVE)	Germany	Y	Y	https://rave-offshore.de/en/about-rave.html
19	European Offshore Wind Deployment Centre	UK	Demo project	Y	https://group.vattenfall.com/uk/what-we-do/our-projects/european-offshore-wind-deployment-centre
20	Marine Energy Test Centre	Norway	Y		https://metcentre.no/about-us/

Ref #	Name	Location	Open to all?	Environmental focus explicitly mentioned?	Learn more
21	Borssele Wind Farm Site V	Netherlands	Demo project		https://www.vanoord.com/en/updates/borssele-wind-farm-site-v-turning-innovations-reality/
Test Centres and Sites					
22	Marine Energy Engineering Centre of Excellence	UK	Y	Y	https://www.meece.org.uk/
23	Energy and Environment Research Group	UK	Y	Y	https://www.swansea.ac.uk/science-and-engineering/research/engineering/water-energy/energy-environment/
24	Marine Energy Test Area	UK	Y		https://www.meta.wales/
25	Offshore Test Site	Netherlands	Y		https://www.northseafarmers.org/offshore-test-site
26	OceanACT	Portugal	Test initiative		https://www.wavec.org/en/test-sites/pagina-de-test-site
27	Fast Flow Facility	UK	Y		https://www.hrwallingford.com/facilities/fast-flow-facility
28	CNR-INSEAN – Circulating Water Channel	Italy	Y	Y	http://www.inm.cnr.it/labs/circulating-water-channel/
29	Lir National Ocean Test Facility	Ireland	Y		https://www.lir-notf.com/
30	Oceanic Platform of the Canary Islands Test Site	Spain	Y	Y	https://www.plocan.eu/en/test-site/
31	Oceanide	France	Y		https://www.oceanide.net/en/index.php
32	Dynamic Marine Component Test Facility	UK	Y		https://renewable.exeter.ac.uk/facilities/dmac/
Wave and Tidal Test Sites					
33	Paimpol-Brehat Tidal Turbine Test Site	France	Y		https://testsites.bretagneoceanpower.fr/en/
34	Wave Hub	UK	Y		https://tethys.pnnl.gov/project-sites/wave-hub

Ref #	Name	Location	Open to all?	Environmental focus explicitly mentioned?	Learn more
35	Tidal Thames Test Site	UK	Y		https://www.pla.co.uk/Environment/Alternative-Energy/Tidal-Energy-and-its-importance
36	Falmouth Bay Test Site	UK	Y		https://www.fabtest.com/
37	EMEC Fall of Warness Grid Connected Tidal Test Site	UK	Y	Y	https://www.emec.org.uk/facilities/tidal-test-site/
38	EMEC Scapa Flow Scale Wave Test Site	UK	Y	Y	https://www.emec.org.uk/facilities/scale-test-sites/
39	EMEC Shapinsay Sound Scale Tidal Test Site	UK	Y	Y	https://www.emec.org.uk/facilities/scale-test-sites/
40	EMEC Billia Croo Grid-Connected Wave Test Site	UK	Y	Y	https://www.emec.org.uk/facilities/wave-test-site/
41	Folkecenter Wave Test Station	Denmark	Y		https://tethys.pnnl.gov/project-sites/folkecenter-wave-test-station
42	SmartBay Marine and Renewable Energy Test Site	Ireland	Y		https://www.smartbay.ie/
43	Pacwave	USA	Y	Y	https://pacwaveenergy.org/
44	SEM-REV	France	Y	Y	https://sem-rev.ec-nantes.fr/english-version/sem-rev/centrale-nantes-test-site-history
45	Atlantic Marine Energy Test Site	Ireland	Y		https://www.oceanenergyireland.com/test-facilities/atlantic-marine-energy-test-site/index.xml
46	Biscay Marine Energy Platform	Spain	Y		https://www.bimep.com/en/

9.3 Appendix 3: Summary of direct feedback from 1-2-1 consultations

Stakeholder	Engagement method	Summary of Response	Appetite to support future Test & Demo site(s)
Natural England	1-2-1 Engagement & Stakeholder Workshop	As commissioning authority for this work Natural England were engaged multiple times during the delivery of this commission. They are supportive of the concept for an environmentally focused trial and demonstration site(s) and keen to understand the positions of other stakeholders.	Yes supportive
Crown Estate	1-2-1 Engagement & Stakeholder Workshop	Crown Estate indicated a clear enthusiasm for the concept of new environmentally focused offshore demonstration locations in both their 1-2-1 and stakeholder workshop contributions. Representatives indicated intelligence gathered through research on site could inform multiple ongoing workstreams including those addressing environmental / nature-focused design standards, marine compensation under the Habitats Regulations, supporting co-existence and co-location, and new technology advancements such as in floating offshore wind. It could support innovation providing evidence of relative impacts if environmental mitigation measures are used. Crown Estate representatives indicated that they would be interested in being involved in supporting progress of this concept, not only through the award the relevant seabed leases, but also to ensure the concept is driven forward through inclusion in relevant work streams going forward. It was suggested that as this concept is developed over time, the Offshore Wind Industry Council (OWIC) may be a suitable source of future funding. Further comments from Crown Estate are quoted and discussed widely in the body of this report.	Yes supportive

Stakeholder	Engagement method	Summary of Response	Appetite to support future Test & Demo site(s)
Marine Management Organisation (MMO)	1-2-1 Engagement & Stakeholder Workshop	In their 1-2-1 discussion with the research team, much of the time with MMO representatives was spent discussing the process for gaining a marine licence for the proposed trial /demonstration site(s). However, support was offered for the project concept, with representatives interviewed indicating this provision could be really important from the MMO's perspective. It was recognised that there are many areas of uncertainty as to the long term and cumulative environmental impacts on new and existing technology used at offshore wind farms. It was suggested that initiatives such as this to support greater demonstration of environmental impacts could help developers by providing better evidence to support their EIAs. The representative interviewed indicated an understanding within MMO that, for developers, the potential monitoring requirements upon new technologies incorporated into the wind farm design and operation made through the licencing process a particular burden. Support was re-iterated through the MMO contribution to the stakeholder workshop where MMO highlighted that, considering the timescales for developing a new offshore demonstration site and getting research up and running on the site, the ability of this initiative to influence key questions raised in consenting today may be limited due to this timescale. However, it was noted that any new site or network of suites could be valuable to address long-term questions on environmental impacts.	Yes supportive
Department for Environment, Food and	1-2-1 Engagement &	Through their one-to-one interview and contribution to the stakeholder workshop, Defra also indicated support for trial and demonstration site(s) with this environmental focus, to address research questions in offshore wind as well as other marine sectors.	Yes supportive

Stakeholder	Engagement method	Summary of Response	Appetite to support future Test & Demo site(s)
Rural Affairs (Defra)	Stakeholder Workshop	A number of research topics were suggested for any new site(s) including cumulative impact of multiple offshore wind farms and other marine industries, particularly in the context of identifying information that may inform future marine spatial planning / marine spatial prioritisation; how do you manage those multiple conflicting or overlapping interests and impacts? Representatives from Defra did raise questions about how the development could be funded during their interview with the research team. Representatives interviewed recommended that building the case for why government should fund or match fund this could be quite the challenge in this current economic climate where there is an expectation of significant reductions in R&D budgets by 2025. A strong business case was suggested as vital to take this work forward. It was suggested to take this work forward, the policy teams within Defra and DESNZ should be engaged and involved.	
Environmental Agency	1-2-1 Engagement & Stakeholder Workshop	Whilst their official responsibility covers land up to the high-water line, the Environment Agency do have an active interest in this work and are keen to support it. The consenting and permitting process needs to be refreshed and needs to be quicker. Regulation should be more flexible and much quicker. Their comments at the workshop re-iterated their support for the concept of future environmentally focused trial and demonstration site(s), stating an optimism that this initiative may lead to increased awareness of the importance of minimising environmental impacts of offshore wind and encourage developers/ operators and the supply chain to seek to understand these impacts in greater detail. Issues such as bio-diversity net gain are very	Yes supportive

Stakeholder	Engagement method	Summary of Response	Appetite to support future Test & Demo site(s)
		valuable concepts. They also suggested that the site(s) and data provided could be relevant to other industries which may generate similar impacts "*…such as cable laying impacts, noise impacts, non-natives etc.*", suggesting these facilities could be beneficial to other marine sectors. During the stakeholder workshop Environment Agency representatives re-iterated the importance of data collection and sharing from any new trial / demonstration site(s), supporting suggestions data collection should be mandatory from any new facilities to avoid missing valuable lessons learned.	
Centre for Environment, Fisheries and Aquaculture Science (Cefas)	1-2-1 Engagement & Stakeholder Workshop	Through one-to-one discussion and active contributions to the workshop, the Cefas team engaged in this study were supportive of the concept for dedicated offshore demonstration site(s) addressing environmental issues. Several possible areas for research that could be addressed at a new network of sites were suggested. The OWEER (Offshore Wind and Environmental Evidence Register) was highlighted as a source of information listing valuable research areas for future testing. Cefas suggested that testing scenario should be as far reaching as possible; the design of research projects undertaken at any site or network of sites should be as holistic as possible, opening the scope to include monitoring of as many impacts as possible and gaining maximum value from each project. In terms of identifying potential demonstration site locations, in the one to one and workshop session Cefas indicated the "research question" – the hypothesis we want to test – should drive a huge amount of the location, water depth, sediment type, hydrographic conditions etc. when it comes to choosing a site. Data availability highlighted as key.	Yes Supportive

Stakeholder	Engagement method	Summary of Response	Appetite to support future Test & Demo site(s)
		In terms of operation of the suggested site(s), the inclusion of a steering group was considered valuable to set the objectives for each site and support and drive the research activity on site. Cefas themselves would be interested to get involved at both an advisory level and as potential users undertaking research projects themselves.	
NatureScot	1-2-1 Engagement	NatureScot are supportive of more rigorous testing and investigation of environmental impacts across offshore wind and recognise technology testing often focuses on proof of concept and should be encouraged to take a more holistic approach addressing wider environmental impact more closely. They were broadly supportive of the concept for environmentally focused trial and/or demonstration site(s) and recognised that an already consented, dedicated location for this activity may take some or all of the initial burden off the companies or research groups undertaking the research. However, it was noted that any new site should not duplicate any testing or trial environments that are already available elsewhere. It was recognised a good provision of test and demonstration facilities across Scotland already, some of whom have hosted testing of environmental measures such as including around monitoring of operational noise generation, although it was recognised this may have been more of an afterthought rather than a research priority. Opportunities to conduct testing at existing demonstration sites and/or commercial projects should be fully explored and maximised. The challenge of financing any new site was also highlighted. In one-to-one discussion representatives identified a number of potential research topics for further testing, from biodiversity net gain and nature inclusive design to cable installation and protection approaches, electrification of wind farm vessels, to colocation with other marine industries. The discussion	Broadly supportive

Stakeholder	Engagement method	Summary of Response	Appetite to support future Test & Demo site(s)
		also highlighted initiatives including the Crown Estates Offshore Wind Evidence and Change Program looking strategically at the research challenges facing offshore wind and it was suggested an in-depth mapping exercise of research topics should be undertaken in collaboration with these existing funded initiatives.	
Offshore Wind Industry Council's Pathways 2 Growth (P2G) Workstream	1-2-1 Engagement	The P2G group indicated they were supportive of the concept for new trial and demonstration facilities to test environmental impacts and mitigation measures and are very interested to be engaged and involved as this work progresses. Discussion identified that industry need to look at environmental impact mitigation, and that testing of new and novel technologies and approaches in the field should be progressed now if these solutions are to be ready for commercial roll out beyond 2030. The representative interviewed suggested the concept could be put to the P2G Coordination Group for consideration at the next stage, and if taken up could be incorporated into a roadmap of work being driven forward by industry and government representatives participating in the group (includes all SNCBs, MMO, Marine Scotland, developers represented by trade bodies, BEIS, Defra, Daera and Scottish government). The discussion also advocated for using existing commercial sites where possible but recognised that arranging access can be a challenge which is being explored by the ECOWIND project.	Yes supportive
Offshore Renewable Energy Catapult	One to One Engagement	Through discussions with the Offshore Renewable energy Catapult team, clear support was indicated by representatives engaged. It was highlighted that companies and researchers have often found it very challenging to get lease agreements, licences and other relevant permissions to do a temporary	Yes supportive

Stakeholder	Engagement method	Summary of Response	Appetite to support future Test & Demo site(s)
		installation offshore, so a dedicated site(s) to support offshore environmental testing would be of great benefit. They highlighted that many of the testing and demonstration projects they host at their existing facilities are supported by grant funding. Examples discussed include the Maritime Development Challenge Fund co-funded by the Department for Transport (DfT). Individual projects also receive varied levels of assistance form the OREC team to get their projects off the ground. A variety of research topics were suggested as highlighted in the body of this report. Specific recommendations in terms of length of testing, support for SMEs in designing and delivering their testing, and incorporating a rigorous approach to managing on site H&S were highlighted. Key challenges of operating a site were noted as being keeping costs down, managing logistics of demonstration operations, and managing stakeholders. These are elaborated further in the body of this report.	
Joint Nature Conservation Committee (JNCC)	Stakeholder Workshop	JNCC were invited to take part in a one-to-one interview in contribution to this research however they were unable to participate in the timeframe available. Representatives did attend the stakeholder workshop but did not explicitly state their support of otherwise. Further discussions with this body in the next stage of work are suggested.	Position not explicitly stated
Natural Resources Wales (NRW)	Stakeholder Workshop	NRW were invited to take part in a one-to-one interview in contribution to this research however they were unable to participate in the timeframe available. Representatives did attend the stakeholder workshop but did not explicitly state their support of otherwise. Further discussions with this body in the next stage of work are suggested.	Position not explicitly stated

Stakeholder	Engagement method	Summary of Response	Appetite to support future Test & Demo site(s)
Department of Agriculture, Environment and Rural Affairs (DAERA)	Stakeholder Workshop	DAERA were invited to take part in a one-to-one interview in contribution to this research however they were unable to participate in the timeframe available. Representatives did attend the stakeholder workshop but did not explicitly state their support of otherwise. Further discussions with this body in the next stage of work are suggested.	Position not explicitly stated

9.3 Appendix 4: Offshore Trial Area Demand Survey

In light of energy security pressures and the climate emergency, offshore wind has become more important than ever and looks set to grow at an exciting, accelerated pace over the coming years. However, as technology efficiencies improve and projects grow larger and are installed in greater numbers, demonstrating and minimizing the environmental impacts of new components, processes and installation techniques is becoming increasingly important as regulators, developers and supply chain companies seek to drive down the environmental footprint of their projects.

Natural England have commissioned a study to determine the potential for establishing an offshore trial or demonstration site(s) within England's territorial waters. where new and novel technologies could be trialed and monitored to establish potential environmental impact pathways.

The purpose of this questionnaire is to understand your requirements for trialling/demonstration sites with a focus on assessing environmental impacts and mitigation solutions for offshore wind related products and services, your experiences in accessing these to date, and any barriers you have experienced in developing, testing and prototyping your products.

This questionnaire has been developed by Opergy on behalf of Natural England. The responses you provide will be held in confidence and analysed anonymously.

Your Details

This section captures your contact and company details.

1. Name
2. Email
3. Phone number
4. Company you represent
5. In which UK region(s) are your operations based?

Previous Trial or Demonstration Activities

This section asks you about previous product/service/technology trialling or demonstration activities you have undertaken in the past 5 years, with a particular focus on where you have sought to demonstrate environmental impacts.

1. a) Have you undertaken or supported any product/service/technology trials and/or demonstration activities in the past 5 years? If so, please briefly describe what you trialled and achieved.

   b) Did the trialling or demonstration include any specific activities to measure or monitor environmental impacts?

   c) Where was this testing/demonstration undertaken?

2. What, if any, barriers did you experience in accessing trial/demonstration sites or facilities in the past?

3. Have you wanted to complete trial/demonstrate activities and not been able to find a site with the right conditions/access?

Current and Future Requirements for Trial or Demonstration Offshore

This section asks about your current and future needs to trial and/or demonstrate your product/service/technology, with a particular focus on where you have sought to demonstrate environmental impacts. It seeks to identify your future needs to undertake environmental trials and the specific site/facilities requirements you may have.

1. a) Have you undertaken any previous environmental impact research studies/assessments on your product/service/technology? If so, what have you undertaken?

   b) What, if any, challenges or impacts of your product/service/technology have you identified that may require offshore measurement and monitoring at a trial or demonstration area?

2. a) What technologies/innovations do you have a need to test in the short – medium term (next 5 – 10 years)?

   b) At what stage of the project development process is your technology suitable for?

   - Pre-consenting / Consenting
   - Construction / Installation
   - Operations and Maintenance
   - Decommissioning

   c) What environmental receptors might your product/service/technology affect, e.g., marine mammals, birds, water quality, benthic habitats, oceanography, etc.

   d) What, if any, specific activities to measure or monitor environmental aspects or impacts do you intend to include in these activities?

3. a) What are your principal requirements for an offshore trial or demonstration site(s)?

   - Proximity to project location
   - Proximity to port infrastructure
   - Grid connection availability
   - Existing subsea infrastructure or hardware, e.g., boulders and UXOs, cables, pipelines, platform/turbine foundations, etc.

- Environmental conditions e.g., Seabed morphology, benthic habitats, tidal range, water depth, etc.

- Other (please specify)

b) Over what timescales do you wish to trial your product/service/technology to sufficiently monitor environmental effects e.g. a tidal or lunar cycle, quarterly, 1, 2, 3 years, etc.

4. a) Do you have the expertise, technology and finance to undertake your own environmental monitoring within a trial area, or would you require the monitoring to be undertaken on your behalf e.g., in the case of benthic surveys, drop-down videos, habitat mapping?

   b) Do you require technical/environmental, commercial, financial, or other support to pursue the testing or trial discussed? If yes, what level of support would you require? what options have you explored, and what support do you need?

5. Would having environmental data which you could submit to developers or projects to support and demonstrate environmental impacts improve consenting, streamline your product/service/technology development?

6. Do you believe there are any gaps in the UK market for an accessible trial facility(ies) that meets your own or the industry's needs?

www.gov.uk/natural-england