FORESEA'S SKILL PLAN

Deliverable DT2.3.2

Abstract

This deliverable reports on the review of soft services provided by open sea test centres in the North West Europe area within a global context. The outcomes are benchmarked against the future requirements of the industry to inform a future investment plan to maintain the NWE leading position in marine renewables.

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1. Introduction

The present deliverable is a long term outcome of the European project called FORESEA, funded by Interreg NWE, which gathers four marine testing facilities: ECN-SEMREV (France), EMEC (Scotland), Smartbay (Ireland) and DMEC (Netherlands). The facilities are supported by industry body Ocean Energy Europe. The FORESEA project encourages long term testing and low-carbon technology de-risking. It will result in a minimum of 26 Ocean Energy (OE) technology pre-commercial demonstrations, over 60,000 hrs of operation, work with over 60 SME's, sustaining 60+ jobs and helping to secure at least €30M or more of investment into OE companies.

The FORESEA project will also enhance the expertise and infrastructure in NWE and put in place a NWE OE Roadmap to ensure the long term impact of this project. For this purpose, a benchmark of the existing infrastructure and the future needs of the ocean energy industry was required.

The soft services provided by the test centres have been reviewed and benchmarked against the future requirements of industry. An action plan was put in place to address these. The partnership will follow this plan to maintain the NWE leading position.

The development of an investment plan for the NWE area which will cover floating wind, wave and tidal stream energy, will be achieved in a third deliverable. This investment plan will seek to deliver the funds required to realise the skills and infrastructure plans.

Ecole Centrale de Nantes (ECN) has commissioned that Cruz Atcheson Consulting Engineers Lda. (CA) to conduct a comparative study of the offshore marine renewable energy (MRE) test sites within the framework of the FORESEA project. In the present context, MRE technologies include wave energy converters (WECs), tidal energy converters (TECs) and floating wind turbines (FWTs).

The scope of work involved a review of profile of the open-ocean test sites, with a focus on the North-West Europe region, leading to strategic recommendations regarding the positioning of the FORESEA test sites.

The CA approach was based on a 3C's model (Customers, Capabilities and Competitors, see the schematic below) and the coupling of these factors to assess the market position that best

suits all the key attributes and constraints. A series of strategic recommendations which aim to help the FORESEA test sites to position themselves within the market place is presented, informing future decisions on how best to support the development of the FORESEA test sites' key competencies and services.

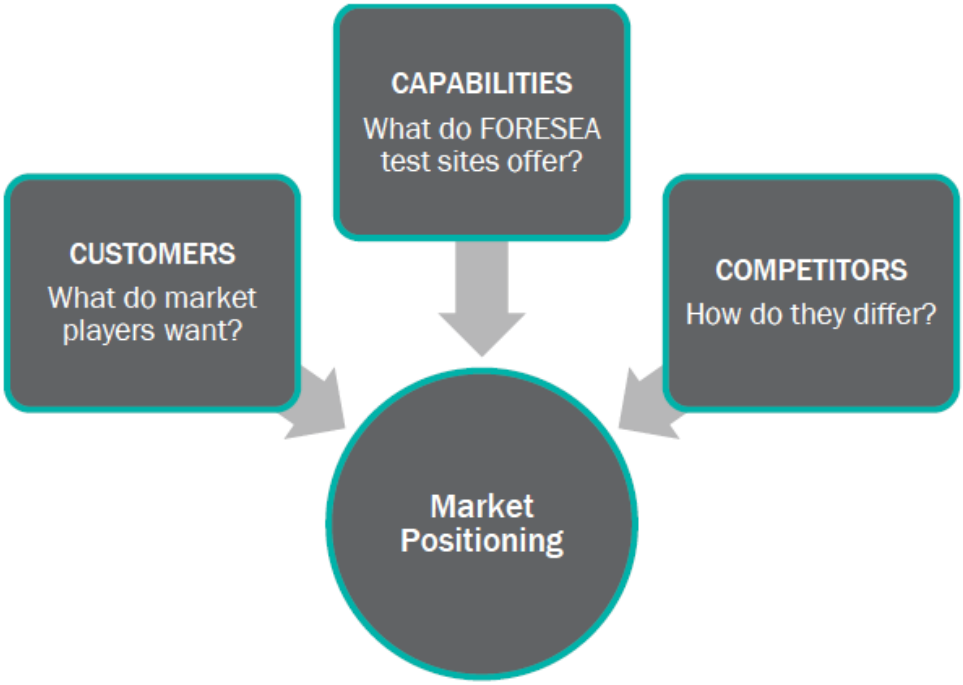

Figure 1-1 Outline structure of the CA approach to the market positioning of the FORESEA test sites

This report is organised in five main sections: following this introduction (Section 1), a review of the capabilities of the FORESEA test sites, in terms of competencies and services, is provided in Section 2. The main competitors to the FORESEA test sites are then reviewed in Section 3. Following industry consultation activities, a characterisation of the potential customers of the FORESEA test sites is detailed in Section 4. Finally, the report is concluded in Section 5 with a high-level gap analysis of the FORESEA test sites' offer, including a proposed segmentation of the customer base and strategic recommendations for the positioning of the FORESEA test sites.

The appendix of the present report contains the comprehensive results of CA's benchmarking analysis.

A similar benchmarking exercise focusing on the infrastructure aspects was conducted in parallel, following a similar methodology and using the same consultation activities. The results are presented in the DT2.3.1 FORESEA deliverable.

2. Capabilities – Current test site competencies and services (FORESEA test sites)

The first factor in the 3C model is related to an analysis of the *Capabilities* of the FORESEA test sites: SEM-REV (Nantes, France), the European Marine Energy Centre, EMEC (Orkney, UK), SmartBay (Galway, Ireland) and the Dutch Marine Energy Centre, DMEC (Alkmaar, Netherlands). The objective of such review is to gain a detailed understanding of the range of the offer proposed by the FORESEA test sites in terms of the available / planned competencies and services. Competencies are identified here as the skills that are currently available to the customers, with the potential to inform or frame a deployment campaign at the test site. On the other hand, services are identified in the context of this study as key activities offered by the test site to support the deployment campaign and the fulfilment of their underlying objectives.

The purpose of such analysis is two-fold: firstly, to map the current capabilities in order to more readily recognise gaps in the current offer, and secondly to identify potential niches which FORESEA test sites can uniquely fill to meet the market requirements.

To gain a deeper understanding of the current capabilities of the FORESEA test sites, an online consultation targeting the four members of the FORESEA consortium was conducted, aiming to address the key attributes as identified at first. The survey was created with the objective of providing a more detailed overview of the test sites' capacities and available / planned services offer, and addressed aspects such as:

- Competencies:

    - Legal Framework
        - Pre-permitted site
        - Existence of a power purchase agreement
        - Support in further applications (if applicable)

    - Availability of Site Specific Data
        - Metocean data measurement
        - Metocean hindcasts

    - Bathymetry data
    - Geomorphology data
    - Environmental studies data

- Supply Chain / R&D
    - Connection to the industry supply chain
    - Connection to other test sites
    - Connection to research / funding programmes

- Market Engagement
    - Industry group
    - Website
    - Presence at conferences

➢ Services:

- Support to development
    - Independent verification
    - Support to certification
    - Resident engineering and / or generic R&D support

- Support to monitoring
    - Resource monitoring and support
    - Environmental impact monitoring and support
    - Device monitoring and support

- Operational support
    - Planning and supervision of marine works and operations
    - Professional diving and specially trained maritime work teams
    - Logistical support (e.g. transport, partner searches)

- Policy / contractual / legal support (pending on status of licensing):
    - Support understanding local / national policy

- Outreach support:
  - Local public outreach
  - Support to finding housing, office space, relocation assistance

The key outcomes in terms of Competencies and services are summarised in the tables below.

Table 2-1 Summary Information for the FORESEA test sites: competencies

Category	Evaluation Criteria		SEM-REV	EMEC	SmartBay	DMEC
Administrative Framework	Pre-permitted site		Yes	Yes	Yes, for technologies fitting a broad envelope	No
	Power purchase agreement		Yes	Yes	N/A	N/A
	Support in further applications (if applicable)		N/A	N/A	N/A	Yes
Availability of Site Specific Data	Metocean data measurements		Free / paid access	Free / paid access	Free access	Free access
	Metocean hindcasts		Free / paid access	Free / paid access	Free access	Free access
	Bathymetry data		Paid access	Paid access	Free access	Free access
	Geomorphology data		Paid access	Paid access	Free access	Not available
	Environmental data		Paid access	Paid access	Free access	Free access
Supply Chain / R&D	Connection to the industry supply chain		Wide coverage of activities	Partly covered	Wide coverage of activities	Wide coverage of activities
	Connection to other sites		Yes	Yes	Yes	Yes
	Connection to research/funding programmes	Involvement in research programmes	More than 1 programme	More than 1 programme	More than 1 programme	More than 1 programme
		Scale (local, national, international)	Local, national, international	Local, National, International	National, international	National, international
		Involvement in funding programmes	More than 1 programme	More than 1 programme	More than 1 programme	More than 1 programme
		Scale (local, national, international)	Local, national, international	Local, National, International	Local, national, international	National, international
Market Engagement	Industry group		Active member	Active member	Active member	Active member
	Website		Regularly updated	Regularly updated	Regularly updated	Regularly updated
	Presence at conferences		Frequent	Frequent	Frequent	Frequent

Table 2-2 Summary Information for the FORESEA test sites: services

Category	Evaluation Criteria	SEM-REV	EMEC	SmartBay	DMEC
Support to Development	Independent verification	Planned (next 5 years)	Yes	Yes	Planned (next 5 years)
	Support to certification	No	Planned (next 5 years)	No	Yes
	Resident engineering and/or generic R&D support	Yes	Yes	Yes	Yes
Support to Monitoring	Resource	Yes	Yes	Yes	Yes
	Environmental impact	Yes	Yes	Yes	Yes
	Device	Yes	Yes	Yes	Yes
Operational Support	Planning and supervision of marine works and operations	Yes	Yes	Yes	Yes
	Safety responsibility	No	Provides developers with emergency response procedures and relevant standard operating procedure	No	Yes
	Professional diving and specially trained maritime work teams	No	No	Yes	No
	Logistical support	Yes	Yes	Yes	Yes
Policy Support	Support understanding local / national policy	Yes	Yes	Yes	Yes
Outreach Support	Local public outreach	Yes	Yes	Yes	Yes
	Support to finding housing, office space, relocation assistance	Yes	Yes	Planned (next 5 years)	No

3. Competition – Competencies and services of open-ocean test sites

A high-level review of the competencies and services available in test sites outside the FORESEA programme was also conducted, based on the analysis of public-domain data. Test sites suitable for the testing of floating wind turbines, tidal and wave energy technologies were assessed. The purpose of such analysis is two-fold: firstly, to provide case studies from which the FORESEA test sites can gain market insights, and secondly to identify potential niches which FORESEA test sites can uniquely fill.

The competitors identified in a first phase, including both operational and planned offshore test facilities suited for MRE technology deployment, were analysed.

The key findings of this review are presented in this report by the following order of importance and level of detail:

- Level 2: North / West Europe test sites (excluding Level 1 FORESEA sites)
- Level 3: Other sites worldwide

For the Level 2 test sites, the desktop review was guided by the key attributes of interest identified, and covered the following test facilities:

- Wave Hub, Cornwall, UK
- FabTest, Falmouth, UK
- Atlantic Marine Energy Test Site (AMETS), Ireland
- Biscay Marine Energy Platform (BiMEP), Spain
- Plataforma Oceanica de Canaria (PLOCAN), Spain
- Ocean Plug, Portugal
- Rundee Environmental Centre (REC), Norway
- Danish Wave Energy Centre (DanWEC), Denmark

The outcomes of the review are presented in the summary table (see next page), which gathers the main features of each test site to facilitate comparison.

Table 3-1 Summary Information for the Level 2 test sites: competencies and services (Part 1/2)

Category		Wave Hub	FaBTest	AMETS	BiMEP
Competencies	Administrative Framework	Fully consented Power purchase agreement	5 types of devices pre-consented for deployment	Unknown - Site under development	Pre-permitted
	Availability of Site Specific Data	Freely available	Available	Available	Available
	Supply Chain / R&D	Connection to the supply chain: Full coverage of activities Connection to other sites: Yes Connection to several research/funding programmes, at local to international scale	Connection to the supply chain: Full coverage of activities Connection to other sites: WaveHub Connection to several research / funding programmes, at local and regional scale	Connection to other sites: SmartBay via SEAI	Connection to the supply chain: Wide range of activities Several collaboration R&D projects, at local to international scale
	Market Engagement	Member of several industry groups https://www.wavehub.co.uk/ Regularly updated	http://fabtest.com/ Regularly updated Presence at conferences / exhibitions	No dedicated website	Member of Wave energy basque country http://bimep.com/ Regularly updated
Services	Support to Development	Available	Available	Unknown	Available
	Support to Monitoring	Available	Available	Unknown	Available
	Operational Support	Available	Available	Unknown	Available
	Policy Support	Available	Available	Unknown	Available
	Outreach Support	Available	Unknown	Unknown	Available

Table 3-2 Summary Information for the Level 2 test sites: competencies and services (Part 2/2)

Category		PLOCAN	Ocean Plug	REC	DanWEC
Competencies	Administrative Framework	Test site area authorised by the Council of Ministers agreement in 2014	Unknown - Site under development Power purchase agreement according to the Ministerial order 202/2015 Support in further applications planned	Unknown	Support in further applications planned
	Availability of Site Specific Data	Facilitated through open-ocean observatory	Free access	Available	Available
	Supply Chain / R&D	Connection to several research / funding programmes, at national to international scale	Connection to the supply chain: Partial coverage of activities	Unknown	Unknown
	Market Engagement	Strongly engaged in research market www.plocan.eu/ Regularly updated	http://oceanplug.pt/ Existing	www.rundecentre.no Existing	http://www.danwec.com Existing
Services	Support to Development	Unknown	Unknown	Unknown	Available
	Support to Monitoring	Available	Available	Available	Available
	Operational Support	Available	Available	Available	Available
	Policy Support	Available	Available	Available	Available
	Outreach Support	Available	Available	Available	Unknown

For the Level 3 test sites, the review was conducted at a higher-level, as only limited information is available. The assessment of the competencies and services offered was based on the analysis of public-domain data, for the following countries and test sites:

- U.S:
    - o Pacific Marine Energy Center (PMEC)
    - o California Wave Energy Center (CalWave)
    - o Hawaii National Marine Renewable Energy Test Center (HINMREC)
- New Zealand: New Zealand Marine Energy Center (NZMEC)
- Japan: Nagasaki Marine Industry Cluster Promotion Association (NaMICPA)
- China

Most of these sites have recently been announced and are only planned for development. The service offer and competencies available are typically not clearly defined for such sites when compared to established sites. More information on the planned infrastructure and comparison with the other test sites is available is DT2.3.1.

4. Customers – Industry test sites competencies and services requirements

A third aspect influencing the positioning of the FORESEA test sites is the dominant features of their potential customers. Having assessed both the capabilities and the competitors of the FORESEA test sites, it is key to accurately profile the potential customers, identifying and where possible predicting their current and future needs.

The stakeholder consultation is also presented in DT2.3.1, to facilitate its reading. The key findings of the consultation that focus on competencies and services requirements are summarised in the table 4-1.

A stakeholder consultation exercise was completed to ascertain the particular requirements and interests of potential users of open-ocean test sites for MRE technologies. The potential customers targeted included technology, project and component developers identified as being likely to invest in or conduct an ocean deployment. The topics covered in the survey focused on technologies and subcomponents for wave, tidal and floating wind energy sectors, and included:

- An overview of the respondent's technology and testing status
- Information regarding a respondent's future short to long term testing plan.
- General requirements regarding the ideal infrastructure of a test site (e.g.: grid connection, onshore and offshore features).
- General requirements regarding the services provided by a test site (e.g.: consenting status of the site, connection to the supply chain, areas of support).

The stakeholder survey was disseminated via the following methods:

- Based on the list of targeted entities identified in a first phase, 96 selected entities were contacted via email by CA on behalf on ECN with a direct invitation to participate in the survey. A flyer outlining the project background and aims, including a link to the online survey, was provided in attachment to the invitation emails. The flyer was drafted by CA and circulated to ECN for approval.

- Public advertisement of the consultation, with a link to the survey, was issued on various media platforms, including LinkedIn, Interreg North-West Europe FORESEA website and Tidal Energy Today.
- A flyer containing a link to the survey was distributed during the Ocean Energy Europe conference held in Nantes (24th to 26th of October 2017).

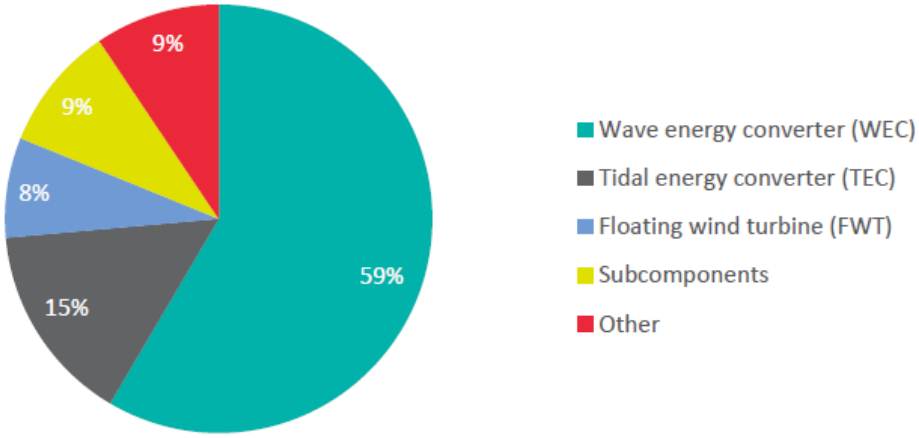

Figure 4-1 Responses to the FORESEA consultation: type of technology breakdown

At the time of the survey closure, a total of 53 responses had been received. Overall, it was found that:

- The majority of the respondents were WEC developers (60%), followed by tidal developers (approximately 15%), subcomponent developers (9%), floating wind developers (approximately 8%) and others (9%), which includes e.g. OTEC, floating solar, etc.
- From all the respondents, 25% consider themselves to be in a low TRL (1 to 3), while over 45% believe they are at an intermediate TRL level (4 to 6).
- Approximately 50% of all respondents have spent less than €5m to date in their development programmes.
- In terms of past open-ocean testing activities:
    - Despite the early-stage nature, over 50% of the WEC respondents have confirmed to have completed an open-ocean testing in the past. From the

replies to an adjacent question, CA understands that the majority of such deployments occurred in nursery / sheltered locations, as well as intermediate scale test sites.
    - There is wider experience from TEC developers in past, current and planned deployments, particularly at full-scale.
    - Past open-ocean deployments have taken place at full-scale already for FWT developers.
    - The subcomponent respondents do not exhibit any previous or current experience in open-ocean testing.
- In terms of an interest in using open-ocean test facilities:
    - All WEC respondents confirmed their interest
    - The majority of TEC respondents showed an interest in open-ocean test sites, although the consensus is not as unanimous as in the wave energy case (reference to site ownership is made in the situations were no interest is declared).
    - The FWT respondents did mark an interest in open-ocean test sites.
    - Future deployments for subcomponent technologies are planned and a strong interest in using open-ocean test facilities is clear.

Finally, the following table summarises the key outcomes regarding the future needs and requirements of the potential open-ocean test sites' customers (based on customer survey responses).

Table 4-1 Summary of the customer requirements for open-ocean test site competencies and services (based on customer survey responses)

Category	Customer Requirements
Administrative Framework	Must-have: Faster consenting is seen as the most attractive feature of an open-ocean test site
Availability of Site Specific Data	Nice-to- have: Availability of real-time resource measurements is mostly important for low TRL developers. Overall, more than 50% of the respondents ranked it as '*very important*'.
Supply Chain / R&D	Connection to the supply chain: Nice-to-have: 68% of the respondents stated that the provision of supply chain may be of interest.
	Connection to other test sites: Not important: Partnership with other testing facilities is in general the lowest attraction for developers.
	Connection to R&D / funding programmes: Must-have: 60% of the respondents value the access to suitable incentives / support mechanisms for test programmes as '*very important*'. More than 70% of the respondents ranked the support in funding / grant application as one of their priorities.
Market Engagement	Nice-to-have: Connection to the market is ranked 8th in the attractive features of an open-ocean test site.
Support to Development	Nice-to-have: 64% of the respondents '*may be interested*' in support to device development activities.
Support to Monitoring	Nice-to-have: Respondents are in general '*may be interested*' in support to monitoring activities.
Operational Support	Nice-to-have: Respondents are overall mildly interested in operational support (e.g. O&M planning or specialist support for offshore inspections).
Policy Support	Must-have: Consenting support is the critical factor in terms of service offered, with 76% of the respondents ranking it as one of their priority.
Outreach Support	Nice-to-have / Must-have: although local stakeholder engagement support is of medium interest to the overall respondents, highly experienced developers rank this support as one of their priorities.

5. Provision of Strategic Recommandations

Having assessed the Capabilities (Section 2), the Competitors (Section 3) and the dominant requirements of potential Customers of the FORESEA test sites (Section 4), the 3C factors can be combined to inform the market positioning of the FORESEA test sites and to issue recommendations on strategies for the development of additional competencies, services and infrastructure. To this objective, CA followed a three-step approach:

- Firstly, and using the capabilities and customer consultation findings, a high-level gap analysis of the FORESEA test sites' offering was conducted (see Section 5.1).
- Secondly, the current positioning of the reviewed test sites was characterised in the form of a perceptual map, in an effort to identify areas where the FORESEA test sites could contribute significantly with their capabilities (see Section 5.2).
- Thirdly, the findings of the customer consultation were condensed in a customer segmentation exercise, defining multiple customer segments that's, in CA's opinion, condition the FORESEA test sites' value proposition (see Section 5.3).

The purpose of such analysis is twofold: firstly, to recognise gaps in the current offer; and secondly, to identify potential niches which FORESEA test sites can uniquely fill to meet the market requirements. Ultimately, the analysis is expected to contribute to the creation of strategies for the development of the test sites.

5.1 FORESEA Test Sites and the Customer Requirements

Using the sector review data gathered from the two consultations exercises, a qualitative assessment of the main gaps between the test site capabilities (analysed in Section 2) and the customers' requirements (analysed in Section 4) in terms of competencies and services was conducted. The findings of the assessment are summarised in Table 5-1 and Table 5-2, using a traffic-light system based on the evaluation criteria detailed in Section 2. In such system, red indicates a potential weakness whereas green indicates a strong feature and good alignment with the customers' requirements. Such visual presentation aims at easily identifying key areas for priority development, and to contribute to the formulation of strategic recommendations to position the FORESEA test sites.

Table 5-1 and Table 5-2 present the high-level gap analysis with a core focus on the test sites' competencies and services, respectively. A similar overview focusing on the current infrastructures is presented in DT2.3.1.

From a competencies and services offer perspective, the FORESEA test sites' capabilities are overall well aligned with the customer's current requirements. In CA's opinion, a key item to consider is the strong desire from the customers to ultimately connect their technology to the grid, in an approximately 10-year timeframe. The existence of e.g. a power purchase agreement is therefore a potential feature that may attract developers to a test site, along with the support in obtaining the required licenses and permits for increasingly larger deployments.

Table 5-1 High Level gap analysis: services competencies of FORESEA open-ocean test sites vs. customer requirements

Category	Evaluation Criteria	SEM-REV	EMEC	SmartBay	DMEC	Customers' requirements
Administrative Framework	Pre-permitted site	Yes	Yes	Yes	No	Must-have: Faster consenting is seen as the most attractive feature of an open-ocean test site
	Power purchase agreement	On a case by case basis	Yes	N/A	No	
	Support in further applications	N/A	N/A	N/A	Yes	
Availability of Site Specific Data	Metocean data measurements	Free / paid access	Free/paid access	Free access	Free access	Nice-to-have: Availability of real-time resource measurements is mostly important for low TRL developers. Overall, more than 50% of the respondents ranked it as '*very important*'.
Supply Chain / R&D	Connection to the industry supply chain	Wide coverage of activities	Partly covered	Wide coverage of activities	Wide coverage of activities	Nice-to-have: 68% of the respondents stated that the provision of supply chain may be of interest.
	Connection to other sites	Yes	Yes	Yes	Yes	Not important: Partnership with other testing facilities is in general the lowest attraction for developers.
	Connection to research/funding programmes	More than 1 programme, at local, national and international scales	More than 1 programme, at national and international scales	More than 1 programme, at local, national and international scales	More than 1 programme, at national and international scales	Must-have: 60% of the respondents value the access to suitable incentives / support mechanisms for test programmes as '*very important*'. More than 70% of the respondents ranked the support in funding / grant application as one of their priorities.
Market Engagement	Industry group	Active member	Active member	Active member	Active member	Nice-to-have: Connection to the market is ranked 8th in the attractive features of an open-ocean test site.
	Website	Regularly updated	Regularly updated	Regularly updated	Regularly updated	
	Presence at conferences	Frequent	Frequent	Frequent	Frequent	

Table 5-2 High Level gap analysis: services offered at FORESEA open-ocean test sites vs. customer requirements

Category	Evaluation Criteria	SEM-REV	EMEC	SmartBay	DMEC	Customers' requirements
Support to Development	Independent verification	Planned (next 5 years)	Yes	Yes	Planned (next 5 years)	Nice-to-have: 64% of the respondents *'may be interested'* in support to device development activities.
	Support to certification	No	Planned (next 5 years)	No	Yes	
	Resident engineering and/or generic R&D support	Yes	Yes	Yes	Yes	
Support to Monitoring	Resource	Yes	Yes	Yes	Yes	Nice-to-have: Respondents are equally split between *'may be interested'* and *'very interested'* in support to monitoring activities.
	Environmental impact	Yes	Yes	Yes	Yes	
	Device	Yes	Yes	Yes	Yes	
Operational Support	Planning and supervision of marine works and operations	Yes	Yes	Yes	Yes	Nice-to-have: Respondents are overall mildly interested (68% of *'may be interested'*) in operational support (e.g. O&M planning or specialist support for offshore inspections).
	Safety responsibility	No	Yes	No	Yes	
	Professional diving and specially trained maritime work teams	No	No	Yes	No	
	Logistical support	Yes	Yes	Yes	Yes	
Policy Support	Support understanding local / national policy	Yes	Yes	Yes	Yes	Must-have: Consenting support is the critical factor in terms of service offered, with 76% of the respondents ranking it as one of their priority.
Outreach Support	Local public outreach	Yes	Yes	Yes	Yes	Nice-to-have / Must-have: although local stakeholder engagement support is of medium interest to the overall respondents (60% of *'may be interested'*), highly experienced developers rank this support as one of their priorities.
	Support to finding housing, office space, relocation assistance	Yes	Yes	Planned (next 5 years)	No	

5.2 FORESEA Test Sites and the Competition

By coupling the capabilities of the FORESEA test sites (Section 2) with the sector review data gathered from the competition analysis (Section 3) and CA's judgment / experience, the key findings can be condensed in a perceptual map to illustrate the current positioning of the test sites with regard to the level infrastructures and competencies.

Following the results of the customer survey (Section 4), two key dimensions were identified to ranks the reviewed test sites: target testing scale and tolerance to risk.

- The first proposed dimension (target testing scale) can be used to evaluate the capability of the test site to support small to large scale deployments. It can be related to e.g. the availability of grid connection and the availability of specific services, as customers at late development stages may focus on long-term, grid connected full-scale deployments, whereas early stage developers seek R&D and engineering support.
- The second proposed dimension (tolerance to risk) aims to assess the capability of the test sites to host innovative technologies and / or attract less risk tolerant developers. The willingness to host particular technologies can be related in part to the availability of R&D / funding programmes and policy support to encourage innovative technology and early stage deployments, whereas e.g. development support services can be perceived by developers as a desire to follow industry best practices and used to reduce / transfer risk responsibility.

The resulting map of the test sites is presented in Figure 5-1. The size of the circles is proportional to the average level of support and level of infrastructure of each reviewed test site. In particular, the smaller circles correspond to the test sites under planning (marked with a dotted pattern) or less experienced test sites, where only limited data is available. The FORESEA test sites are highlighted in green, whilst the Level 2 test sites are represented in red.

To select the site's position on the perceptual map, key features were selected as representatives of each axis. Using the summary tables, marks between 1 and 9 were associated with each key feature for each site, and the average on each axis was estimated to give the site's position. The horizontal axis positions the test sites with regard to their capability to support small / early stage to large scale deployments. It considers the scale targeted, the capacity of the grid connection, the expansion planned and the support to

engineering and R&D. The vertical axis positions the test sites with regards to the capability to host innovative vs. less risk tolerant developers. It considers the test site's experience, development support, connection to funding programmes and policy support.

Overall, the following observations are, in CA's opinion, relevant:

- SEM-REV, as a full-scale grid connected test site, is well suited for technology deployments of more experienced developers ready to progress to full-scale deployments.
- EMEC's offer, including both scaled and full-scale grid connected sites, covers both early and later stage deployments. This, along with the extent of the service offering, leads to a ranking towards the middle of the perceptual map.
- The focus of DMEC on TEC deployments exposes the test site to less risky technologies, whilst SmartBay, as a non-grid connected, intermediate scale test site, targets mostly early stage developers.

The distribution of the FORESEA test sites (in green), spread over the different axes of the perceptual map, may be considered when targeting different customer segments. The current test site landscape illustrated in Figure 5-1 positions the majority of the sites in the second and fourth quadrants of the perceptual map. The absence of an offer for the first and third quadrants may be explored in a segment targeting approach, should customers with such characteristics exist in sufficient numbers. Such features and associated strategies are explored in Sections 5.3.

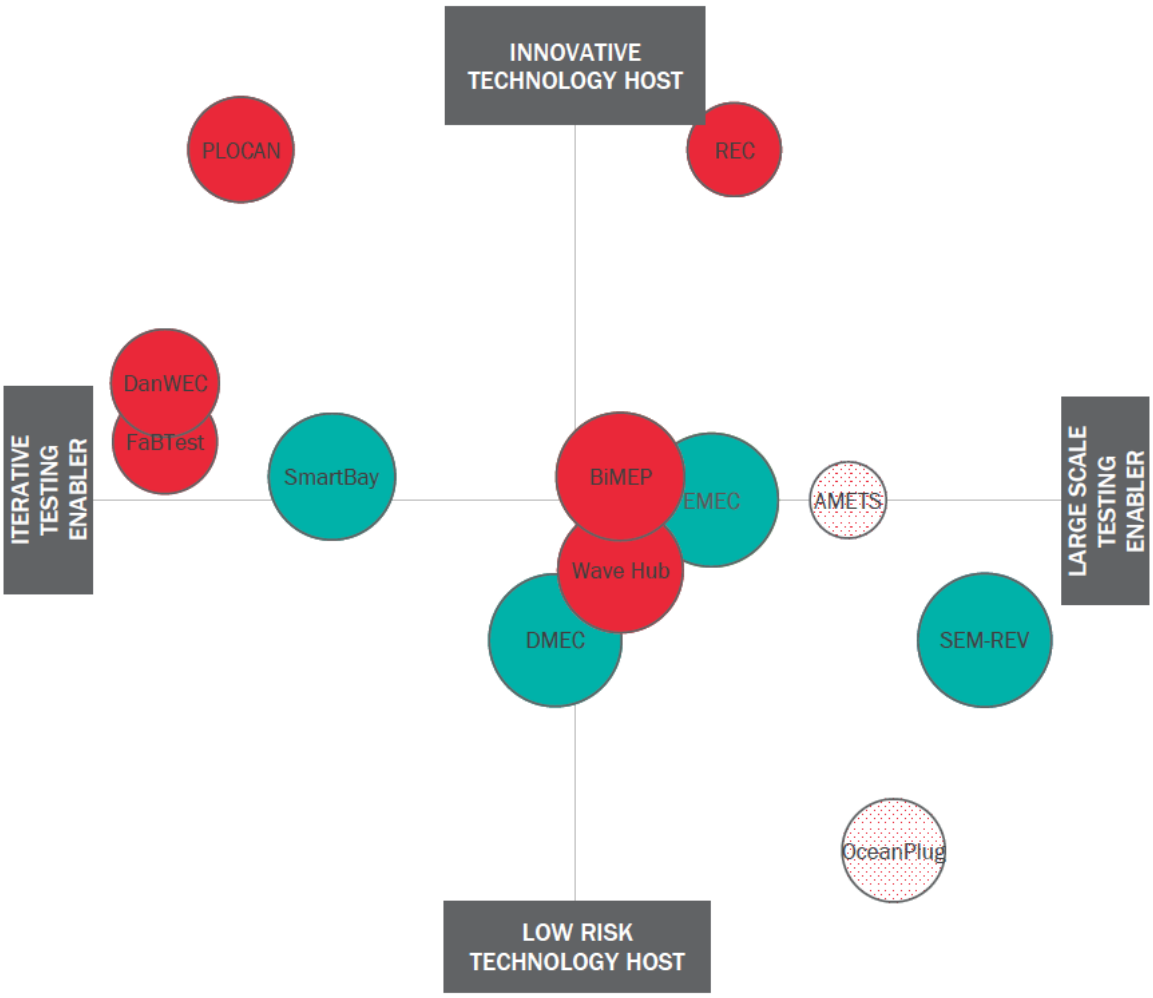

Figure 5-1 Perceptual map: current positioning of the FORESEA and Level 2 open-ocean test sites

5.3 Customer Segmentation

To assist in the positioning of the FORESEA test sites, in CA's experience it is useful to assess if the findings presented in Section 4 can be used to define specific customer segments.

In CA's opinion, the multiple customer segments identified can be summarised as illustrated in Figure 5-2. Following the results of the customer survey, and in overall alignment with the perceptual map's axes, two key dimensions were identified to characterise the potential customers of the FORESEA test sites: strategy for development and attitude towards risk. The

first proposed dimension (strategy for development) can be used to assess if a customer is mostly driven by the desire to develop a commercial scale project or the technology itself. The second proposed dimension (attitude towards risk) can be related to the degree of novelty of the technology and the approach in its development. Using the proposed dimensions, in CA's opinion four customer segments can be justified: *technology innovators, rocket path developers, incremental testers and best practice followers.*

The segmentation aims to help inform and optimise the strategic decisions and development paths of the FORESEA test sites, in particular when considering a potential segment targeting strategy. For example, SmartBay could be well positioned to target a "Technology innovators" segment. A segment targeting approach should involve the creation of specific value proposition(s), focusing on particular services / assets relevant to the segment(s) targeted.

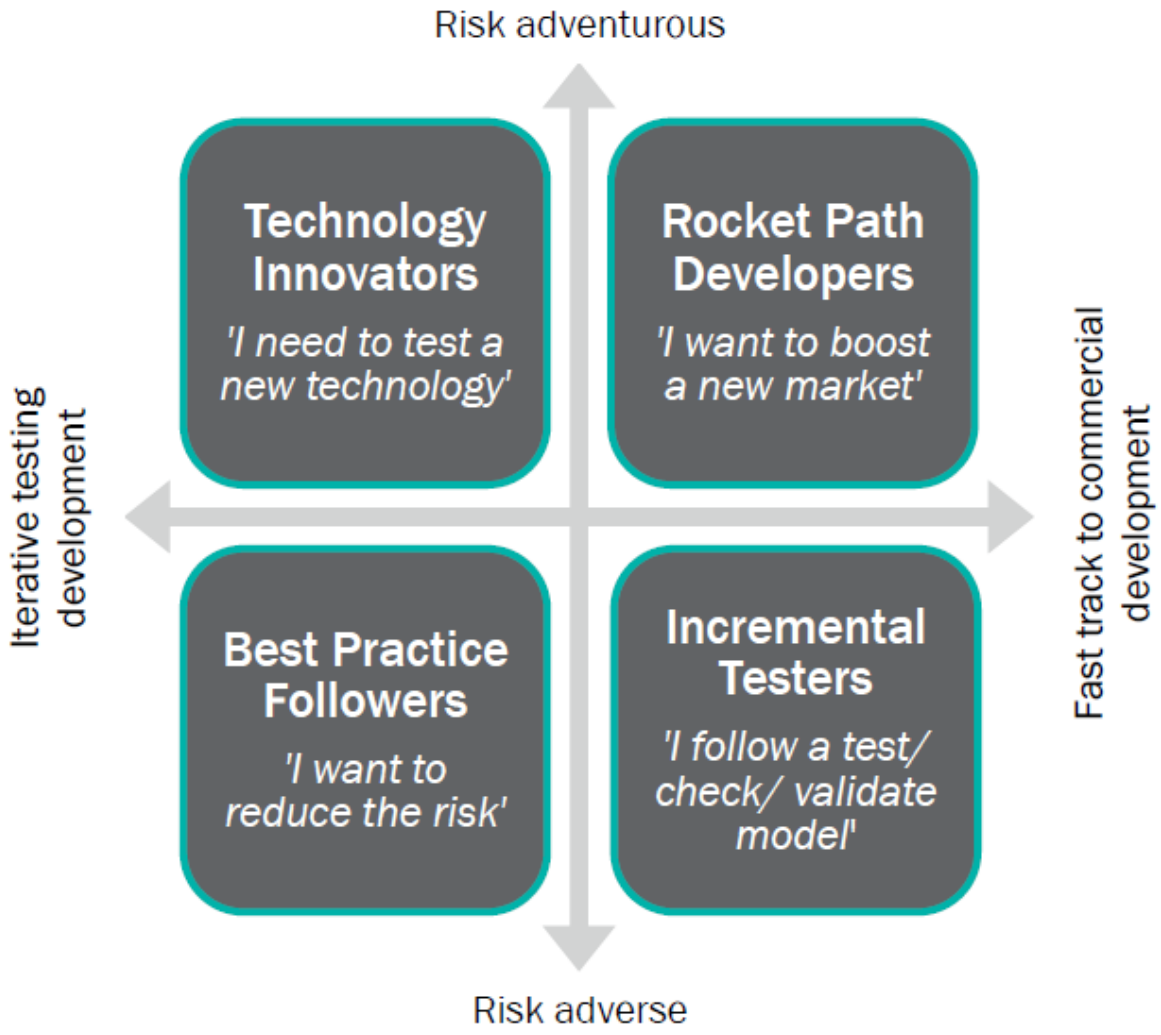

Figure 5-2 Proposed customer segmentation

The fundamental beliefs of each customer segment are conceptualised in Figure 5-3. These beliefs can in turn be explored and linked to the capabilities available in the FORESEA test sites (described in Section 2), and Figure 5-3 attempts to bridge by addressing the key characteristics of the target customer segments. In short:

- **'Technology Innovators'** can be associated as early-stage technology developers, with a high tolerance for risk and a large value given to iterative testing to prove their technology. Technology innovators require a stage gate approach for the development

plan, and nursery and intermediate scale testing facilities are likely to be of interest to this segment in a short- and medium-term horizon. Technology innovators want to focus on their core engineering / design / development activities, while indirect services such as consenting support may be of interest. As early-stage developers, they can be characterised with a low TRL and low level of funding; they typically largely require R&D support and funding resources.

- **'Rocket Path Developers'** can be characterised by a strong desire to accelerate the technology development and deployment plans to boost the market. Developers in this segment are willing to progress quickly in their TRL development, with fast progression early-stage testing to large deployment plans. Need for grid connected deployment at full-scale test site is foreseen in a short- to medium-term horizon. This can be enabled by consenting support or access to R&D / funding programmes.
- **'Best Practice Followers'** are risk-advert developers, willing to progress slowly in their development plans to ensure adherence with (perceived) best practices and ease the way to certification and commercial deployment. Iterative deployments at nursery, intermediate- and full-scale deployments are to be expected, consolidated by e.g. support to development, monitoring and operational activities from the test site.
- **'Incremental Testers'** show a strong commercial focus, and a desire to progress fast in their deployment plans, scheduled incrementally from small to large scale. Such developers typically foresee grid connected deployments at full-scale test sites in a short-term horizon. In general risk-advert, they value support services for e.g. development, monitoring and operational activities.

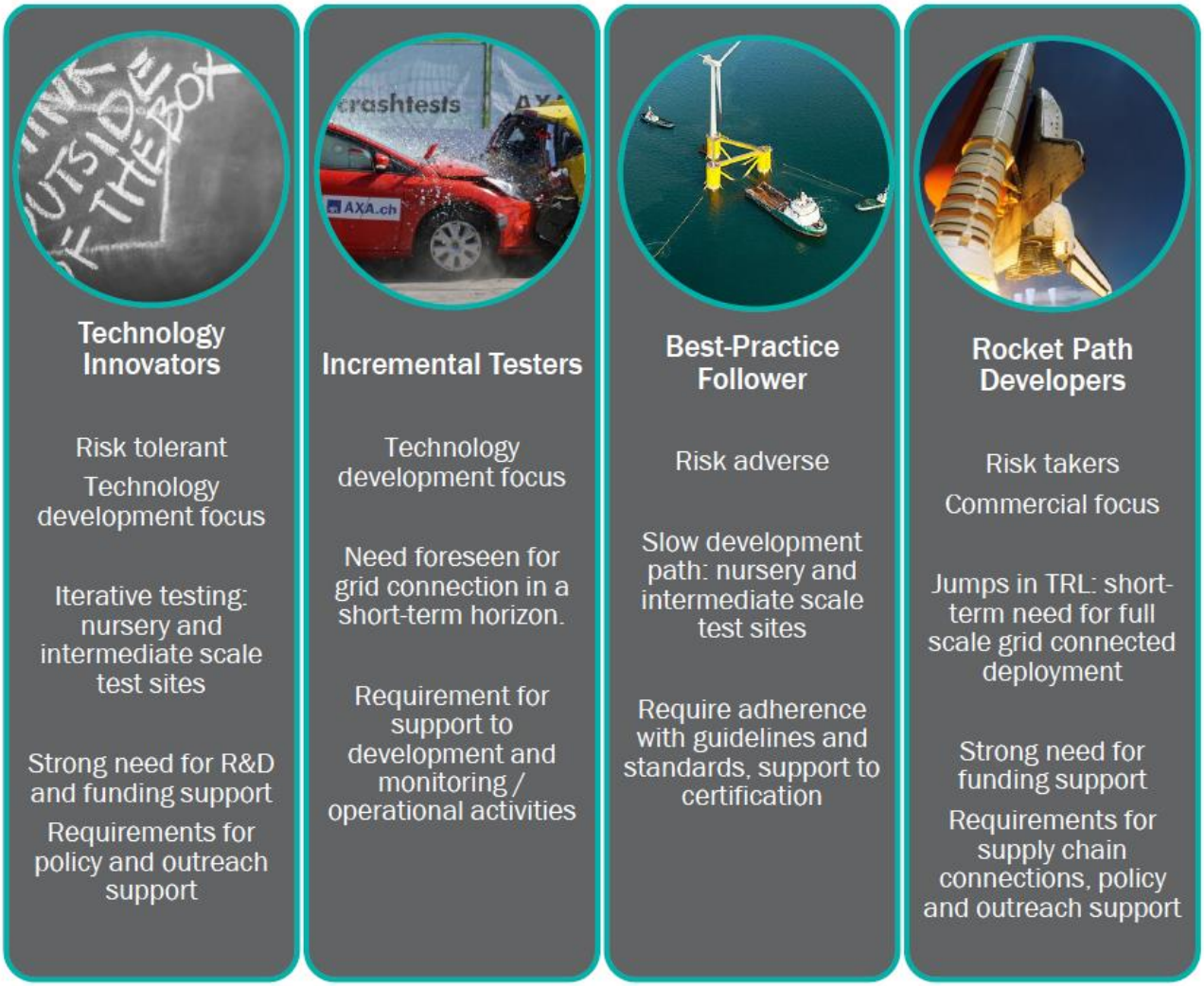

Figure 5-3 Open-ocean test sites: key characteristics of the target customer segment

REPORT

D2.3.2: PROGRAMME FOR COMPETENCIES AND SERVICES

Ecole Centrale Nantes

DOCUMENT №: 1057-R-03
REVISION №: B
DATE: 16/02/2018

cruz atcheson
CONSULTING ENGINEERS

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REPORT TITLE	D2.3.2: Programme for Competencies and Services
DOCUMENT №	1057-R-03
REVISION №	B
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DATE OF ISSUE	16/02/2018

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DOCUMENT CLASSIFICATION

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REVISION HISTORY

Revision №	Date	Comments
A	08/12/17	Initial Release – For Client Feedback
B	16/02/18	Final Release – Following Client Feedback

Contents

1 INTRODUCTION

Ecole Centrale de Nantes (ECN) has commissioned Cruz Atcheson Consulting Engineers Lda. (CA) to conduct a comparative study of the offshore marine renewable energy (MRE) test sites within the framework of the FORESEA project.

The CA scope of work is divided into two key phases [2]: in Phase 1, the general methodology for the completion of the comparative study was detailed; in Phase 2, the methodology was applied and the data collected processed, leading to the compilation of the D.2.3.1 and D.2.3.2 FORESEA deliverables.

This report summarises the outcomes of the benchmarking exercise conducted in Phase 2 on the competencies and services aspects, and constitutes the D.2.3.2 FORESEA deliverable. It documents the benchmarking exercise conducted following the "3C" model presented in [2]. It aims to inform the FORESEA test site operators on the industry's requirements in terms of open-ocean test site competencies and services, and ultimately provide strategic recommendations to best adhere to the sector's needs. Particular attention is given to possible synergies and common paths to be followed by the different FORESEA test sites.

This report is organised in five main sections: following this introduction (Section 1), a review of the capabilities of the FORESEA test sites, in terms of competencies and services, is provided in Section 2. The main competitors to the FORESEA test sites are then reviewed in Section 3. Following a range of industry consultation activities, a characterisation of the potential customers of the FORESEA test sites is detailed in Section 4. Finally, the CA report is concluded in Section 5 with a high-level gap analysis of the FORESEA test sites' offer, a proposed segmentation of the customer base and strategic recommendations for the positioning of FORESEA test sites.

CA notes that a similar benchmarking exercise focusing on the infrastructure aspects was conducted in parallel, following a similar methodology and using the same consultation activities. The results are presented in the D.2.3.1 FORESEA deliverable [3].

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2 CAPABILITIES – CURRENT TEST SITE COMPETENCIES AND SERVICES (FORESEA TEST SITES)

The first factor in the 3C model is related to an analysis of the *Capabilities* of the FORESEA test sites: SEM-REV (Nantes, France), the European Marine Energy Centre, EMEC (Orkney, UK), SmartBay (Galway, Ireland) and the Dutch Marine Energy Centre, DMEC (Alkmaar, Netherlands). The objective of such review is to gain a detailed understanding of the range of the offer proposed by the FORESEA test sites in terms of the available / planned competencies and services. Competencies are identified here as the skills that are currently available to the customers, with the potential to inform or frame a deployment campaign at the test site. On the other hand, services are identified in the context of this study as key activities offered by the test site to support the deployment campaign and the fulfilment of their underlying objectives.

The purpose of such analysis is two-fold: firstly, to map the current capabilities in order to more readily recognise gaps in the current offer, and secondly to identify potential niches which FORESEA test sites can uniquely fill to meet the market requirements.

To gain a deeper understanding of the current capabilities of the FORESEA test sites, an online consultation targeting the four members of the FORESEA consortium was conducted, aiming to address the key attributes as identified in Phase 1 [2].
The survey was created with the objective of providing a more detailed overview of the test sites' capacities and available / planned services offer, and addressed aspects such as:

- Competencies:
  - Legal Framework
    - Pre-permitted site
    - Existence of a power purchase agreement
    - Support in further applications (if applicable)
  - Availability of Site Specific Data
    - Metocean data measurement
    - Metocean hindcasts
    - Bathymetry data
    - Geomorphology data
    - Environmental studies data
  - Supply Chain / R&D
    - Connection to the industry supply chain
    - Connection to other test sites
    - Connection to research / funding programmes
  - Market Engagement
    - Industry group
    - Website
    - Presence at conferences
- Services:
  - Support to development
    - Independent verification
    - Support to certification
    - Resident engineering and / or generic R&D support
  - Support to monitoring
    - Resource monitoring and support
    - Environmental impact monitoring and support
    - Device monitoring and support
  - Operational support
    - Planning and supervision of marine works and operations

        - Professional diving and specially trained maritime work teams
        - Logistical support (e.g. transport, partner searches)
    - Policy / contractual / legal support (pending on status of licensing):
        - Support understanding local / national policy
    - Outreach support:
        - Local public outreach
        - Support to finding housing, office space, relocation assistance

Sections 2.1 to 2.4 present an overview of the current capabilities of the FORESEA test sites, with a core focus on their competencies and services (a similar overview focusing on the infrastructure is presented in [3]). To conclude, a summary table is presented in Section 2.5, gathering the main features of each site to facilitate immediate comparison.

2.1 SEM-REV, France

As part of the experimental facilities of Ecole Centrale de Nantes, SEM-REV is an open-ocean test site that aims to support the development of the marine renewable energy (MRE) industry by enabling the validation and optimisation of technologies in real open-ocean conditions.

SEM-REV's objective is served through a research program based on four points:

- Increase awareness of the marine environment.
- Support the development of MRE Technologies (floating wind turbines (FWTs), wave energy converters (WECs) and related components.
- Consider the whole energy system from conversion to transport and storage.
- Address the Security, Safety, Education & Marine Operations challenges.

The SEM-REV test site was launched in 2007 following the signature of a government/regional planning agreement, and subsequently obtained permit for WEC and FWT technologies. The export cable was installed in 2012 (as per the routing detailed in Figure 2-1).

Figure 2-1 Map of the SEM-REV open-ocean energy test site (from www.sem-rev.ec-nantes.fr)

The offshore test site obtained a series of permits and authorisations enabling the use of the 1km² offshore area, namely: the French "Water Act", a temporary concession for the occupation of the restricted sea zone, and a power exploitation permit granted by the Ministry of Energy.

SEM-REV is located approximately 40km from St-Nazaire harbour and approximately 20km from Le Croisic, in a sandy seabed area where the water depth ranges between 32 and 36m (LAT). The annual average wave power flux is 12kW/m, with a 10-year return significant wave height of 8.3m and a 50-year return significant wave height of 9.6m. The 1h averaged, 10m high mean wind velocity is 7.5m/s and the 50-year wind velocity is 29m/s (1h, 10m height).

The onshore research centre is located in Penn Avel Park, on the coast, and belongs to the Coastal Reserve. The research centre has a workshop and offices for the SEM-REV team and industrial partners who are carrying out tests.

Currently, two two-year projects are being deployed on the test site fort testing: the FP7 Floatgen project, consisting of a floating wind turbine based on a concrete floater, a synthetic rope mooring system and a dynamic umbilical; and the BPI France IHES project, consisting of a floating WEC concept including the Pywec PTO, developed by Pytheas.

The offshore test site enables:

- 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: marine environment and other usages
- Respect of rules regarding maritime safety
- Support for the developers in terms of marine operations: booking of naval means, divers, sub-contracting to qualified staff
- Support for transport and logistic activities: storage in harbour in the area, handling, booking of handling zones

Table 2-1 and Table 2-2 present key information on the competencies (administrative framework, availability of site specific data, supply chain / R&D, market engagement) and services, respectively, available at the SEM-REV test site, based on the survey responses.

Table 2-1 Summary information for the SEM-REV test site competencies

Administrative Framework	Pre-permitted site		Seabed lease and environmental licence for 20 years
	Power purchase agreement		On a case by case basis
	Support in further applications		N/A
Availability of Site Specific Data	Metocean data measurements		Free / paid access
	Metocean hindcasts		Free / paid access
	Bathymetry data		Paid access
	Geomorphology data		Paid access
	Environmental data		Paid access
Supply Chain / R&D	Connection to the industry supply chain		Vessels, Offshore specialist contractors, Moorings and foundations contractors, Subcomponent manufacturers
	Connection to other sites		Through FORESEA
	Connection to research/funding programmes	Research programmes	WEAMEC, ANR, FP7, Investissement d'avenir on R&D projects, FORESEA
		Scale	Local, national, international
		Funding programmes	Funding local: regional funding for building the site, Investissement d'avenir on R&D projects on SEMREV
		Scale	Local, national, international
Market Engagement	Industry group		FEE: France Energies Eoliennes, SER: syndicat des énergies renouvelables, FEM: France Energie Marine, WEAMEC: West Atlantic Marine Energy Centre
	Website		www.sem-rev.ec-nantes.fr
	Presence at conferences		Approx. 5-10/yr: FOWT (France), Seanergy (France), ICOE, Offshore Wind Energy (UK 2017), OEE conference

Table 2-2 Summary information for the SEM-REV test site services

Support to Development	Independent verification	Planned (next 5 years)
	Support to certification	No
	Resident engineering and/or generic R&D support	Yes
Support to Monitoring	Resource	Yes
	Environmental impact	Yes
	Device	Yes
Operational Support	Planning and supervision of marine works and operations	Yes
	Safety responsibility	No
	Professional diving and specially trained maritime work teams	No
	Logistical support	Yes
Policy Support	Support understanding local / national policy	Yes
Outreach Support	Local public outreach	Yes
	Support to finding housing, office space, relocation assistance	Yes

2.2 European Marine Energy Centre, UK

Established in 2003, The European Marine Energy Centre (EMEC) was the first centre of its kind to provide developers of both wave and tidal energy converters with purpose-built, open-ocean testing facilities.

Orkney was selected as EMEC's based primarily because of its wave regime, strong tidal currents, existing grid connection, sheltered harbour facilities and the renewable, maritime and environmental expertise that exists within the local community. Figure 2-2 displays the layout of the Billia Croo wave energy test site at EMEC along with an illustration of the facilities.

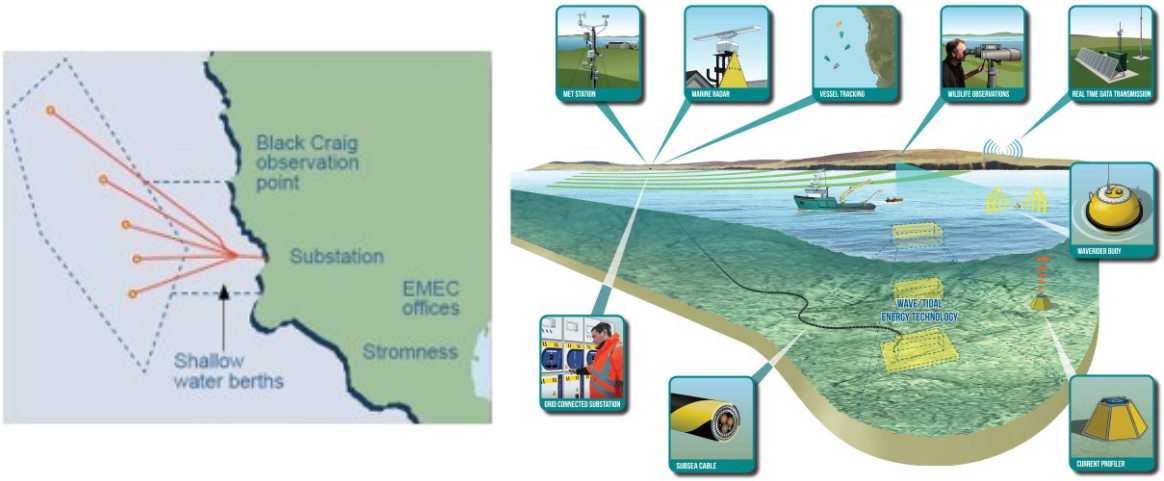

Figure 2-2 Illustration of the Billia Croo wave energy test site [4] (with the permission of EMEC)

EMEC's operations are now spread over four sites across Orkney, namely:

- Billia Croo wave energy test site, Stromness, Mainland Orkney (grid connected)
- Fall of Warness tidal energy test site, off the island of Eday (grid connected)
- Scale wave test site at Scapa Flow, off St Mary's Bay
- Scale tidal test site at Shapinsay Sound, off Head of Holland

The Billia Croo wave energy test site contains six connection points in water depth of up to 70m. This site is located to the west of the Orkney islands in the prevailing direction of swells from the Atlantic, with waves of up to 19m. The Fall of Warness tidal site is located to the west of the island of Eday and consists of eight connection points in water depths of between 25 and 50m. The site is located in a straight between islands with tidal flows of up to 4m/s.

In addition to EMEC's grid connected sites, EMEC also offers scale test sites in the sheltered conditions of Scapa Flow and Shapinsay Sound. The Scapa Flow scale site is dedicated to wave energy technologies. It is located between the islands of Mainland and Burray, in 25m water depth and with an average significant wave height between 0.25m and 0.75m. The Shapinsay Sound scale site is dedicated to tidal energy technologies. It is located between Mainland and Shapinsay, in 25m water depth and with a peak tide of 1.5m/s.

The scale sites aim to close the gap from tank testing to fully exposed ocean testing, and act as a stepping stone towards larger scale projects. Such accessible real sea testing aims to allow marine energy developers and suppliers to learn real-life lessons at a lower cost, reducing the need for big vessels or large equipment.

EMEC actively offers the following key set of services, amongst others:

- Testing hardware procurement
- Deployment methodologies and procedures
- Operational management
- Health and safety
- Procedures and protocols
- Consenting
- Data collection and interpretation
- Research methodologies

Table 2-3 and Table 2-4 present key information on the competencies (administrative framework, availability of site specific data, supply chain / R&D, market engagement) and services, respectively, available at the EMEC test site, based on the survey responses.

Table 2-3 Summary information for the EMEC test site competencies

Administrative Framework	Pre-permitted site		Yes
	Power purchase agreement		Yes
	Support in further applications		N/A
Availability of Site Specific Data	Metocean data measurements		Free / paid access
	Metocean hindcasts		Free / paid access
	Bathymetry data		Paid access
	Geomorphology data		Paid access
	Environmental data		Paid access
Supply Chain / R&D	Connection to the industry supply chain		Vessels, Offshore specialist contractors (e.g. divers)
	Connection to other sites		Runs International WaTERS group that seeks to get test centres to liaise and synchronise activities. Provides consultancy services to other test sites; Involved in MaRINET2, METCERTFIED and Marinerg-i.
	Connection to research / funding programmes	Research programmes	Partner in many UK research projects: STORM, CLEMATIS, HiDrive, and InSTREAM
		Scale	Local, National, International
		Funding programmes	Leads FORESEA, is a partner in MaRINET 2, Partner in many EU research projects: FloTEC, WaveBoost, LAMWEC, CEFOW, InToTidal, Ocean_2G, octARRAY, MONITOR, RiaSoR2, MET-CERTIFIED, Marinergi, BIG HIT, Surf 'n' Turf, and EMEC-ETV
		Scale	Local, National, International
Market Engagement	Industry group		Orkney Renewable Energy Forum - Board Member Scottish Govt - Marine Policy Group Scottish Renewables
	Website		http://www.emec.org.uk/
	Presence at conferences		Attended 39 conferences/events in 2016/17, 40 in 2015/16 including All-Energy, Scottish Renewable Marine Conference, RUK Wave & Tidal Conference, OEE Conference, ICOE, and EWTEC/AWTEC

Table 2-4 Summary information for the EMEC test site services

Support to Development	Independent verification	Yes
	Support to certification	Planned (next 5 years)
	Resident engineering and/or generic R&D support	Yes
Support to Monitoring	Resource	Yes
	Environmental impact	Yes
	Device	Yes
Operational Support	Planning and supervision of marine works and operations	Yes
	Safety responsibility	Provides emergency response procedures and relevant standard operating procedure
	Professional diving and specially trained maritime work teams	No
	Logistical support	Yes
Policy Support	Support understanding local / national policy	Yes
Outreach Support	Local public outreach	Yes
	Support to finding housing, office space, relocation assistance	Yes

2.3 SmartBay, Ireland

Ireland's 1:4 scale ocean energy test site SmartBay is located within the Galway Bay Marine and Renewable Energy Test Site and is situated 1.5km offshore in water depths ranging from 20–23m. The site has provided test and validation facilities for several wave energy devices and components to date (e.g. Wavebob).

Figure 2-3 Aerial view of the Galway bed cable (from www.smartbay.ie)

In 2015 a subsea observatory was installed at the site, with a four-kilometre cable providing a physical link to the shore at Spiddal, Co. Galway. The subsea observatory enables the use of cameras, probes and sensors to permit continuous and remote live underwater monitoring. The cable supplies power to the site and allows data from the site to be transferred for researchers testing innovative marine technology including renewable ocean energy devices. The installation of this infrastructure was the result of the combined efforts of the Marine Institute, SEAI, the Commissioners of Irish Lights, Smartbay Ireland and the Marine Renewable Energy Ireland (MaREI) Centre. The project was part-funded under the Science Foundation Ireland (SFI) "Research Infrastructure Call" in 2012. Separately, SEAI announced a Memorandum of Understanding with Apple in November 2015 to promote the development of ocean energy in Ireland. Apple has committed a €1 million fund that will help developers who receive a SEAI grant to test their ocean energy prototypes in the Galway Bay Marine and Renewable Energy Test Site.

Table 2-5 and Table 2-6 present key information on the competencies (administrative framework, availability of site specific data, supply chain / R&D, market engagement) and services, respectively, available at the SmartBay test site, based on the survey responses.

Table 2-5 Summary information for the SmartBay test site competencies

Administrative Framework	Pre-permitted site		Yes, for 30 years from Dec 2017 for technologies fitting a broad envelope; otherwise, consenting to be granted on a case by case basis
	Power purchase agreement		N/A
	Support in further applications		N/A
Availability of Site Specific Data	Metocean data measurements		Free access
	Metocean hindcasts		Free access
	Bathymetry data		Free access
	Geomorphology data		Free access
	Environmental data		Free access
Supply Chain / R&D	Connection to the industry supply chain		Vessels, Offshore specialist contractors, Moorings and foundations contractors, Subcomponent manufacturers, others
	Connection to other sites		MoU in place with OBSEA and PLOCAN. Links with other R&D test facilities in Europe in temporary partnerships via H2020 projects (e.g. FixO3 and Jerico-Next)
	Connection to research/funding programmes	Research programmes	Irish Prototype Development Fund, H2020, FP7, Interreg (several regions), National Infrastructure Access Programme, OceanERAnet, Galway County Council education programme
		Scale	National, international
		Funding programmes	Same programmes as listed in Research programmes
		Scale	Local, national, international
Market Engagement	Industry group		OEE (member, attend meeting and events); Marine Renewables Industry Association (member, attend regular meetings); Galway Chamber of Commerce (board member)
	Website		http://smartbay.ie/
	Presence at conferences		Ocean Energy Europe, Offshore Energy Europe, Oceanology International, Ocean Business, Offshore Wind, All Energy Europe, EWTEC, all attended regularly

Table 2-6 Summary information for the SmartBay test site services

Support to Development	Independent verification	Yes
	Support to certification	No
	Resident engineering and/or generic R&D support	Yes
Support to Monitoring	Resource	Yes
	Environmental impact	Yes
	Device	Yes
Operational Support	Planning and supervision of marine works and operations	Yes
	Safety responsibility	No
	Professional diving and specially trained maritime work teams	Yes
	Logistical support	Yes
Policy Support	Support understanding local / national policy	Yes
Outreach Support	Local public outreach	Yes
	Support to finding housing, office space, relocation assistance	Planned (next 5 years)

2.4 Dutch Marine Energy Centre, the Netherlands

The Dutch Marine Energy Centre (DMEC) has two test facilities:

- An inshore testing facility in one of the sluice gates in the Afsluitdijk near Den Oever, and
- An offshore connection point in Marsdiep between Den Helder and Wadden island of Texel.

The inshore test site at Den Oever is located in two ducts of the Afsluitdijk, in an existing 16m wide, 4.2m deep sluice that discharges water from the IJsselmeer to the Wadden Sea twice a day. The facility is suitable to intermediate scale testing of tidal stream turbines (dimensions of about 10 x 3m) and enables testing in real-sea conditions in a ducted channel. Laminar flow speeds typically range between 1.5 and 4.5m/s. In 2015 Tocardo deployed an array of three turbines at the test site, with a total capacity of about 300kW [5].

The offshore Marsdiep test site is situated in open water that experiences bidirectional tidal flows of 1.0 – 2.0m/s. The 1km^2 site is close to both the harbours of Den Helder and NIOZ on the Wadden island of Texel. The connection points is located 800m from shore in water depth of 25m, and is connected to the grid. Tidal energy devices of all types and maturity levels can be tested here. The test site has been used previously to test the BlueTEC platform, carrying a Tocardo turbine [6].

Table 2-7 and Table 2-8 present key information on the competencies (administrative framework, availability of site specific data, supply chain / R&D, market engagement) and services, respectively, available at the EMEC test site, based on the survey responses.

Table 2-7 Summary information for the DMEC test site competencies

Administrative Framework	Pre-permitted site		No
	Power purchase agreement		N/A
	Support in further applications		Yes
Availability of Site Specific Data	Metocean data measurements		Free access
	Metocean hindcasts		Free access
	Bathymetry data		Free access
	Geomorphology data		Not available
	Environmental data		Free access
Supply Chain / R&D	Connection to the industry supply chain		Vessels, Offshore specialist contractors, Moorings and foundations contractors, Subcomponent manufacturers, others
	Connection to other sites		Within MaRINET2 project and within our own national network of test facilities and knowledge institutes. International WATERS
	Connection to research/funding programmes	Research programmes	Dutch Marine Energy Centre Innovation Accelerator, Environmental Impacts Blue Energy, METCERTIFIED
		Scale	National, international
		Funding programmes	DMEC Innovation Accelerator, FORESEA, MaRINET2, MET-CERTIFIED
		Scale	National, international
Market Engagement	Industry group		Ocean Energy Europe: Participation in meetings and attendence of yearly events Energy from Water Association (EWA)
	Website		http://www.dutchmarineenergy.com
	Presence at conferences		Conferences attended: 3-5 per year Attended this year: North Sea Offshore, European Wave & Tidal Energy Conference, Ocean Energy Europe, Offshore Energy, AquaTech, International Water Week

Table 2-8 Summary information for the DMEC test site services

Support to Development	Independent verification	Planned (next 5 years)
	Support to certification	Yes
	Resident engineering and/or generic R&D support	Yes
Support to Monitoring	Resource	Yes
	Environmental impact	Yes
	Device	Yes
Operational Support	Planning and supervision of marine works and operations	Yes
	Safety responsibility	Yes
	Professional diving and specially trained maritime work teams	No
	Logistical support	Yes
Policy Support	Support understanding local / national policy	Yes
Outreach Support	Local public outreach	Yes
	Support to finding housing, office space, relocation assistance	No

2.5 Summary Table

Table 2-9 provide a summary of the key information presented in this section for the FORESEA test sites.

Table 2-9 Summary information for the FORESEA test sites: competencies

Category	Evaluation Criteria		SEM-REV	EMEC	SmartBay	DMEC
Administrative Framework	Pre-permitted site		Yes	Yes	Yes, for technologies fitting a broad envelope	No
	Power purchase agreement		Yes	Yes	N/A	N/A
	Support in further applications (if applicable)		N/A	N/A	N/A	Yes
Availability of Site Specific Data	Metocean data measurements		Free / paid access	Free / paid access	Free access	Free access
	Metocean hindcasts		Free / paid access	Free / paid access	Free access	Free access
	Bathymetry data		Paid access	Paid access	Free access	Free access
	Geomorphology data		Paid access	Paid access	Free access	Not available
	Environmental data		Paid access	Paid access	Free access	Free access
Supply Chain / R&D	Connection to the industry supply chain		Wide coverage of activities	Partly covered	Wide coverage of activities	Wide coverage of activities
	Connection to other sites		Yes	Yes	Yes	Yes
	Connection to research/funding programmes	Involvement in research programmes	More than 1 programme	More than 1 programme	More than 1 programme	More than 1 programme
		Scale (local, national, international)	Local, national, international	Local, National, International	National, international	National, international
		Involvement in funding programmes	More than 1 programme	More than 1 programme	More than 1 programme	More than 1 programme
		Scale (local, national, international)	Local, national, international	Local, National, International	Local, national, international	National, international
Market Engagement	Industry group		Active member	Active member	Active member	Active member
	Website		Regularly updated	Regularly updated	Regularly updated	Regularly updated
	Presence at conferences		Frequent	Frequent	Frequent	Frequent

Table 2-10 Summary information for the FORESEA test sites: services offered

Category	Evaluation Criteria	SEM-REV	EMEC	SmartBay	DMEC
Support to Development	Independent verification	Planned (next 5 years)	Yes	Yes	Planned (next 5 years)
	Support to certification	No	Planned (next 5 years)	No	Yes
	Resident engineering and/or generic R&D support	Yes	Yes	Yes	Yes
Support to Monitoring	Resource	Yes	Yes	Yes	Yes
	Environmental impact	Yes	Yes	Yes	Yes
	Device	Yes	Yes	Yes	Yes
Operational Support	Planning and supervision of marine works and operations	Yes	Yes	Yes	Yes
	Safety responsibility	No	Provides developers with emergency response procedures and relevant standard operating procedure	No	Yes
	Professional diving and specially trained maritime work teams	No	No	Yes	No
	Logistical support	Yes	Yes	Yes	Yes
Policy Support	Support understanding local / national policy	Yes	Yes	Yes	Yes
Outreach Support	Local public outreach	Yes	Yes	Yes	Yes
	Support to finding housing, office space, relocation assistance	Yes	Yes	Planned (next 5 years)	No

3 COMPETITION – COMPETENCIES AND SERVICES OF OPEN-OCEAN TEST SITES OUTSIDE FORESEA

A high-level review of the competencies and services available in test sites outside the FORESEA programme was conducted, through the analysis of public-domain data. Test sites suitable for the testing of floating wind, tidal and wave energy sectors were assessed. The purpose of such analysis is two-fold: firstly, to provide case studies from which the FORESEA test sites can gain market insights, and secondly, to identify potential niches which FORESEA test sites can uniquely fill.

The *Competitors* identified in Phase 1 [2], including both operational and planned offshore test facilities suited for MRE technology deployment, were analysed. For each test site, the review was guided by the key attributes of interest introduced in Phase 1 [2].

The key findings of this review are presented in this section, in the following order of importance and level of detail:

- Level 2 (Section 3.1): North / West Europe test sites (excluding Level 1 FORESEA sites)
- Level 3 (Section 3.2): Other sites worldwide

The section concludes with a summary table gathering the main features of each test site to facilitate comparison (see Section 3.3).

3.1 Level 2: Test Sites in North / West Europe

3.1.1 Wave Hub, Cornwall, UK

Wave Hub is a grid connected test site for full-scale testing of wave and floating offshore wind energy technologies, which can support a range of different technologies. The site comprises an 8km^2 consented area, located 16km off the coast of Hayle and over 100km from the larger dock facilities at Falmouth. In November 2016, it was announced that Wave Hub is to be formally transferred to Cornwall Council [8].

Wave Hub has a connection agreement (see Figure 3-1) with Western Power Distribution, including the required parameters of electrical quality which reflect Grid Code Compliance. Wave Hub customers are required to operate within these parameters. For Power Purchase Agreement (PPA), customers can choose to apply for project accreditation under the Renewable Obligation (RO) or Contracts for Difference (CFD) feed in tariff scheme [7].

The site is fully consented and has a 25-year seabed lease. Developers coming to Wave Hub need to apply for their own Marine Licence. Wave Hub's team can advise and support developers through this process, as well as the capability of providing a full range of baseline data. Device developers are responsible for the installation and ongoing operation and maintenance of their device(s). However, dedicated operational teams can be requested for support.

Deployments have already taken place at WaveHub. For example, Seatricity's Oceanus 2 WEC was installed in May 2016 (not grid connected) and decommissioned a year later – see [9]-[10]. In November 2016, Carnegie's received £9.6 million from the European Regional Development Fund (ERDF) for its planned deployment plan at WaveHub of a single 1MW grid connected CETO 6 WEC. Finally, in February this year, GWave announced its plans for a 9MW wave energy project to be deployed at Wave Hub [11].

Table 3-1 presents key information on the competencies and services available or planned at the WaveHub site, categorised into legal framework, availability of site specific data, supply chain / R&D, market engagement and services offered.

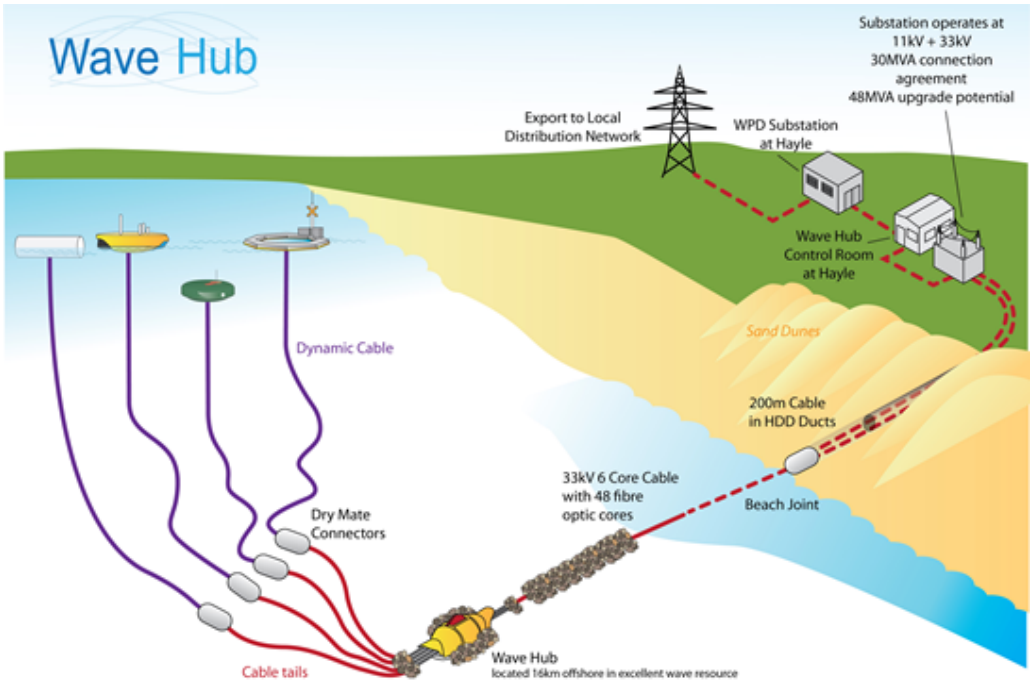

Figure 3-1 Overview of Wave Hub site connection layout (from [12])

In February this year (2017) was announced the launch of Marine Hub Cornwall [14], with the objective to provide a co-ordinated offer to the marine renewable energy sector, combining assets such as Wave Hub and FabTest (see also Section 3.1.2), with local supply chain and existing and planned programmes of activity such as the new Marine–i Challenge Fund or Invest in Cornwall support.

Wave Hub Ltd is also the third-party manager for demonstration zones in Pembrokeshire (Wales). The primary aim is to help marine energy developers to test in open sea conditions, fostering a growing marine energy industry in the region. Pembrokeshire is located in the proximity of deep water port facilities and has a dedicated Energy Enterprise Zone with business development incentives that stimulates the energy sector supply chain.

In order to support O&M operations at the Pembrokeshire Demonstration Zone, Pembroke Port is currently investing in a Masterplan to adapt part of the site for use as a specialist facility for testing, manufacture and export of marine renewable devices [13].

The site aims to provide a single point of access for marine energy developers, gathering in working groups all wave and tidal developers with an interest in Wales, and linking them to relevant Government departments (e.g. Energy Policy and Economy, Science and Transport). Sub-group meetings are focusing on consenting and research, development opportunities and best practice on specific topics.

Table 3-1 Summary information for the Wave Hub test site competencies and services

Administrative Framework	Fully consented, with a 25-year seabed lease. Developers coming to Wave Hub need to apply for their own Marine Licence Grid connection agreement with Western Power Distribution + power purchase agreement in place
Availability of Site Specific Data	Live wave data from a buoy operating within the Wave Hub Safety Zone. Data is freely available and can be streamed direct on request. Long term hindcast data by University of Exeter Wave Hub Environmental Statement 2006 Baseline environmental data available
Supply Chain / R&D	Connection to the industry supply chain: Full coverage of activities Connection to other sites: FabTest, Pembrokeshire, South West Mooring Test Facility Connection to research/funding programmes: Partnership for Research in Marine Renewable energy (PRIMaRE), Invest in Cornwall, Marine-i, ERDF, at local to international scale
Market Engagement	Industry groups: Cornwall Marine Network, Marine Offshore Renewables (MOR) group, South West Marine Energy Park (SWMEP), Invest in Cornwall and The Growth Hub. Website: www.wavehub.co.uk Regularly updated
Support to Development	In-house team of specialists
Support to Monitoring	Test site instrumentation and communications
Operational Support	Dedicated operational team Overall site safety monitoring, communications and central emergency response function
Policy Support	Marine Licence application support
Outreach Support	Nearby business park offers office & industrial accommodation

3.1.2 FaBTest, Falmouth, UK

The Falmouth Bay Test (FaBTest) site is a pre-consented 2.8km^2 test area for wave and tidal energy devices and allows up to three devices to be deployed concurrently. The test area is situated in Falmouth Harbour, between 3 to 5km offshore in Falmouth Bay (see Figure 3-2).

The FaBTest site is administered by Falmouth Harbour Commissioners (FHC) supported by a steering group. The steering group is divided into two sub-groups, a core group ('Regulatory Body') and the industry group. The Regulatory Body has two permanent members, FHC and the University of Exeter. Operational site support is provided by the offshore renewable energy group from the University of Exeter.

FHC hold a Marine Licence and a seabed lease agreement with The Crown Estate for the FaBTest site. The site pre-consent allows the following types of devices to be deployed (subject to permits issued by FHC) [15]:

- 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;
- Subsystem connectors and umbilicals.

Provided that a device fits within the defined device descriptions, the application process for a deployment at the FaBTest site is streamlined. The application requires evidence of engineering due diligence, environmental and other risk assessments, as well as deployment and decommissioning plans, and evidence of required insurance and financial bonds [15].

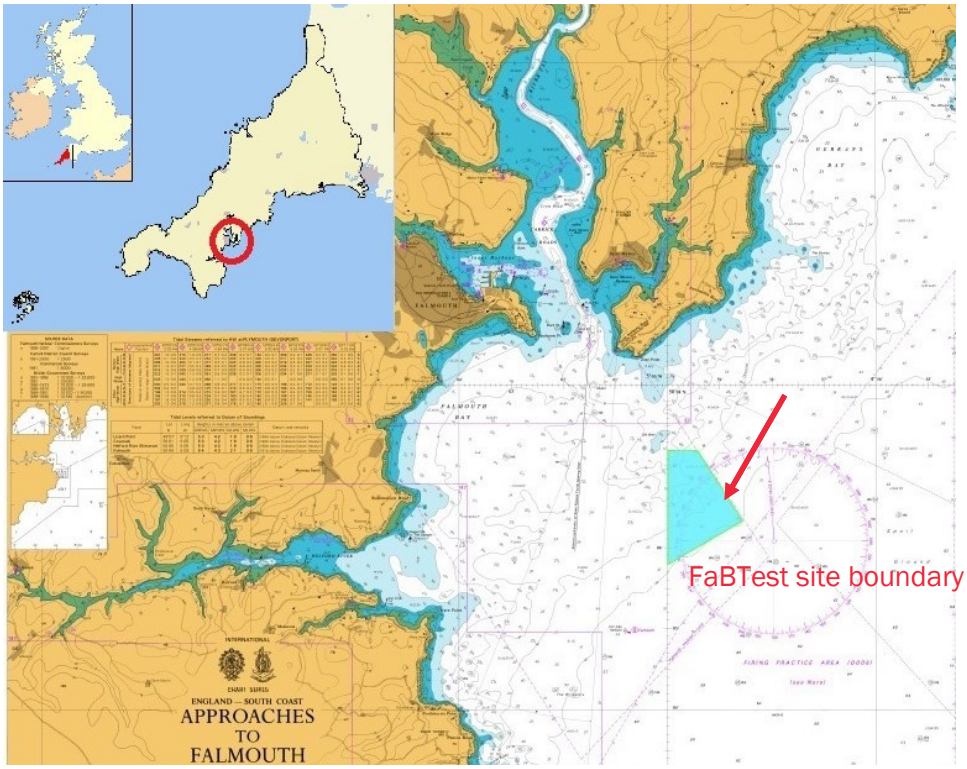

Figure 3-2 Overview of FaBTest site boundaries (from [15])

A range of data, including bathymetry, wave and current climate and environmental conditions, is collected by the University of Exeter which is made available to developers and stakeholders when applying for deployment.

In February this year (2017) was announced the launch of Marine Hub Cornwall [14], with the objective to provide a co-ordinated offer to the marine renewable energy sector, combining assets such as Wave Hub (see also Section 3.1.1) and FaBTest, with local supply chain and existing and planned programmes of activity such as the new Marine–i Challenge Fund or Invest in Cornwall support.

Table 3-2 Summary information for the FabTest test site competencies and services

Administrative Framework	Pre-consented test site for marine energy converter deployment (short term).
Availability of Site Specific Data	Oceanor Seawatch Mini II wave buoy, Datawell Waverider Mk3 buoy, ADCPs Wave data from hindcast model running from March 2000 to November 2008, constructed using SWAN Defra, Natural England & JNCC via website www.mczmapping.org/#. Geophysical survey conducted at the site in 2014. Anthropogenic underwater noise and seabed condition (video imagery)

Supply Chain / R&D	Connection to the industry supply chain: Access to supply chain, experienced in delivering marine renewable projects Connection to other sites: Wave Hub, South West Mooring Test Facility Connection to research / funding programmes: Through University of Exeter (UoEx), Regional Growth Fund, at local and regional scale
Market Engagement	Industry groups: The FaBTest steering group has representatives from industry, academia, agencies and other stakeholders. Website: www.fabtest.com Regularly updated Presence at conferences / exhibitions: 2 Primare conferences, SmartGrid seminar and Marine energy seminar since 2014
Support to Development	The FaBTest site has a detailed application process for developers seeking to deploy at FaBTest. Resident engineering and/or generic R&D support: Offshore Renewable Energy Group (OREG, UoEx)
Support to Monitoring	Metocean data management is led by the OREG, UoEx. Measured data is transmitted in real time to the UoEx storage system. Data can be shared with developers via the website. Support to environmental impact and device monitoring available from the OREG, UoEx
Operational Support	Operational support provided by the OREG, UoEx The FHC-FaBTest Operating Policy (FHC/FT/102) document is available. FHC supported by the Regulatory Body will ensure that a QHSE management plan (submitted as a part of the application process) is in line with the FHC-FaBTest Operating Policy for all permitted work at the test site.
Policy Support	Detailed description of the application process for deployment available on the FaBTest website [15].
Outreach Support	Unknown

3.1.3 Atlantic Marine Energy Test Sites (AMETS), Ireland

Figure 3-3 Location of AMETS [16]

The Atlantic Marine Energy Test Site (AMETS) is being developed by the Sustainable Energy Authority of Ireland (SEAI) to facilitate testing of full scale marine energy converters in an energetic ocean environment. AMETS is located off Annagh Head, west of Belmullet in County Mayo (Ireland) and will be connected to the national grid (see Figure 3-3). The Frenchport (Annagh Peninsula) was identified as a possible support base, and construction of extra slipway adjacent to existing pier is being considered in that perspective.

The Foreshore Lease for AMETS was signed by the Minister of Environment Communities and Local Government in January 2015, following a detailed assessment and approval process. The lease provides the legal basis for operating the test site for a period of 35 years.

The grid connection agreement is in place with ESBN since 2011. A grid connection route has been designed and submitted as part of the substation planning permission application, awarded in April 2017.

As the site is not yet in operation, the range of services offered is for now limited to a suite of detailed information provided to developers showing an interest in deploying at the AMETS site. Such information includes live met-ocean data measurements, numerical wave modelling reports including wave propagation and wave energy assessments, offshore site investigations including vibrocores and multi-beam surveys.

Table 3-3 summarises the key information available for the AMETS test site, limited to the administrative framework and the availability of site specific data due to the early stage of development of the test site.

Table 3-3 Summary information for the AMETS test site competencies and services

Administrative Framework	Unknown
Availability of Site Specific Data	Available

3.1.4 Biscay Marine Energy Platform (BIMEP), Spain

The Biscay Marine Energy Platform (BiMEP), an open-ocean test facility promoted by Ente Vasco de la Energia (EVE) and Institute for Energy Diversification and Saving (IDAE) in the Basque Country, was officially inaugurated in July 2015. BiMEP currently offers, amongst other services, provision of environmental data (including historical and geophysical data, forecasts on wave conditions) monitoring services (oceanographic parameters and power generation), and 24/7 surveillance and emergency response.

BiMEP hosts the first floating wave energy device connected to the grid in Spain. Oceantec Energías Marinas deployed its floating 30kW OWC WEC, Marmok-A-5 at BiMEP in October 2016 [17]. The device was connected to the grid in early December 2016. A second 12-month deployment phase was scheduled for 2017 but no recent information was found confirming its completion. Other projects that are also carrying out trials at BiMEP but without grid connection, e.g. ZUNIBAL S.L. is testing the ANTEIA metocean buoys.

Close to the current location, another open-ocean area was identified for potential extension of the infrastructure towards floating offshore wind trials [18].

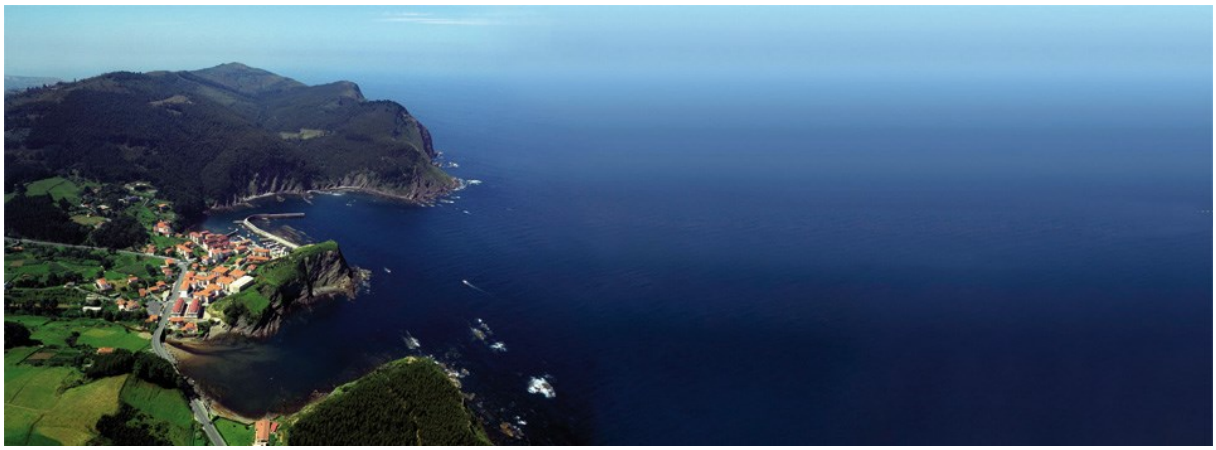

Figure 3-4 Overview of BiMEP site and facilities (from www.bimep.com)

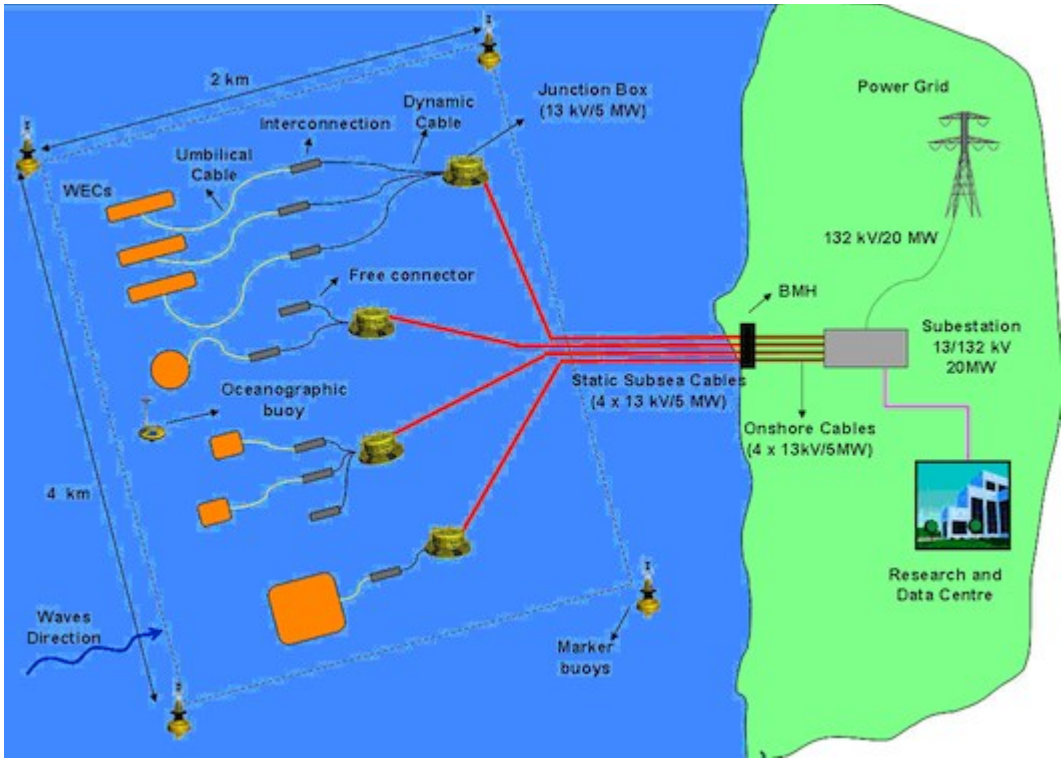

Figure 3-5 Schematic of the Biscay Marine Energy Platform (BiMEP) (from www.tethys.pnnl.gov/annex-iv-sites/biscay-marine-energy-platform-bimep)

Table 3-4 presents key information on the competencies and services available or planned at the BiMEP site, categorised into administrative framework, availability of site specific data, supply chain / R&D, market engagement and services offered.

Table 3-4 Summary information for the BiMEP test site competencies and services

Administrative Framework	Pre-permitted for WEC technology Concession of marine-terrestrial public-domain granted in 2012.
Availability of Site Specific Data	Historical and geophysical data. Real time data on oceanographic parameters (SCADA application) 24, 48 and 72-hour forecasts on wave conditions, to help organise operations, plan power generation and anticipate emergency situations
Supply Chain / R&D	Connection to the industry supply chain: Wide range of activities covered Connection to other sites: none known Connection to research / funding programmes: Launch of collaboration R&D projects to develop enabling technology, resource assessment and environmental and pre-regulatory aspects; MaRINET; At local to international scale
Market Engagement	Industry group: Wave energy Basque country Website: www.bimep.com
Support to Development	Verification of mechanical, electrical, oceanographic and environmental aspects Power performance assessment; Quality of Power; Advanced mechanical, electrical, resource and environmental analyses
Support to Monitoring	Real-time metocean data; Forecasts Environmental conditions of the area Real-time electrical generation data
Operational Support	Management of local contractors for device installation, recovery and maintenance activities Monitoring of alarms; Device surveillance; Management of emergencies
Policy Support	Assistance with accessing financial support (public and private)
Outreach Support	Hiring office space for monitoring purposes and warehouse space

3.1.5 Plataforma Oceanica de Canarias (PLOCAN), Spain

Oceanic Platform of the Canary Islands (PLOCAN) offers a marine test site for marine energy converters. The PLOCAN test site was authorized by the Cabinet of Ministers in March 2014 including a marine area of 23km^2 from the coast to 600m depth.

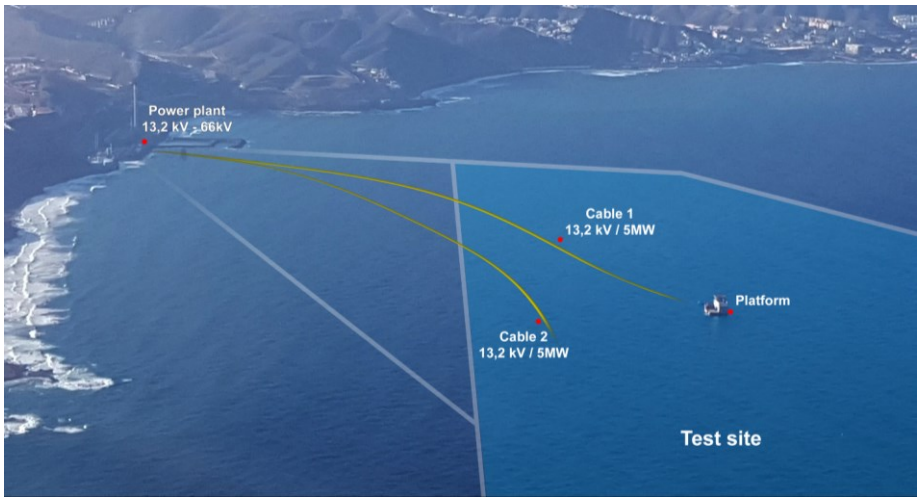

Figure 3-6 Overview of PLOCAN site and facilities (from www.plocan.eu)

PLOCAN includes an offshore platform, located 1.5km from shore and at 30m depth, which has recently been fixed to the seabed at the north-east of Gran Canaria Island [17]. The platform is a multipurpose infrastructure providing workshops, laboratories, classrooms, training rooms and open working areas around a test tank to facilitate sea trials and launching vehicle to the sea.

The onshore headquarters for the test site is located in Taliarte next to the Port of Taliarte, about 20km from the city of Las Palmas.

PLOCAN offers user-oriented services technological (e.g. testing marine devices, data collection and analysis, environmental studies) as well as non-technological (e.g. fundraising, permits, logistics, health and safety) – see Table 3-5.

Table 3-5 Summary information for the PLOCAN test site competencies and services

Administrative Framework	Test site area authorised by the Council of Ministers agreement in 2014
Availability of Site Specific Data	PLOCAN facilities include an open-ocean observatory. This includes a surface buoy with a large meteorological and oceanographic set of sensors, which collect data in real time. This data is available through EMODNet.
Supply Chain / R&D	PLOCAN is a research infrastructure that offers multipurpose technical-scientific services. As well as offering marine energy testing facilities, other services provided by PLOCAN include: an ocean observatory, a base for underwater vehicles, training platform and innovation hub for R&D&I Several programmes at national and international scales including MARINERG-I, MARINET2, AORAC-SA, (http://www.plocan.eu/index.php/en/projects)
Market Engagement	Strongly engaged in research market www.plocan.eu
Support to Development	
Support to Monitoring	Marine environmental monitoring and impact Systems, structures and components monitoring and impact
Operational Support	PLOCAN manages a wide range of vehicle, including underwater unmanned vehicles (UUV) Boats (two) operated by PLOCAN personnel available
Policy Support	Permits and authorisations
Outreach Support	Accommodation and offices available on the platform. Onshore headquarters has meeting rooms and offices.

3.1.6 Ocean Plug, Portugal

In Portugal, a specific site for offshore renewable energy developments was designated by the Portuguese Government in 2008. Located offshore S. Pedro de Moel, between Figueira da Foz and Nazaré, and with an area of 320km^2, the site is a demarcated maritime space in water depths ranging between 30 and 90m.

In 2010, ENONDAS (a subsidiary of the Portuguese Grid Transmission System Operator, REN) received from the Portuguese Government a public concession for this site for 45 years. ENONDAS has adopted the trading name of Ocean Plug. However, until 2017 there has not been much progress regarding the development of the pilot zone.

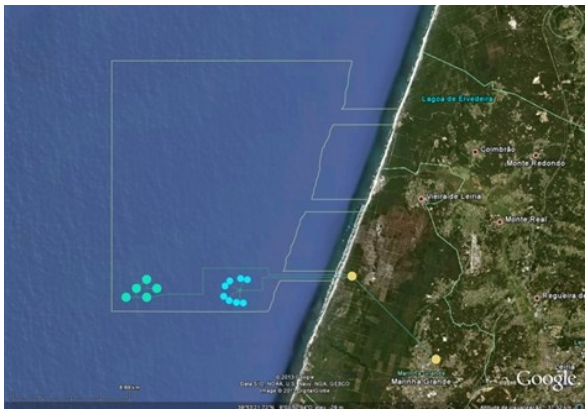

Figure 3-7 Overview of Ocean Plug site (from www.oceanplug.pt)

The Ocean Plug site promotes the proximity of the site to the offshore industry actors (e.g. marine operators, ports, electrical components manufacturers) and research centres such as universities or R&D institutes, providing direct access for the developers to the supply chain.

Table 3-6 presents key information on the competencies and services available or planned at the the Ocean Plug site, categorised into administrative framework, availability of site specific data, supply chain / R&D, market engagement and services offered.

Table 3-6 Summary information for the Ocean Plug test site competencies and services

Administrative Framework	Site under development – 45-year public concession for the generation of wave energy (since 2010). Includes authorisation for the installation of infrastructure and connection to the public grid Electricity produced is remunerated according to the Ministerial order 202/2015 (link) and is defined by the ordinance of the government member responsible for the Energy area. (art. 39º of Law Decree nº5/2008). Support to changes, modifications and extensions to licensing of prototypes and wave energy farms
Availability of Site Specific Data	Free access Public disclosure of the Study of Geophysical Characterisation Public disclosure of the Study of Environmental Characterisation
Supply Chain / R&D	Universities and agencies focused on R&D in the offshore field; Ports and Shipbuilding yards; Electrical and electronic components industry; Maritime operators
Market Engagement	http://www.oceanplug.pt/en-GB
Support to Development	Unknown
Support to Monitoring	Fostering the environmental and geophysical description and ensuring public access to data Monitoring the testing and operation activities for the abovementioned devices
Operational Support	Fostering and monitoring the installation, testing and operation activities for the abovementioned devices Promote the installation and maintenance of the common infrastructure in the Pilot Area
Policy Support	Licensing the installation of prototypes and wave energy farms in the Pilot Zone, and any changes, modifications and extensions thereto
Outreach Support	Fostering publicity initiatives and training experts in the field of environmental and social-economic impacts

3.1.7 Runde Environmental Centre (REC), Norway

The Runde Environmental Centre (REC), located on Runde Island on the Norwegian west coast, can accommodate wave energy projects for test and demonstration purposes [17]. REC facilitates preparations, licensing, deployment and monitoring of the WECs, and works also on other forms of ocean energy, building national competence and capacity.

REC also hosts other subsea tests for anti-corrosion and anti-fouling. In 2016, a new bathymetric dataset, with 1x1 m resolution, was released by REC, for public use. This unique material is very useful when it comes to licensing and siting of OE devices in the area. The same applies to the wave forecasting model installed in co-operation with the Norwegian Met office.

Table 3-7 presents key information on the competencies and services available or planned at the REC test site, categorised into administrative framework, availability of site specific data, supply chain / R&D, market engagement and services offered

Table 3-7 Summary information for the REC test site competencies and services

Administrative Framework	Unknown
Availability of Site Specific Data	Wave forecasting model Dataset of 1mx1m resolution
Supply Chain / R&D	Unknown
Market Engagement	www.rundecentre.no
Support to Development	Unknown
Support to Monitoring	Facilitate monitoring
Operational Support	Facilitate preparation Facilitate deployment
Policy Support	Facilitate licensing
Outreach Support	A visitor centre is located at REC REC offers rental of offices and research facilities.

3.1.8 Danish Wave Energy Centre (DanWEC), Denmark

The Danish Wave Energy Centre (DanWEC) was established in 2010, in connection with the testing of the wave energy converter Wavestar, which was tested in in Hanstholm during 2009–2013. In 2012, the organisation applied for funding under the Danish Energy Agency to prepare DanWEC for additional WEC testing activities in Denmark.

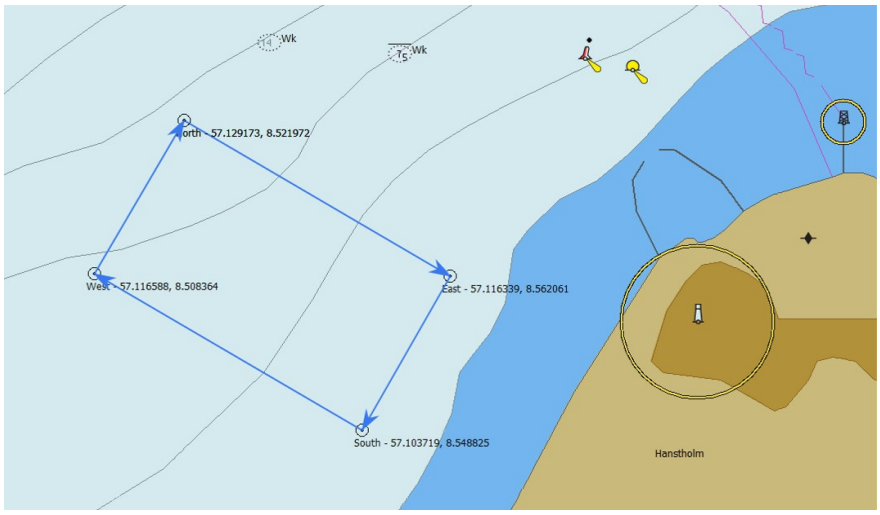

Figure 3-8 Overview of DanWEC site (from www.danwec.com)

The test site provides a number of key services common to other Ports in the North Sea region. When developing DanWEC's service offer, the transferability of experience from the development of the test site at one location to another location with transnational impact was flagged as a critical outcome.

In particular, DanWEC provides legal support and maritime advice, covering health, safety and environmental management advice and counselling and support to permitting, insurance and certification. In terms of data acquisition during testing, the test site can offer hindcast weather, water, wave and current data from offshore instrumentation as reference for the measured energy production.

Day-to-day marine operational support and GPS surveillance can be provided by the Hanstholm Port Facilities, and marine specialists, including technical, craftsman or engineers are available to support the developers. Also, the nearby Aalborg University can deliver independent validation and verification of testing data.

Recently, after a 1:9 scale testing at Nissum Bredning completed in 2013, Wavepiston has redeployed its prototype wave energy system at DanWEC [19]. The deployment of one device took place in May 2017, and the second energy collector is currently under construction.

Table 3-8 presents key information on the competencies and services available or planned at the DanWEC site, categorised into administrative framework, availability of site specific data, supply chain / R&D, market engagement and services offered.

Table 3-8 Summary information for the DanWEC test site competencies and services

Administrative Framework	Support in further applications, as part of the Roadmap produced by the Danish Partnership for Wave Power
Availability of Site Specific Data	Wave conditions Time series of hindcast weather (wind, temp. etc.), water, wave and current (height, direction, frequency etc.) data Seabed characteristics and general bathymetry of the test site berths
Supply Chain / R&D	Unknown
Market Engagement	http://www.danwec.com
Support to Development	Independent validation and verification of testing data Support to address insurance and certification bodies Engineering support at Aalborg University (AAU)
Support to Monitoring	Comprehensive near real time time series of hindcast weather (wind, temp. etc.), water, wave and current (height, direction, frequency etc.) data from wave buoys and other offshore instrumentation, Scatter diagram, Daily weather forecasts Seabed characteristics and general bathymetry of the test site berths
Operational Support	Day-to-day marine operational support and GPS surveillance, Availability to 24/7 marine specialist Dive support available Health, safety and environmental management advice and counselling
Policy Support	Support to easy obtainable periodic permits for testing periods from months to more years
Outreach Support	Unknown

3.2 Level 3: Test Sites in the Rest of the World

For the Level 3 test sites, the review was conducted on a higher-level basis. The assessment of the competencies and services offered was based on the analysis of public-domain data, for the following countries and test sites:

- U.S.:
  - Pacific Marine Energy Center (PMEC, Section 3.2.1),
  - California Wave Energy Center (CalWave, 3.2.2) and
  - Hawaii National Marine Renewable Energy Test Center (HINMREC, Section 3.2.3)
- New Zealand: New Zealand Marine Energy Center (NZMEC, Section 3.2.4)
- Japan: Nagasaki Marine Industry Cluster Promotion Association (NaMICPA, Section 3.2.5)
- China (Section 3.2.6)

Most of these sites have recently been announced and are only planned for development. Therefore, only limited information is available. The key information on their status and development is provided in the subsections below, noting that for test sites under development the service offer and competencies available are typically not clearly defined. More information on the planned infrastructure is available is D2.3.1 [3].

3.2.1 Pacific Marine Energy Center (PMEC), Oregon, U.S.

The Pacific Marine Energy Center (PMEC) comprises four open water test sites:

- The PMEC North Energy Test Site (NETS), Oregon
- The PMEC South Energy Test Site (SETS), Oregon
- Puget Sound and Lake Washington, Washington, and
- The Tanana River Test Site (TRTS), Alaska.

The PMEC-NETS site is in operation since summer 2012. Located at Newport, OR (4 to 6km from shore), the open-ocean test site is 3.5km^2 (1 square nautical mile). The site is currently capable of hosting devices up to 100kW when connected to the Ocean Sentinel instrumentation buoy, or of larger devices if self-contained, for testing from May through September. It offers a portfolio of capabilities to research all aspects of technology development (technology, environment, social). Devices can continue to operate in the ocean test site throughout the year to study other aspects of their devices, such as survivability, biofouling, mooring and anchoring, environmental effect, and other important aspects of their technologies.

The test site is located at depth ranging from 45 to 55m, with sand seabed. Significant wave heights average 1-2.5m during summer months at 6-9s energy periods. During winter months these increase to 2-5m significant wave heights at 8-12s energy periods, with maximum significant wave heights of 7-14m.

The Northwest National Marine Renewable Energy Center (NNMREC) has characterised the environmental conditions of the site, and has conducted a range of environmental monitoring activities, including baseline studies for benthic habitat, marine mammal observations, electromagnetic frequency studies (EMF), and acoustics. The site is fully permitted through the NEPA process, Department of State Lands, the US Coast Guard, and the Army Corp of Engineers.

In parallel, NNMREC is currently in the permitting phase to develop the South Energy Test Site (SETS). SETS will feature full-scale, grid connected testing capabilities. The SETS facility will allow WEC devices to be certified to international standards (e.g. Institute of Electrical and Electronics

Engineers, IEEE). SETS will include multiple connection points, and will be a leading source of research, which will help to answer some of the core questions concerning the industry.

PMEC-SETS will be the NNMREC facility where developers can test utility scale WECs in the ocean with a connection to the electric utility grid via a subsea cable; four connection points are planned. PMEC-SETS is being designed to accommodate single devices, or small arrays in a berth. The anticipated depth range for PMEC-SETS is 65-78m.

The Puget Sound and Lake Washington test sites offer open water testing for intermediate scale WEC devices. These environments provide for 1:7 scale WEC testing compare to the PMEC open-ocean site conditions, and are available from October through March.

Finally, the Tanana River Test Site provides facilities for testing of hydrokinetic devices, infrastructure and environmental monitoring techniques. The test site is open between May and September each year. NNMREC experts at University of Alaska Fairbanks provide support with hydrological and environmental measurements including measurements of mean flow, turbulent fluctuations, bathymetric surveys, fisheries interaction monitoring and device power performance.

3.2.2 California Wave Energy Test Center (CalWave), California, U.S.

CalWave is proposed to be a U.S. national wave energy test center, located in California, providing an opportunity for leading WEC developers to test their devices in an open-ocean environment.

Pending continued funding support from the U.S. Department of Energy, the CalWave team anticipates completing environmental permitting by the end of 2018, constructing the facility in 2019-2020, bringing the facility online in 2021-2022, and beginning full operations in 2022 [20].

3.2.3 Hawaii National Marine Renewable Energy Test Center (HINMREC) / WETS, Hawaii, U.S.

The Wave Energy Test Site (WETS), located in Kaneohe Marine Corps Base Hawaii (MCBH), comprises three connection points at water depths ranging from 30 to 80m [21].

HINMREC includes a range of services to technology developers, including independent assessment of the power performance (e.g. as power matrices), provision of wave and ocean current measured data (during testing and to calibrate the UH wave hindcast and forecast models). A suite of numerical models is available for virtual testing, modification and device optimisation.

The acoustic signature of devices tested at WETS can be monitored using hydrophones, as input to the environmental impact assessment of WEC devices. Periodic seawater chemical composition surveys in conjunction with ecological surveys have also been implemented to quantify other aspects of the environmental impact due to WEC devices. In-situ surveys can be conducted to quantify the impact due to the sediment transport induced by the WEC moorings.

HINMREC associated faculty will continue to maintain wave hindcast database (Hawaii Wave Energy Resources from 34 Year Hindcast) that provide resource information in the format required to evaluate potential energy contribution of WEC devices. The output from wave arrays will be modelled to estimate ocean area requirements and capacity factor.

3.2.4 New-Zealand Marine Energy Center (NZMEC), New-Zealand

In 2015, the establishment of a marine energy testing facility, the New Zealand Marine Energy Centre (“NZMEC” or “the Centre”) located in the Wellington region, was described in a business case to the Ministry for Business, Innovation and Employment [17]. More recently, the Green Party of New Zealand has put forward this plan as part of the transition away from oil drilling, in the context of general elections campaign [22].

The balance of investment requirements would be provided as in-kind private sector funding from a multinational firm. NZMEC's testing facilities will be located on up to four sites at Baring Head, Moa Point, Cape Terawhiti and Kapiti to provide ocean based pre-commercial scale testing services for wave and tidal energy device developers from nursery (prototype/pilot) through to full scale, grid connected devices. The development is currently on hold awaiting investment.

3.2.5 Nagasaki Marine Industry Cluster Promotion Association (NaMICPA), Japan

In 2013, a 2MW FWT was installed near Kabashima Island, Goto city, Nagasaki [23]. The turbine was deployed at about 100m water depth, 1km away from the shore, in an annual average wind speed field of about 7.5m/s at hub height (c.60m).

In 2015 the Nagasaki Prefecture announced its plan to extend the Goto floating wind power demonstration site and selected three sites dedicated to marine energy testing [24]:

- Hisaka-jima island, Goto city, as nursery site for tidal energy converter (TEC) devices
- Eno-shima and Hira-shima islands, Saikai city, as full-scale site for TEC devices
- Kaba-shima island, Goto city, as full-scale site for FWT devices.

The centre ultimately plans to offer support for companies, scientists and government officials looking to better understand floating wind farms and other marine power technology [25].

The European Marine Energy Centre (EMEC) has signed a contract to provide advice on the development of a marine energy test facility in Nagasaki Prefecture, Japan. EMEC will advise on the wider infrastructure required in the region to support marine energy deployments.

In 2016 the NaMICPA has completed a review of what would be required to enable the Nagasaki Prefecture to develop a local supply chain to complement the proposed test centre [26]. NaMICPA is now conducting an environmental impact assessment (EIA) for the proposed tidal test site [27].

3.2.6 China

China established a special fund for renewable ocean energy in May 2010. In 2015, the government announced its plan to construct three ocean energy test sites off the coast of Shandong, Zhejiang and Guangdong provinces [17], [28]:

- The Shandong site, located at the Weihai Port, will be a shallow water test site. In 2016 the site had completed the preparation for subsea cable system development. The subsea cable is an interconnection hub that will connect the test platform to the test centre. Subsequently, the site committed to start the operation of the monitoring centre.
- The Zheijiang site, located in Zhoushan Islands, will be a full-scale tidal current energy test site. It was announced in 2016 that the feasibility study had passed the inspection of the State Oceanic Administration (SOA) to initiate the comprehensive demonstration project.
- Finally, the Guangdong site, located in Wanshan, will be a full-scale wave energy test site. The 1100m^2 land area was authorised for use in November 2016, and the permit application for the sea areas was by then still in progress.

3.3 Sector Review Summary

Table 3-9 and Table 3-10 provide a summary of the key information presented above for the Level 2 sites, in terms of competencies and services.

Table 3-9 Summary information for the Level 2 test sites: competencies and services (Part 1/2)

Category		Wave Hub	FaBTest	AMETS	BiMEP
Competencies	Administrative Framework	Fully consented Power purchase agreement	5 types of devices pre-consented for deployment	Unknown - Site under development	Pre-permitted
	Availability of Site Specific Data	Freely available	Available	Available	Available
	Supply Chain / R&D	Connection to the supply chain: Full coverage of activities Connection to other sites: Yes Connection to several research/funding programmes, at local to international scale	Connection to the supply chain: Full coverage of activities Connection to other sites: WaveHub Connection to several research / funding programmes, at local and regional scale	Connection to other sites: SmartBay via SEAI	Connection to the supply chain: Wide range of activities Several collaboration R&D projects, at local to international scale
	Market Engagement	Member of several industry groups https://www.wavehub.co.uk/ Regularly updated	http://fabtest.com/ Regularly updated Presence at conferences / exhibitions	No dedicated website	Member of Wave energy basque country http://bimep.com/ Regularly updated
Services	Support to Development	Available	Available	Unknown	Available
	Support to Monitoring	Available	Available	Unknown	Available
	Operational Support	Available	Available	Unknown	Available
	Policy Support	Available	Available	Unknown	Available
	Outreach Support	Available	Unknown	Unknown	Available

Table 3-10 Summary information for the Level 2 test sites: competencies and services (Part 2/2)

Category		PLOCAN	Ocean Plug	REC	DanWEC
Competencies	Administrative Framework	Test site area authorised by the Council of Ministers agreement in 2014	Unknown - Site under development Power purchase agreement according to the Ministerial order 202/2015 Support in further applications planned	Unknown	Support in further applications planned
	Availability of Site Specific Data	Facilitated through open-ocean observatory	Free access	Available	Available
	Supply Chain / R&D	Connection to several research / funding programmes, at national to international scale	Connection to the supply chain: Partial coverage of activities	Unknown	Unknown
	Market Engagement	Strongly engaged in research market www.plocan.eu/ Regularly updated	http://oceanplug.pt/ Existing	www.rundecentre.no Existing	http://www.danwec.com Existing
Services	Support to Development	Unknown	Unknown	Unknown	Available
	Support to Monitoring	Available	Available	Available	Available
	Operational Support	Available	Available	Available	Available
	Policy Support	Available	Available	Available	Available
	Outreach Support	Available	Available	Available	Unknown

4 CUSTOMERS – INDUSTRY TEST SITES COMPETENCIES AND SERVICES REQUIREMENTS

A third aspect influencing the positioning of the FORESEA test sites is the dominant features of their potential customers. Having assessed both the capabilities (Section 3) and the potential competitors (Section 3) of the FORESEA test sites, it is key to accurately profile the potential customers, identifying and where possible predicting their current and future needs.

This section outlines the findings of a stakeholder consultation exercise completed to ascertain the particular requirements and interests of potential users of open-ocean test sites for marine renewable energy technologies. Following an overview of the consultation approach (Section 4.1), the dominant characteristics of potential target customers for the FORESEA test sites are drawn from the analysis of the survey results (Section 4.2). Additionally, notes on the future customer needs and requirements are also extracted from the responses (Section 4.3). CA notes that the stakeholder consultation is also presented in [3], to facilitate its reading. The key findings of the consultation that focus on competencies and service requirements are summarised in Section 4.4.

These results and findings from the consultation exercise are instrumental in guiding final investment decisions related to both service offering (see Section 5 of this report) and infrastructures (see Section 5 of [3]) of the FORESEA sites.

4.1 Overview of the Approach

An online stakeholder survey was conducted between the 18th of October and the 15th of November 2017. Based on the evaluation criteria defined in Phase 1 [2], CA drafted 34 survey questions that were reviewed and approved by ECN, OEE and the FORESEA test sites members. The survey was designed to capture the main requirements of the potential customers, in a format capable of being completed in approximately 10 minutes.

The potential customers targeted included technology, project and component developers identified as being likely to invest in or conduct an ocean deployment within a 5- to 10-year timeframe. The topics covered by the survey focused on technologies and subcomponents for wave, tidal and floating wind energy sectors, and included:

- An overview of the respondent's technology and testing status.
- Information regarding a respondent's future short to long term testing plan.
- General requirements regarding the ideal infrastructure of a test site (e.g.: grid connection, onshore and offshore features).
- General requirements regarding the services provided by a test site (e.g.: consenting status of the site, connection to the supply chain, areas of support).

The stakeholder survey was disseminated via the following methods:

- Based on the list of targeted entities identified in Phase 1 [2], 96 selected entities were contacted via email by CA on behalf on Ecole Centrale de Nantes with a direct invitation to participate in the survey. A flyer outlining the project background and aims, including a link to the online survey, was provided in attachment to the invitation emails. The flyer was drafted by CA and circulated to ECN for approval [29].

- Public advertisement of the consultation, with a link to the survey, was issued on various media platforms, including LinkedIn [30], Interreg North-West Europe FORESEA's website [31], Tidal Energy Today's news [32].
- A flyer containing a link to the survey [33] was distributed during the Ocean Energy Europe conference in Nantes (24th to 26th of October 2017).

At the time of the survey closure, a total of 53 responses had been received. The following sections present the survey aggregated survey responses and analysis, split into two distinct parts:

- Overall description of the respondents' technology and development status (see Section 4.2), including:
  - Technology developed
  - Estimated TRL and funding spent to date
  - Past open-ocean testing activities
- Future customers' needs and requirements (see Section 4.3), including:
  - Short to long term testing plan
  - Ideal infrastructure at a test site
  - Services provided by a test site

4.2 Profiling the Target Customers

To initiate the profiling of the potential customers of the FORESEA test sites, survey respondents were asked to specify which type of technology they are developing. From a total of 53 responses, roughly 60% of respondents selected wave energy technologies (see Figure 4-1). This was followed by tidal technologies (approximately 15%), subcomponents (9%), floating wind (approximately 8%) and others (9%), which includes e.g. OTEC, floating solar, etc.

As a minimum, the dominant interest of the respondents in wave energy technologies allows the results related to this category to be considered with additional confidence. The interest of respondents in these types of technologies may also allow inferences regarding the type of client to be targeted by FORESEA test sites (see Section 5).

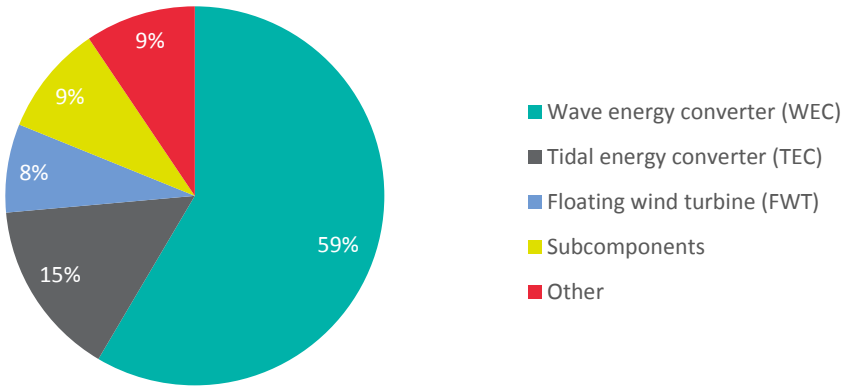

Figure 4-1 Responses to the FORESEA consultation: type of technology breakdown

Although the responses are assessed per technology type in the following subsections (Sections 4.2.1 to 4.2.5), generic findings can also be gathered when assessing two key features: technology development stage (measured via TRL) and funding to date. At a high-level, these can be summarised as follows:

- From all the respondents, 25% consider themselves to be in a low TRL (1 to 3), while over 45% believe they are at an intermediate TRL level (4 to 6) – see Figure 4-2.
- Approximately 50% of all respondents have spent less than €5m to date in their development programmes – see Figure 4-3.

These high-level results are, in CA's opinion, indicators of the early stage nature of the developments associated with the respondents to the FORESEA consultation exercise. These salient features are explored when considering the positioning of the FORESEA sites (see Section 5).

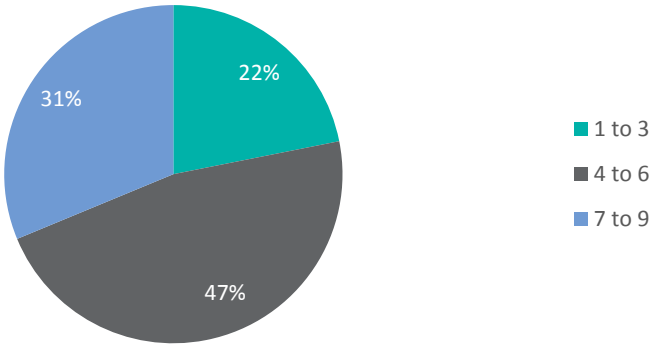

Figure 4-2 Responses to the FORESEA consultation: TRL breakdown

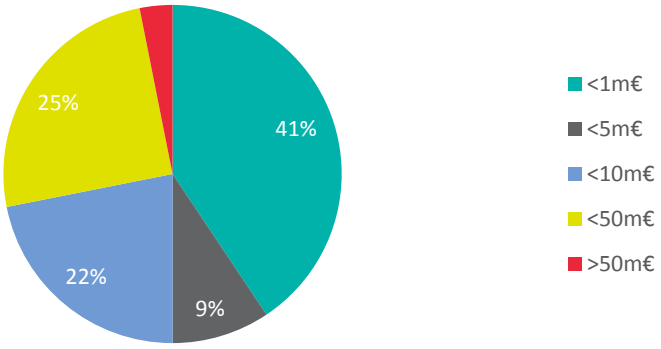

Figure 4-3 Responses to the FORESEA consultation: funding spent to date

4.2.1 WEC Developers

A series of six initial questions in the survey specifically targeted respondents with an interest in wave energy technologies (identified from the response to Question 1). Figure 4-4 to Figure 4-8 illustrate some of the responses received. The key findings from the responses are also summarised in the points below.

- From the 19 responses, 7 (approximately 37%) identified point absorbers as the type of WEC under development. This finding is consistent with recent industry consultation exercises – see e.g. [34].

- Over 60% of the respondents (12 out of 19) claimed to be a TRL ≤ 5. In CA's opinion, this is consistent with the current status of the wave energy industry and a reflection of the maturity of such market.
- A similar conclusion can be made when analysing Figure 4-6: over 40% of the respondents (8 out of 19) identified the spending to date as lower than €1m.
- Despite the early-stage nature, over 50% of the respondents have confirmed to have completed open-ocean testing in the past (see Figure 4-7). From the replies to an adjacent question (see Figure 4-8), CA understands that the majority of such deployments occurred in nursery / sheltered locations, as well as intermediate scale test sites.
- Finally, respondents were asked to confirm their interest in using open-ocean test facilities, and all confirmed an interest.

The features listed above may be explored when considering the positioning of the FORESEA sites, aiming to couple the specific needs of this customer type with the infrastructure / service offering (see Section 5).

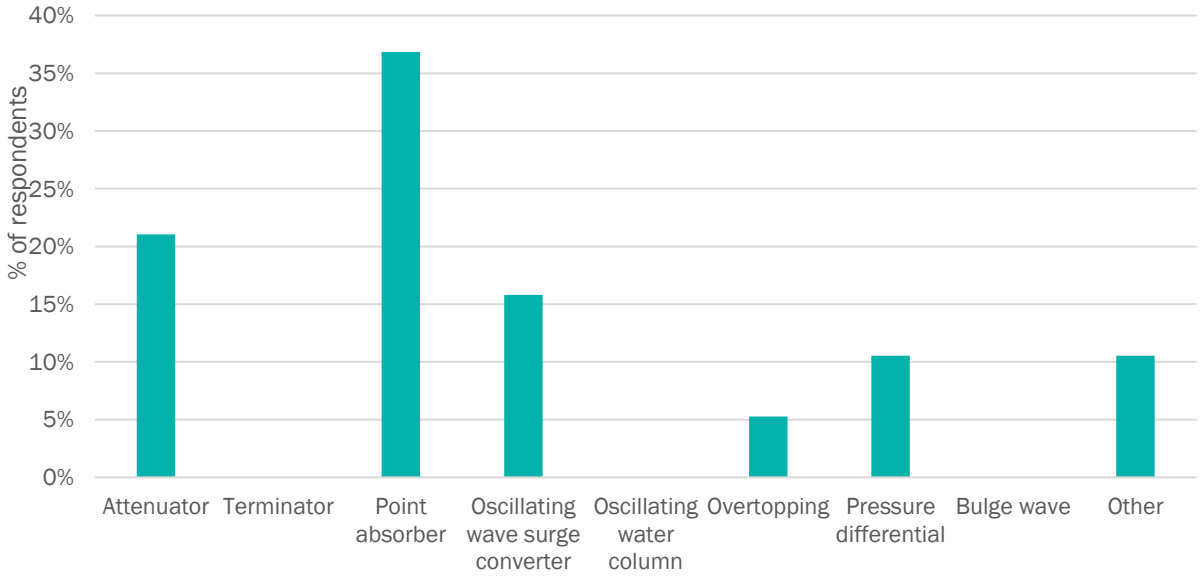

Figure 4-4 Responses to the FORESEA consultation: type of WECs under development

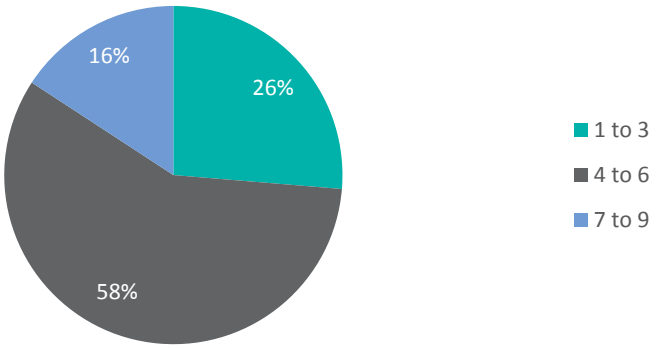

Figure 4-5 Responses to the FORESEA consultation: TRL of WEC technologies

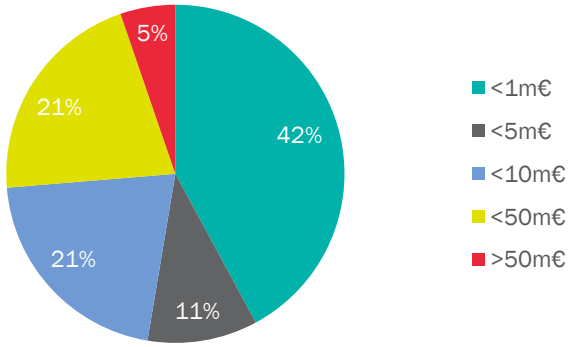

Figure 4-6 Responses to the FORESEA consultation: funding spent to date in WEC development

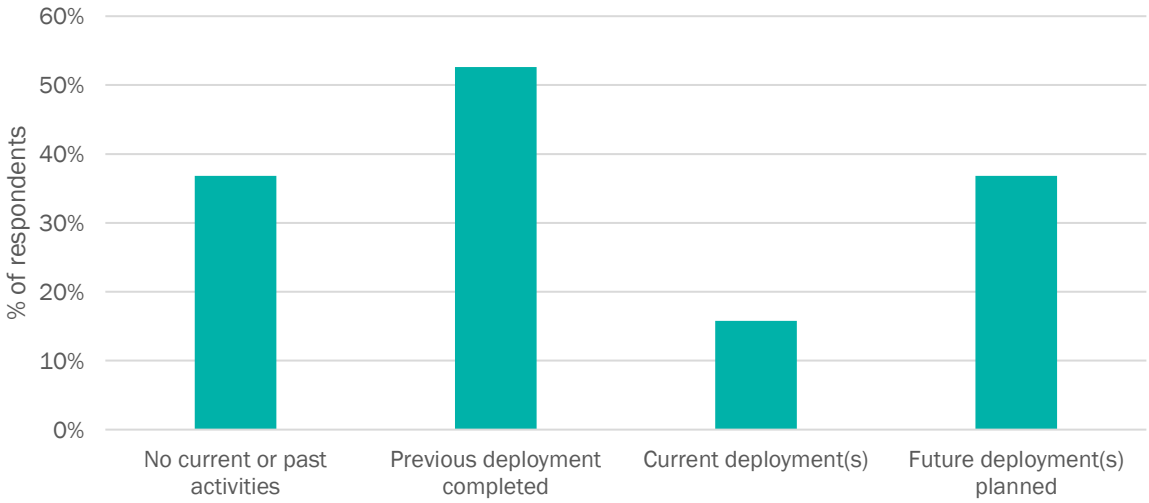

Figure 4-7 Responses to the FORESEA consultation: status of open-ocean test activities (WECs)[2]

[2] Note that respondents could select multiple answers, therefore the total is above 100%.

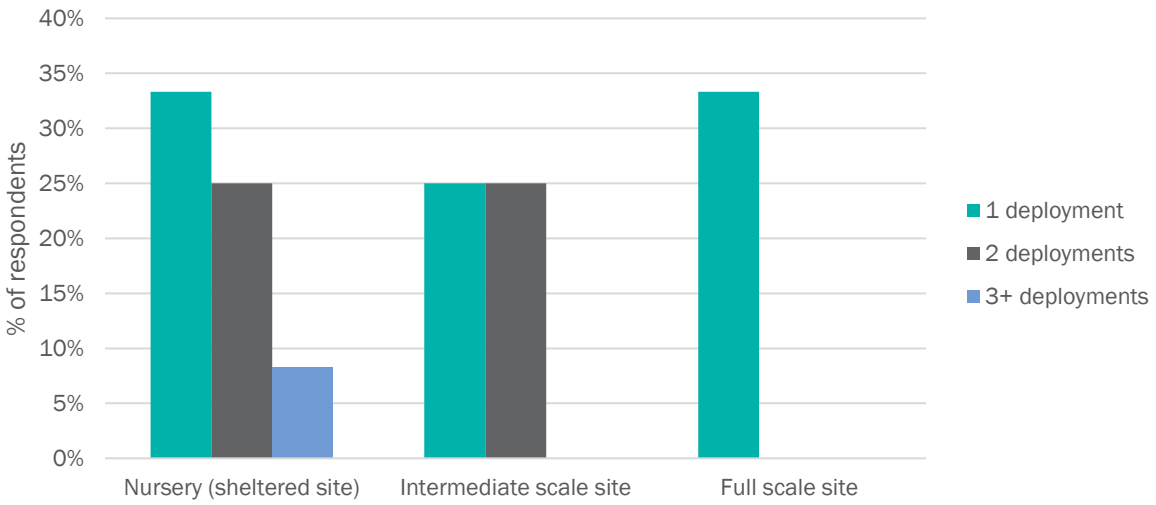

Figure 4-8 Responses to the FORESEA consultation: nature of previous open-ocean test activities (WECs)

4.2.2 TEC Developers

Similar to the analysis documented in Section 4.2.1, specific commentary can be made with regard to TEC technologies. While noting the reduced sample size, the following key notes can be inferred from the responses to the FORESEA survey:

- The majority of the respondents is developing a horizontal axis TEC.
- Higher TRLs (≥6) and higher levels of funding have been spent to date, when compared to the WEC related responses (min < €10m).
- There is wider experience in past, current and planned deployments, particularly at full-scale.
- The majority of respondents still show an interest in open-ocean test sites, although the consensus is not as unanimous as in the WEC case (reference to site ownership is made is the situations were no interest is declared).

Overall, and although limited in number, the responses from those interested in TEC technologies, reveal experience in previous deployments, multiple scales leading to full-scale, across multiple sites. These characteristics, along with the predisposition / capability to allocate wider amounts of funding, may be explored when considering the positioning of the FORESEA sites (see Section 5).

4.2.3 FWT Developers

A third type of potential customers identified for the FORESEA test sites are represented by floating wind technology (FWT) developers. The following key characteristics can be drawn for FWT developer responses:

- All the respondents estimated the level of development of their technology at high TRLs (≥7).
- Past open-ocean deployments have taken place at full-scale already.
- The respondents did mark an interest in open-ocean test sites.

Although the responses from FWT technology developers reveal experience in open-ocean deployments, the limited number of responses may also be a sign of lack of interest from this specific sector, more willing to develop

private sites or deploy at commercial scale. These specificities should be considered when deriving the positioning of the FORESEA sites (see Section 5).

4.2.4 Subcomponents Developers

Developers of subcomponent / subsystems were also specifically targeted in the FORESEA consultation exercise. Noting the limited number of responses, the following characteristics for subcomponent developers can be extracted when analysing the survey replies:

- PTO developers and metocean equipment providers responded to the survey.
- TRLs of 5-6 were identified as the current readiness levels, with limited amounts of funding to date (few €m).
- The respondents did not exhibit any previous or current experience in open-ocean testing. However, future deployments are planned and a strong interest in doing so is clear.

The similarities of these characteristic with those connected with other types of customers (e.g. WEC developers; see Section 4.2.1) may be considered in the positioning exercise for the FORESEA sites (see Section 5).

4.2.5 Other Stakeholders

Aside from the four types of potential customers identified for the FORESEA test sites and characterised in the above subsections, a number of other respondents provided their feedback to the survey. Overall, no particular trend can be drawn from the responses, given the reduced size of the sample and the disparity in the answer. A summary of responses under the category of '*Other*' technology types are listed below:

- Respondents to the '*Others'* technology type category are developing e.g. river energy systems, floating solar technologies or wind / tidal / solar energy farms.
- The estimated level of development for these technologies covers a large range of the TRL scale (from TRL 2 to TRL 7).
- The level of funding spent to date is consistently below 10m€.
- Technologies that have reached a high TRL and spent a larger amount of funding to date reveal experience in previous deployments, at multiple scales leading to full-scale and across multiple sites.
- In general, there is a large interest in open-ocean test sites, although some particular cases referred to e.g. requirement of benign bodies of water to justify a lack of interest.

4.3 Future Customers' Needs and Requirements

In this section, the future needs and requirements of the potential open-ocean test sites' customers are analysed. Following the structure of the survey, the section is split into five main topics:

- Target / planned development horizon at open-ocean test sites: Section 4.3.1
- Important infrastructures requirements: Section 4.3.2
- Important services requirements: Section 4.3.3
- Attractive features of open-ocean test sites: Section 4.3.4
- Ideal leasing settings, both in terms of duration and fees: Section 4.3.5

Finally, the section concludes with a summary of the consultation findings in Section 4.4, gathering the key outcomes of the survey in terms of infrastructure requirements, to guide the market positioning exercise of the FORESEA test sites and the provision of strategic recommendations in Section 5.

4.3.1 Target / Planned Development Horizon at Open-Ocean Test Sites

Overall, based on the survey results the respondents interested in open-ocean testing are targeting deployments between nursery and intermediate scale sites in the short term (next one to next five years), shifting to full-scale sites in the medium to long term (within five to ten years). This trend is illustrated in Figure 4-9.

The survey responses indicate that although the desire to test at nursery and intermediate scale is important to consider in the short term, full-scale, grid connection testing becomes important in the medium horizon and is likely to dominate the open-ocean testing requirements from then on.

In terms of target deployments per technology type, the survey responses indicate that:

- In general, both WEC and TEC survey respondents are targeting deployments at multiple scales leading to full-scale testing. Note that, similar to FWT developers, TEC developers and most of the WEC developers indicated that they ultimately require grid connection.
- Floating wind technology developers plan to progress from intermediate scale sites to full-scale grid connected within the next five years. Survey respondents did not specify a requirement for nursery sites, nor for full-scale sites without grid connection.
- Survey responses from subcomponent developers indicate a plan to deploy at nursery test sites next year only, and then progress to full-scale sites within the next five years. No deployment at intermediate scale sites is indicated as a requirement from survey respondents.

Figure 4-9 Responses to the FORESEA consultation: target / planned development horizon to use open-ocean test facilities in the 10-year horizon

4.3.2 Important Infrastructure Requirements

In the survey, respondents were asked to qualify the importance of different test site infrastructure for their planned deployments (see Figure 4-10).

Overall, the availability of support vessels, grid connection and communication cable and the proximity to a port are typically viewed as critical factors for survey respondents, with more than 60% of the respondents flagging them as '*very important*'. Only two respondents stated that grid connection was '*not important'*, one of them noting that the electricity generated by their WEC is directly used to produce hydrogen on deck.

Availability of real time resource measurements, on-shore facilities, on-shore accessibility and available capacity, although still important, are seen as less critical, with respondents generally split between '*very important'* and '*may be interested'*. In terms of on-shore facilities, one responded commented that a slipway or pontoon with cost effective access would be required at the port, with suitable deep water and cranes readily available during operation.

Pre-installed anchors and mooring points rank lasts in the developers' requirements, with 16% and 32% of the respondents qualifying them as '*not important*', respectively. In CA's experience, developers typically want to use their own proprietary moorings, or need to test different arrangements / layouts that pre-installed moorings could potentially prohibit.

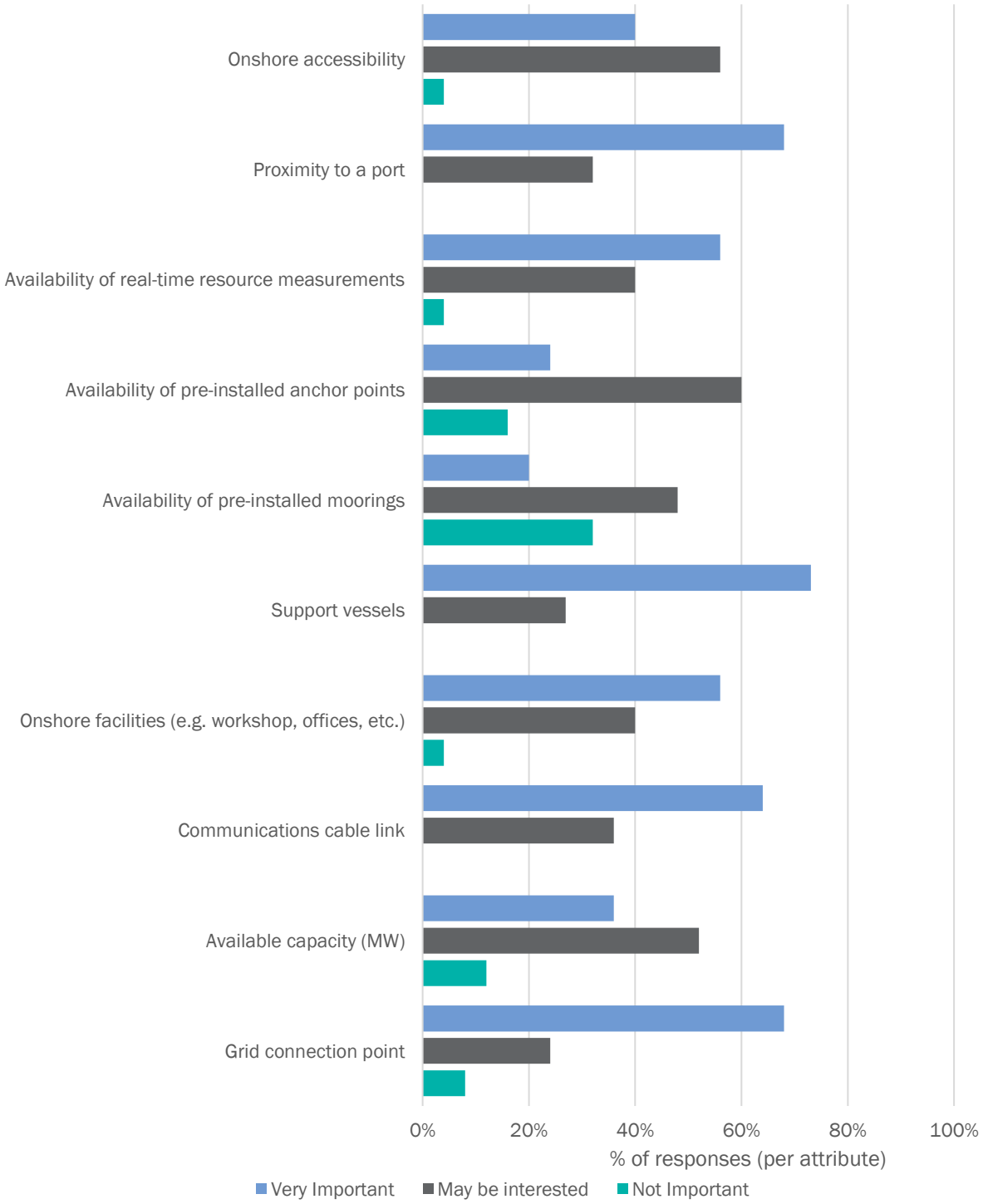

Figure 4-10 Responses to the FORESEA consultation: important infrastructure requirements at an open-ocean test site

Based on the results illustrated in Figure 4-10, Figure 4-11 displays the required open-ocean test site infrastructure ordered by level of importance, estimated from the survey responses as follows: a score of 10 was given to the '*very important'* answer; a score of 5 to the '*may be important'* answer; and a score of 1 to the '*not important'* answer. The total score for each type of infrastructure was then divided by the number of responses (26) times the maximum score (10), to obtain a representative average (presented in Figure 4-11 as a percentage).

It should be noted that the averaged order of importance is similar for all categories of developers (WEC, TEC, FWT and subcomponents) and all level of development (high to low TRLs).

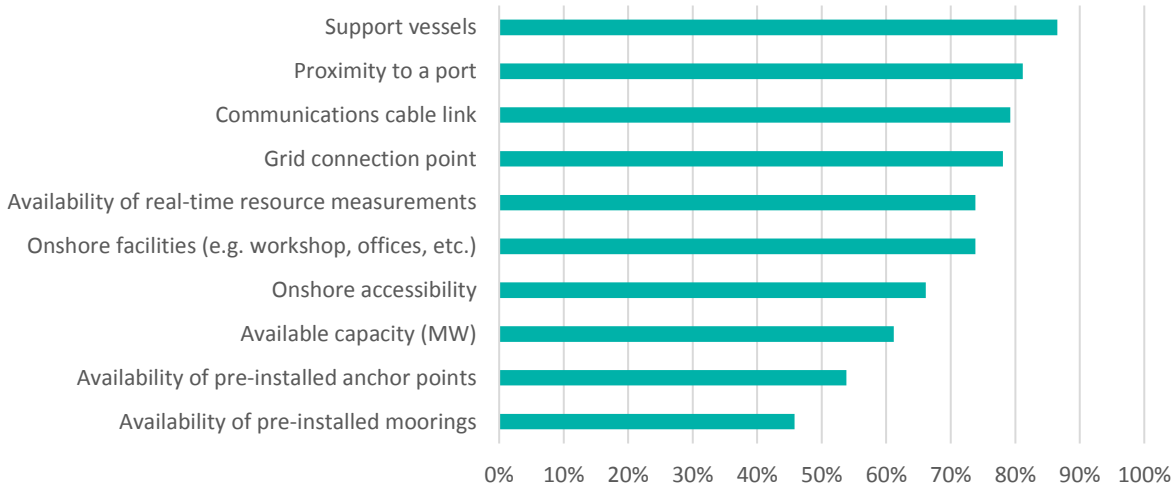

Figure 4-11 Averaged order of importance for the required infrastructure at an open-ocean test site: the higher percentage, the more important the infrastructure, based on survey responses

Overall, the requirements and priorities in terms of infrastructures are relatively similar between the different types of customers – these similarities can be exploited when considering the development strategies of the infrastructures (see also Section 5)

4.3.3 Important Services Requirements

In the survey, respondents were also asked to qualify the importance of key services offered (directly or subcontracted) by an open-ocean test site (see Figure 4-11).

Overall, the most important services flagged by the developers were support services relating to consenting and funding/ grant applications, and access to incentives or support mechanisms of test programmes, with more than 60% of the respondents qualifying such services as '*very important*'. Only two respondents (one WEC developer, one subcomponent developer) ranked the services for funding / grant application and access to incentives or support mechanisms as '*not important'*. These developers had secured a significant amount of funding for one and a grant for open-ocean deployments for the other, which may explain the reduced interest in related support.

The interest in support to resource monitoring activities is equally split between '*very important'* and '*may be interested*' (48% each), whilst the other service categories all score about 60-70% of '*may be interested*' and about 30-40% of '*very important'*. These include support services to device development, environmental monitoring activities, operational support, local stakeholder engagement, specialist support for offshore inspections and provision of supply chain connections.

A specific comment from one respondent is well aligned with the overall results, stating that developers would typically require services to support any activities not related to their core engineering expertise, such as '*securing funding, revenue support, consenting and accessing the grid. These are the things that the centre should be doing in order to enable developer to stay on mission'*.

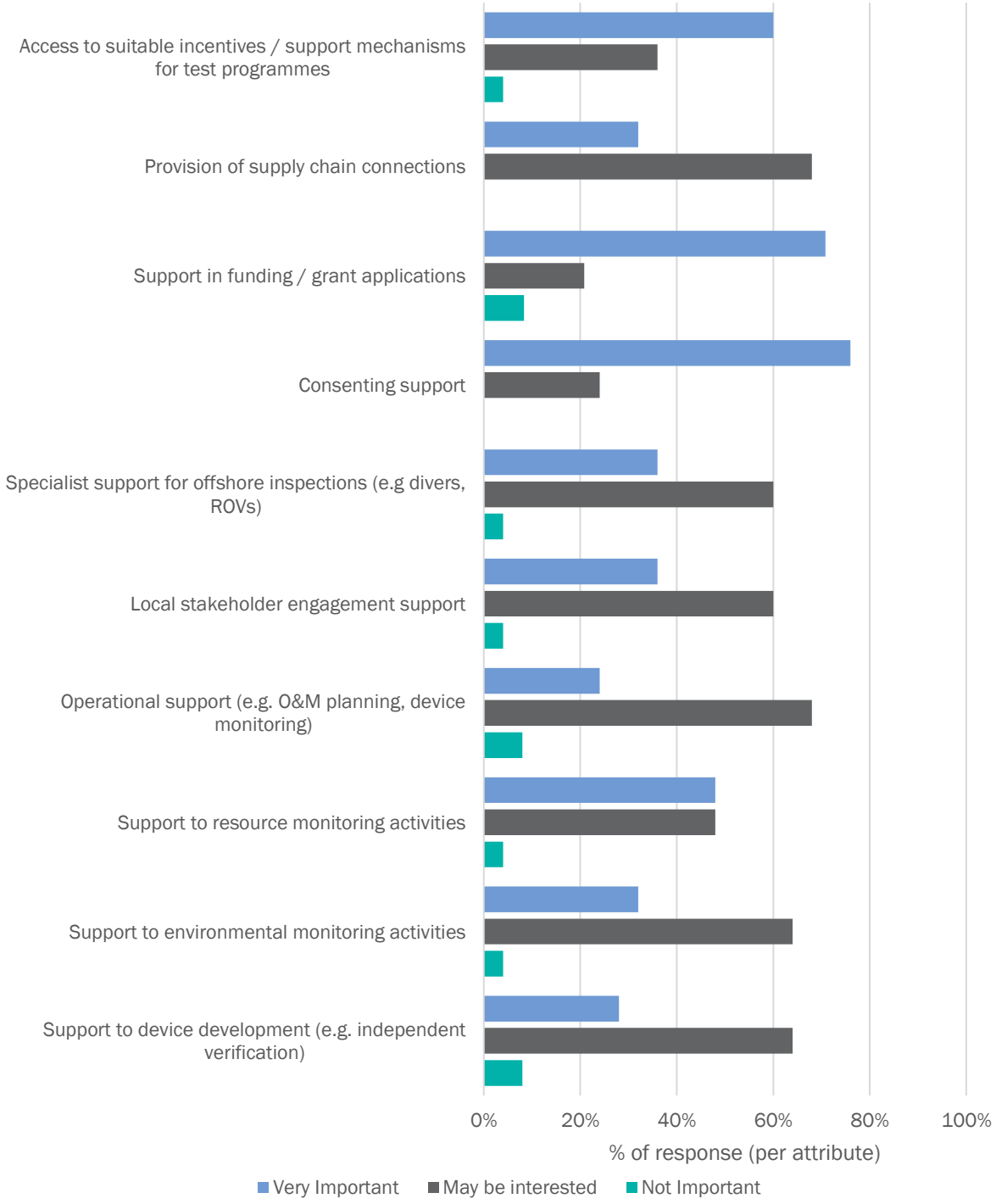

Figure 4-12 Responses to the FORESEA consultation: service requirements at an open-ocean test site

Based on the results illustrated in Figure 4-12, Figure 4-13 displays the required services ordered by level of importance estimated from the survey responses as follows: a score of 10 was given to the '*very important'* answer; a score of 5 to the '*may be important'* answer; and a score of 1 to the '*not important'* answer. The total score for each type of service was then divided by the number of responses (26) times the maximum score (10), to obtain an average. The results are presented in percentages.

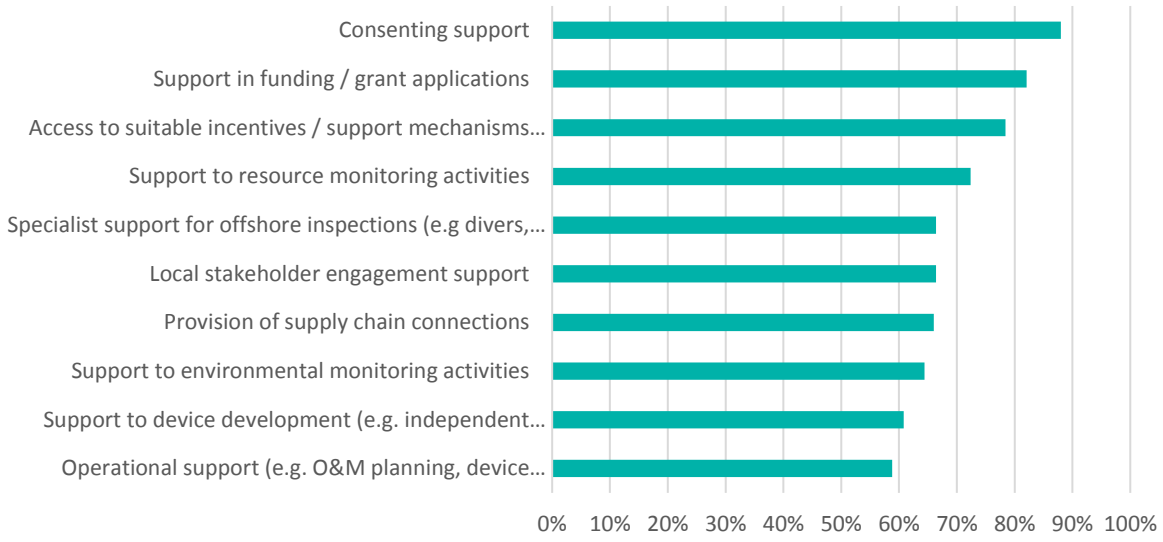

Figure 4-13 Averaged order of importance for the required services at an open-ocean test site: the higher the percentage, the more important the service requirement, based on survey responses

When analysing the ranking by experience level, it can be seen that developers with more open-ocean testing experience (TRL>5, with previous deployment completed) value more a support to local stakeholder engagement, while the connection to the supply chain is seen as more important to lower TRL developers (TRL <4), along with support to offshore inspections.

Considering the range of requirements and differences in priorities by the different types of customers, the test sites could consider a flexible approach in terms of service provision – more consideration is brought on the topic in Section 5.

4.3.4 Attractive Features of Open-Ocean Test Sites

Surveyed entities were asked to rank ten features that would attract them to an open-ocean test site by order of importance (1 being the most important, 10 the least important). Figure 4-14 shows the averaged results from all the respondents.

On average, faster consenting and readiness of infrastructure are shown as the most attractive features of an open-ocean test site. The former is the clear priority for developers currently at a low TRL (<4), along with the range of services and lower risk approach. For developers currently at a higher TRL (>6), the ability to test several design iterations is also of importance, which should be considered when deriving recommendations for the test sites' development strategies (see Section 5). On the other hand, potential partnerships between facilities for smooth progression during testing programmes is not seen as a priority for the survey respondents.

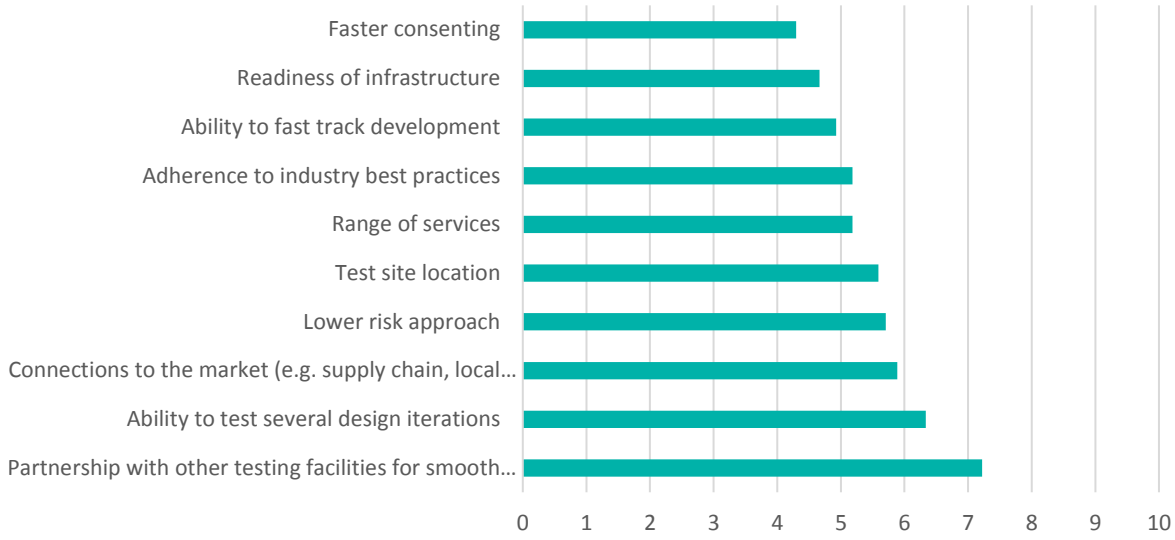

Figure 4-14 Average grade given to features that would attract respondents to an open-ocean test site: a grade of 1 is most attractive feature, a grade of 10 is less attractive feature

4.3.5 Ideal Leasing Settings

According to survey responses, the ideal test site leasing duration for a developers' next deployment is above six months for the majority of respondents, with only 19% of the respondents requiring a lease between three to six months (see Figure 4-15).

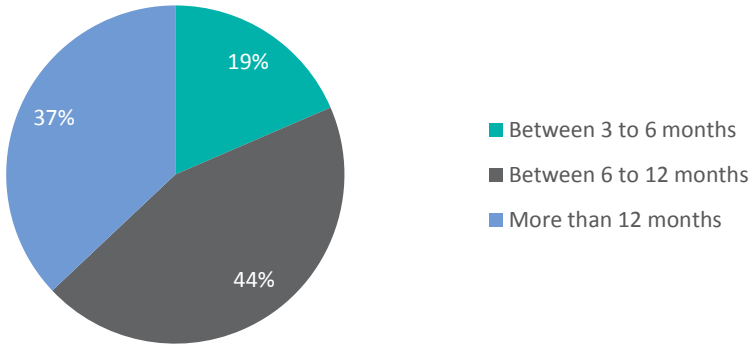

Figure 4-15 Responses to the FORESEA consultation: ideal leasing duration for the next testing deployment

Figure 4-15 compares to the target deployment plan stated by the respondents (see Section 4.3.1), showing that the leasing durations required for next year's deployments is fairly distributed between three months to more than a year. The duration for leases increases with time, with only more than one-year leases required in a 10-year horizon.

Figure 4-17 shows the ideal leasing duration for the different type of sites. It can be seen that according to the respondents, deployments at nursery sites require mostly six- to twelve-month leases (60% of the next deployments at nursery sites), whilst full-scale grid connected deployments will mostly require more than one-year leases (67%). Survey respondents indicate that non-grid

connected deployments typically require shorter leases, with about 67% of such deployments requiring less than six-month leases.

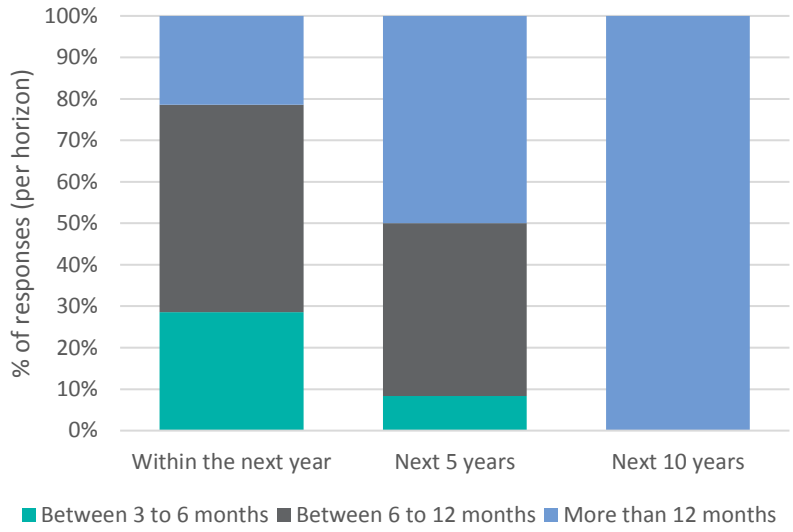

Figure 4-16 Ideal leasing duration for deployments within the next year, next five years and next ten years

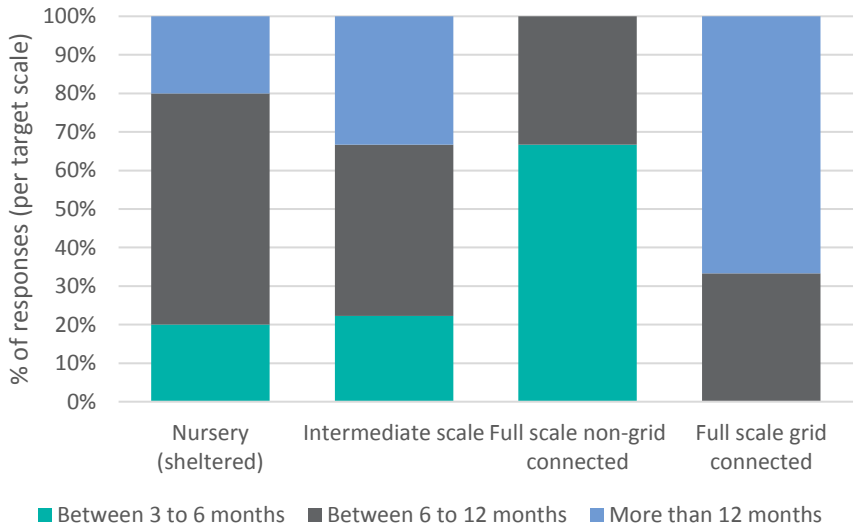

Figure 4-17 Ideal leasing duration for deployments at nursery site, intermediate scale site, full-scale non-grid connected site and full-scale grid connected site

However, responses also indicate that long duration lease may be required for all type of deployment scale. In particular, one developer planning to deploy at an intermediate scale site next year flagged that, in anticipation of potential delays or failures, a minimum lease of 3 years would be required as a contingency strategy.

More than 50% of the survey respondents anticipate a leasing fee under 10k€ per month, and less than 20% would be willing to go above 20k€ (see Figure 4-18). In particular, one developer stated that even a fee of 10k€ per month would still be prohibitive, and would lead to a strategy of securing private sites for a fraction of the cost.

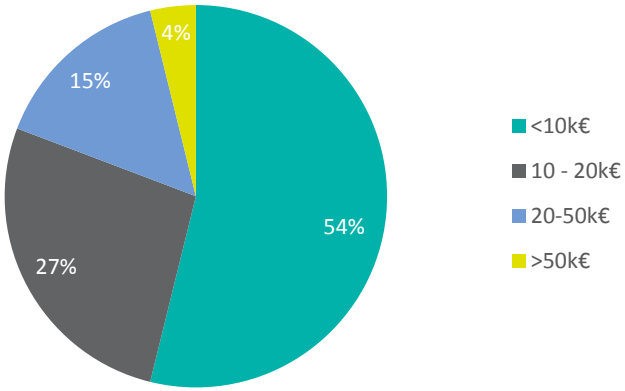

Figure 4-18 Responses to the FORESEA consultation: anticipated monthly equivalent leasing fee for the next testing deployment

In general, survey respondents are less willing to pay large fees for non-grid connected sites, and in some measure for intermediate scale sites, than for the others, as can be seen in Figure 4-19.

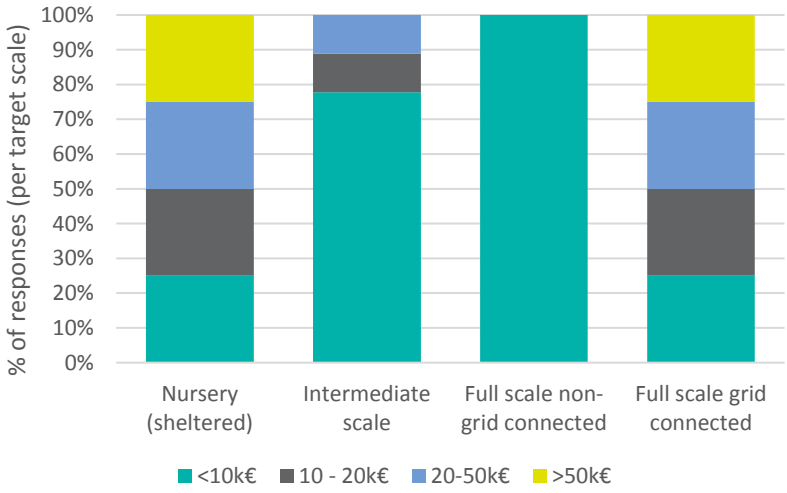

Figure 4-19 Anticipated monthly equivalent fee for the next testing deployment at the different site types

Some respondents stated that the fees should depend upon the services and infrastructures offered and used. Another respondent flagged that the customers are '*bootstrapping entrepreneurs in a non-existing capital market. Policy makers should understand this and design policies financially friendly, especially for the small and micro entities*'. Such comments can be considered when deriving strategic recommendations for the development of the test sites' infrastructure and services (see Section 5)

4.4 Summary of Consultation Findings: Competencies and Services Requirements

Table 4-1 summarises the key findings from the consultation. The information is structured in a format similar to that presented in the capabilities and competition reviews (see Section 2 and 3) to ease the comparison and facilitate the identification of gaps in the test sites' offer, or potential niches in the industry requirements (see Section 5).

Table 4-1 Summary of the customer requirements for open-ocean test site competencies and services (based on customer survey responses)

Category	Criteria	Customer requirements
Administrative Framework	Pre-permitted site	Must-have: Faster consenting is seen as the most attractive feature of an open-ocean test site.
	Power purchase agreement	
	Support in further applications	
Availability of Site Specific Data	Metocean data measurements	Nice-to-have: Availability of real-time resource measurements is mostly important for low TRL developers. Overall, more than 50% of the respondents ranked it as '*very important*'.
	Metocean hindcasts	
	Bathymetry data	
	Geotechnics data	
	Environmental data	
Supply Chain / R&D	Connection to the industry supply chain	Nice-to-have: 68% of the respondents stated that the provision of supply chain may be of interest.
	Connection to other sites	Not important: Partnership with other testing facilities is in general the lowest attraction for developers.
	Connection to research/funding programmes	Must-have: 60% of the respondents value the access to suitable incentives / support mechanisms for test programmes as '*very important*'. More than 70% of the respondents ranked the support in funding / grant application as one of their priorities.
Market Engagement	Industry group	Nice-to-have: Connection to the market is ranked 8th in the attractive features of an open-ocean test site.
	Website	
	Presence at conferences / exhibitions	
Support to development	Independent verification	Nice-to-have: 64% of the respondents '*may be interested*' in support to device development activities.
	Support to certification	
	Resident engineering / generic R&D support	
Support to Monitoring	Resource	Nice-to-have: Respondents are in general '*may be interested*' in support to monitoring activities.
	Environmental impact	
	Device	
Operational Support	Marine works and operations	Nice-to-have: Respondents are overall mildly interested in operational support (e.g. O&M planning or specialist support for offshore inspections).
	Safety responsibility	
	Professional diving and maritime work teams	
	Logistical support	
Policy Support	Support understanding local / national policy	Must-have: Consenting support is the critical factor in terms of service offered, with 76% of the respondents ranking it as one of their priority.
Outreach Support	Local public outreach	Nice-to-have / Must-have: although local stakeholder engagement support is of medium interest to the overall respondents, highly experienced developers rank this support as one of their priorities.
	Support to finding housing, office space, relocation assistance	

5 PROVISION OF STRATEGIC RECOMMENDATIONS

Having assessed the *Capabilities* (Section 2), the *Competitors* (Section 3) and the dominant requirements of potential *Customers* (Section 4), the 3C factors can be combined to inform the market positioning of the FORESEA test sites and to issue recommendations on strategies for the development of additional competencies, services and infrastructure. To this objective, CA followed a three-step approach:

- Firstly, and using the capabilities and customers' consultation findings summaries provided in Section 2.5 and Section 4.4, a high-level gap analysis of the FORESEA test sites' offering was conducted (see Section 5.1).
- Secondly, the current positioning of the test sites was characterised in the form of perceptual maps, in an effort to identify areas where the FORESEA test sites can contribute significantly with their current capabilities (see Section 5.2).
- Thirdly, the findings of the customer's consultation were considered in a customer segmentation exercise, defining multiple customers segments that, in CA's opinion, directly affect the FORESEA test sites' value proposition (see Section 5.3).

The purpose of such analysis is twofold: firstly, to recognise gaps in the current offer; and secondly, to identify potential niches that the FORESEA test sites can uniquely fill. Ultimately, the analysis is expected to contribute to the creation of strategies for the development of the test sites.

5.1 FORESEA Test Sites and the Customer Requirements

Using the sector review data gathered from the two consultation exercises, a qualitative assessment of the main gaps between the test sites capabilities (analysed in Section 2) and the customer requirements (analysed in Section 4) in terms of competencies and services was conducted. The findings of the assessment are summarised in Table 5-1 and Table 5-2, using a traffic-light system based on the evaluation criteria detailed in Section 2. In such system, red indicates a potential weakness whereas green indicates a strong feature and good alignment with the customers' requirements. Such visual presentation aims at easily identifying key areas for priority development and to contribute to the formulation of strategic recommendations to position the FORESEA test sites.

Table 5-1 and Table 5-2 present the high-level gap analysis with a core focus on the test sites' competencies and services, respectively. A similar overview focusing on the current infrastructures is presented in [3].

From a competencies and services offer perspective, the FORESEA test sites' capabilities are overall well aligned with the customer's current requirements. In CA's opinion, a key item to consider is the strong desire from the customers to ultimately connect their device to the grid, in an approximately 10-year timeframe. The existence of e.g. a power purchase agreement is therefore a potential feature that may attract developers to a test site, along with the support in obtaining the required licenses and permits for increasingly larger deployments.

Table 5-1 High level gap analysis: services competencies of FORESEA open-ocean test sites vs. customer requirements

Category	Evaluation Criteria	SEM-REV	EMEC	SmartBay	DMEC	Customers' requirements
Administrative Framework	Pre-permitted site	Yes	Yes	Yes	No	Must-have: Faster consenting is seen as the most attractive feature of an open-ocean test site
	Power purchase agreement	On a case by case basis	Yes	N/A	No	
	Support in further applications	N/A	N/A	N/A	Yes	
Availability of Site Specific Data	Metocean data measurements	Free / paid access	Free/paid access	Free access	Free access	Nice-to-have: Availability of real-time resource measurements is mostly important for low TRL developers. Overall, more than 50% of the respondents ranked it as '*very important*'.
Supply Chain / R&D	Connection to the industry supply chain	Wide coverage of activities	Partly covered	Wide coverage of activities	Wide coverage of activities	Nice-to-have: 68% of the respondents stated that the provision of supply chain may be of interest.
	Connection to other sites	Yes	Yes	Yes	Yes	Not important: Partnership with other testing facilities is in general the lowest attraction for developers.
	Connection to research/funding programmes	More than 1 programme, at local, national and international scales	More than 1 programme, at national and international scales	More than 1 programme, at local, national and international scales	More than 1 programme, at national and international scales	Must-have: 60% of the respondents value the access to suitable incentives / support mechanisms for test programmes as '*very important*'. More than 70% of the respondents ranked the support in funding / grant application as one of their priorities.
Market Engagement	Industry group	Active member	Active member	Active member	Active member	Nice-to-have: Connection to the market is ranked 8th in the attractive features of an open-ocean test site.
	Website	Regularly updated	Regularly updated	Regularly updated	Regularly updated	
	Presence at conferences	Frequent	Frequent	Frequent	Frequent	

Table 5-2 High level gap analysis: services offered at FORESEA open-ocean test sites vs. customer requirements

Category	Evaluation Criteria	SEM-REV	EMEC	SmartBay	DMEC	Customers' requirements
Support to Development	Independent verification	Planned (next 5 years)	Yes	Yes	Planned (next 5 years)	Nice-to-have: 64% of the respondents '*may be interested*' in support to device development activities.
	Support to certification	No	Planned (next 5 years)	No	Yes	
	Resident engineering and/or generic R&D support	Yes	Yes	Yes	Yes	
Support to Monitoring	Resource	Yes	Yes	Yes	Yes	Nice-to-have: Respondents are equally split between '*may be interested*' and '*very interested*' in support to monitoring activities.
	Environmental impact	Yes	Yes	Yes	Yes	
	Device	Yes	Yes	Yes	Yes	
Operational Support	Planning and supervision of marine works and operations	Yes	Yes	Yes	Yes	Nice-to-have: Respondents are overall mildly interested (68% of '*may be interested*') in operational support (e.g. O&M planning or specialist support for offshore inspections).
	Safety responsibility	No	Yes	No	Yes	
	Professional diving and specially trained maritime work teams	No	No	Yes	No	
	Logistical support	Yes	Yes	Yes	Yes	
Policy Support	Support understanding local / national policy	Yes	Yes	Yes	Yes	Must-have: Consenting support is the critical factor in terms of service offered, with 76% of the respondents ranking it as one of their priority.
Outreach Support	Local public outreach	Yes	Yes	Yes	Yes	Nice-to-have / Must-have: although local stakeholder engagement support is of medium interest to the overall respondents (60% of '*may be interested*'), highly experienced developers rank this support as one of their priorities.
	Support to finding housing, office space, relocation assistance	Yes	Yes	Planned (next 5 years)	No	

5.2 FORESEA Test Sites and the Competition

By coupling the capabilities of the FORESEA test sites reviewed in Section 2 with the sector review data gathered from the analysis of the competition (Section 3) and CA's judgment / experience, a perceptual map can be generated to summarise the key findings and present the current positioning of the test sites with regard to the level infrastructures and competencies.

Following the results of the customer survey (Section 4), two key dimensions were identified to characterise the reviewed test sites: target testing scale and tolerance to risk.

- The first proposed dimension (target testing scale) can be used to evaluate the capability of the test site to support small to large scale deployments. It can be related to e.g. the availability of grid connection and the availability of specific services, as customers at late development stages may focus on long-term, grid connected full scale deployments, whereas early stage developers seek R&D and engineering support.
- The second proposed dimension (tolerance to risk) aims to assess the capability of the test sites to host innovative technologies and / or attract less risk tolerant developers. The willingness to host particular technologies can be related in part to the availability of R&D / funding programmes and policy support to encourage innovative technology and early stage deployments, whereas e.g. development support services can be perceived by developers as a desire to follow industry best practices and used to reduce / transfer risk responsibility.

The resulting map of the test sites is presented in Figure 5-1. The size of the circles is proportional to the average level of support and level of infrastructure of each reviewed test site. In particular, the smaller circles correspond to planned or less experienced sites (marked with a dotted pattern), for which limited data is available. The FORESEA test sites are highlighted in green, whilst the Level 2 test sites are represented in red.

Overall, the following observations are, in CA's opinion, relevant:

- SEM-REV, as a full-scale grid connected test site, is well suited for technology deployments of more experienced developers ready to progress to full-scale deployments.
- EMEC's offer, including both scale and full-scale grid connected sites, covers both early and later stage deployments. This, along with the extent of the service offering, leads to a ranking towards the middle of the perceptual map.
- The focus of DMEC on TEC deployments exposes the test site to less risky technologies, whilst SmartBay, as a non-grid connected, intermediate scale test site, targets mostly early stage developers.

The distribution of the FORESEA test sites (in green), spread over the different axes of the perceptual map, may be considered when targeting different customers segments. The current test site landscape illustrated in Figure 5-1 positions the majority of the sites in the second and fourth quadrants of the perceptual map. The absence of an offer for the first and third quadrants may be explored in a segment targeting approach, should customers with such characteristics exist in sufficient numbers. Such features and associated strategies are explored in Sections 5.3.

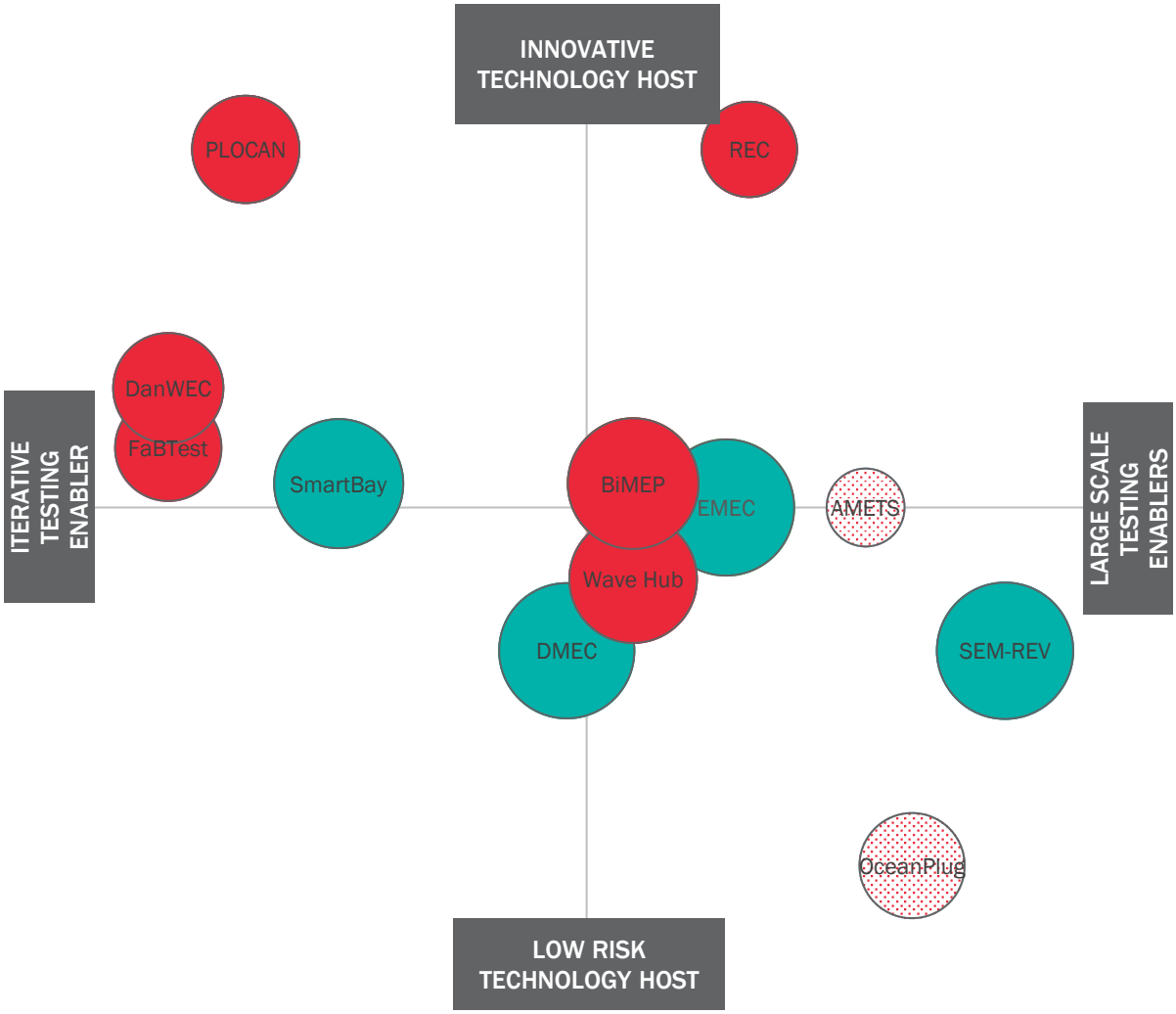

Figure 5-1 Perceptual map: current positioning of the FORESEA and Level 2 open-ocean test sites

5.3 Customer Segmentation

To assist in the positioning of the FORESEA test sites, in CA's experience it is useful to assess if the findings presented in Section 4 can be used to define specific customer segments. In [34], a similar approach was followed, and two types of WEC technology developer '*customer personas*' were identified (large scale enthusiasts and incremental designers). As the needs of multiple technology developers were reviewed for the present exercise, namely WEC, TEC, FWT, subcomponent and others, a broader customer segmentation exercise was conducted.

In CA's opinion, the multiple customer segments identified can be summarised as illustrated in Figure 5-2. Following the results of the customer survey, and in overall alignment with the perceptual map's axes, two key dimensions were identified to characterise the potential customers of the FORESEA test sites: strategy for development and attitude towards risk. The first proposed dimension (strategy for development) can be used to assess if a customer is mostly driven by the desire to develop a commercial scale project or the technology itself. The second proposed dimension (attitude towards risk) can be related to the degree of novelty of the technology and the

approach in its development. Using the proposed dimensions, in CA's opinion four customer segments can be justified: *technology innovators*, *rocket path developers*, *incremental testers* and *best practice followers*.

Figure 5-2 Proposed customer segmentation

The fundamental beliefs of each customer segment are conceptualised in Figure 5-3. These beliefs can in turn be explored and linked to the capabilities available in the FORESEA test sites (described in Section 2). Figure 5-3 attempts to bridge such aspects by addressing the key characteristics of the target customer segments. In short:

- '*Technology Innovators*' can be associated as early-stage technology developers, with a high tolerance for risk and a large value given to iterative testing to prove their technology. Technology innovators require a stage gate approach for the development plan, and nursery and intermediate scale testing facilities are likely to be of interest to this segment in a short- and medium-term horizon. Technology innovators want to focus on their core engineering / design / development activities, while indirect services such as consenting support may be of interest. As early-stage developers, they can be characterised with a low TRL and low level of funding; they typically largely require R&D support and funding resources.
- '*Rocket Path Developers*' can be characterised by a strong desire to accelerate the technology development and deployment plans to boost the market. Developers in this segment are willing to progress quickly in their TRL development, with fast progression from early-stage testing to large deployment plans. Need for grid connected deployment at full-scale test site is foreseen in a short- to medium-term horizon. This can be enabled by consenting support or access to R&D / funding programmes.
- *'Best Practice Followers'* are risk-advert developers, willing to progress slowly in their development plans to ensure adherence with (perceived) best practices and ease the way

to certification and commercial deployment. Iterative deployments at nursery, intermediate- and full-scale deployments are to be expected, consolidated by e.g. support to development, monitoring and operational activities from the test site.

- '*Incremental Testers*' show a strong commercial focus, and a desire to progress fast in their deployment plans, scheduled incrementally from small to large scale. Such developers typically foresee grid connected deployments at full-scale test sites in a short-term horizon. In general risk-advert, they value support services for e.g. development, monitoring and operational activities.

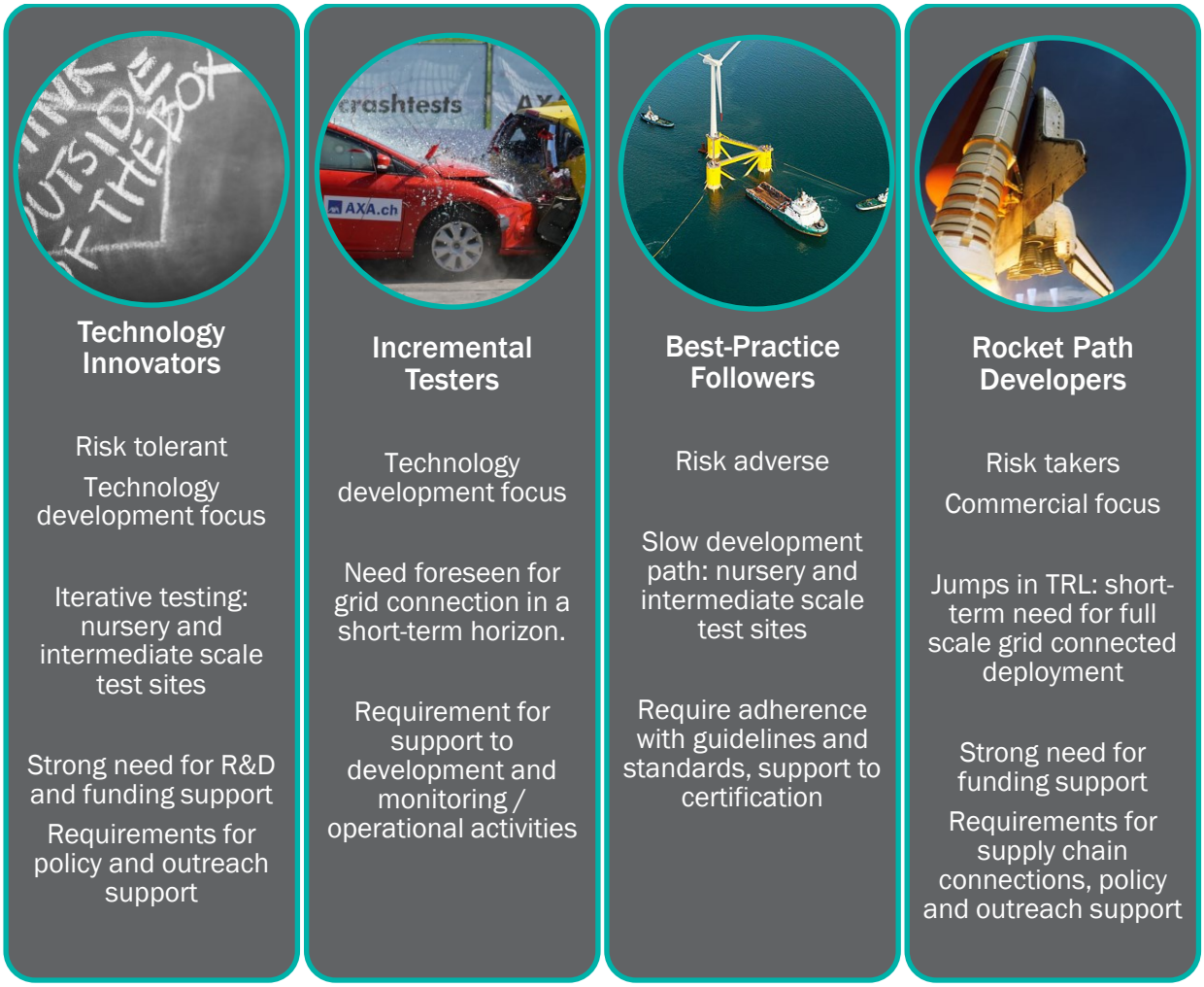

Figure 5-3 Open-ocean test sites: key characteristics of the proposed customer segments

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