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Best Practices Marine Test Sites

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1. Introduction

1.1. The assignment

The Regional Development Agency West Flanders (POM West Flanders, Belgium) is partner of the MET-CERTIFIED Interreg 2 Seas project that aims to make marine energy projects insurable and financeable in the 2 Seas region (UK, FR, NL, BE). This through the development of internationally recognized standards and certification schemes. IMDC and Ecorys were assigned the task to collect newly acquired insights and good practices with regard to the exploitation of test sites and certification and standardization during product development, to put these alongside best practices regarding test facilities in other sectors and to make strategic recommendations on this basis.

1.2. Scope of the study

The study comprises of three subtasks:

- Task 1: analysis of best practices of open water test facilities in the 2 Seas region. Collection of specific information and best practices of the four partners of the MET-CERTIFIED project, i.e. EMEC, PTEC, DMEC and Ifremer and at least two additional open water test facilities in Europe. For the different sites, the following aspects are described and analysed: available infrastructure and facilities, site conditions, available services and certification, management, accreditation, standards, access to users, permits, business model, HSE, intellectual ownership, marketing and promotion. The analysis is based on publicly available information and interviews with the owners of the test facilities.
- Task 2: analysis of best practices of test facilities in other relevant sectors. Five cases of test facilities in other sectors were selected based on criteria agreed with the client. The evolution and experiences of the facilities are described and lessons learned are formulated, comprising the evolution of business models and ownership, offered services, the pathway to commercialisation in these sectors, the role of developing standards, etc.
- Task 3: propose strategic recommendations for further developments of test facilities in the marine energy sector in North Western Europe, including the planned offshore test platform Blue Accelerator of POM West Flanders. The recommendations are based on the best practices and lessons learned from the analysed open-marine test facilities and the other sectors. Potential collaborations are identified and recommendations are given regarding accreditation, preparedness for the future and investment possibilities.

1.3. Reading guidance

Chapter 2 describes the analysis of the partner open marine test facilities and two additional European test sites. Chapter 3 describes and analyses the 5 cases of test facilities in other sectors. Chapter 4 formulates the strategic recommendations. Contact details and references are given in chapter 5 and 6 respectively. Chapter 7 lists abbreviations and some definition of frequently used terms. In the Annexes, overview tables outline the various aspects related to the open-marine test facilities (Annex A) and to the other sectors (Annex B). Annex C presents some specific documents relevant to the test facilities mentioned in the report.

2. Best practices in open water test facilities

2.1. Context

After consultation with the client and partners of the MET-Certified project, it was understood that their main interest is the accreditation of test facilities, i.e. the offering of certification services, the added value of it, and how to make business of it, rather than the development of standards as such. Questions arose including:

- How can certification help to commercialise the wave and tidal industry?
- What is the potential role of test facilities?
- How to be prepared for the future?
- How to cooperate between test facilities? E.g. develop pan-European expertise centrum
- What if all developers want the same test facility, what about the other facilities? List the added value of each test centrum.
- What is the best way for a test facility to become accredited (at low cost)?
- Is there a need for certification in the future? If so, by whom is this needed? How can test facilities meet those needs?
- What kind of business model can be applied? Where can profits come from? Around 50% of the funding is currently provided by EU research projects.

In order to answer these questions, publicly available information was consulted and a selection of test facilities were contacted for a one-hour interview. Of the four partner facilities of the MET-CERTIFIED project (DMEC, EMEC, PTEC, Ifremer), only two could be contacted for an interview: EMEC and DMEC. The contact person of PTEC was willing to answer a questionnaire by email (see 2.3). In addition to that, sufficient information could be collected from publicly available sources. Partner facility Ifremer, however, could not contribute, stating that they offer only onshore test facilities. As only very limited information was publicly available, it was decided to not include the analyses of the Ifremer site in this report. However, in the overview table (Annex A) the restricted material that could be found has been provided.

In addition to the three partner test facilities, three test sites which did not participate in the Project, were also selected for this study, in order to provide case studies from which the project partners can gain market insights and lessons learned. The following sites were selected in agreement with the project partners: SEENEOH in France, FaBTest in the UK and FORCE in Canada. Of these three additional cases, unfortunately FORCE could not be contacted for an interview. The information in this study regarding FORCE is based on publicly available data only. Both SEENEOH and FaBTest contributed to an interview. The locations of the selected cases are shown in Figure 1. An overview of the characteristics of each facility, including Ifremer is given in Annex A. The information is grouped per team: General information, Site conditions, Services and infrastructure, Management and Risk and opportunities.

During the process of the interviews, it was concluded that the viewpoint of the Certification Bodies would also be an added value. In order to capture the Certification Body perspective on the topics object of this study, three interviews have been conducted with the following Certification Bodies: Bureau Veritas (BV), Lloyds Register (LR) and the Belgium standardisation platform CEB-BEC. DNV-GL was also contacted, but no answer was received.

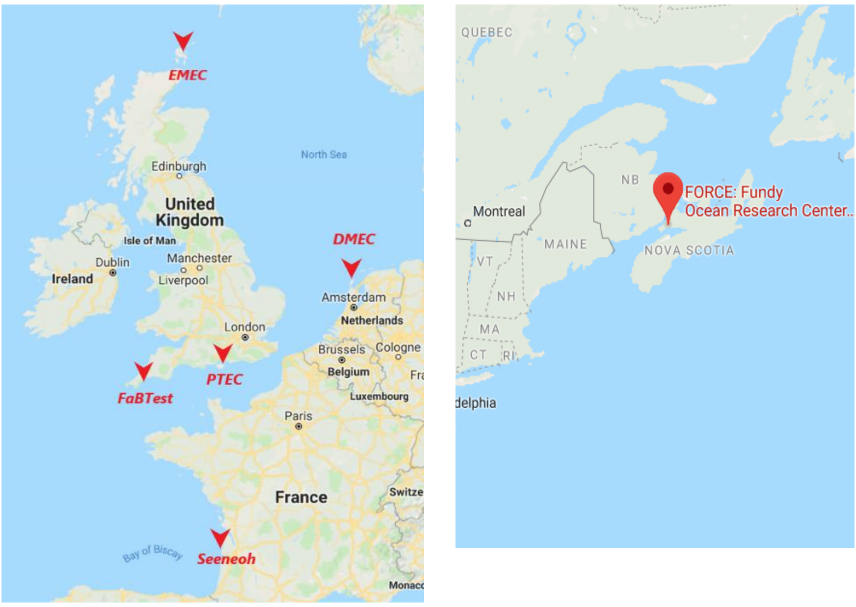


Figure 1 Overview of selected test sites locations

2.2. Short description of selected test facilities

This section provides an overview of the test facilities selected for this study, with further details provided in Section 2.4.

Three of the selected test sites are Project partners: EMEC, DMEC and PTEC. The scope behind this study is to map their current capabilities in order to more readily recognise gaps in the current offer; and secondly to identify potential niches which these test sites can uniquely fill to meet the market requirements. In addition, SEENEOH, FaBTest and FORCE have been selected, in order to provide case studies from which the project partners can gain market insights and lessons learned.
This desktop study aims at providing a good overview of the current conditions of the marine energy test facilities, since different typologies of facilities were selected, in order to cover the widest range as possible.

The **European Marine Energy Centre (EMEC)** is the only one of two accredited open sea wave and tidal test centres for ocean energy in the world, suitable for testing multiple technologies simultaneously in harsh weather conditions. The other being NREL in the USA. It fits the needs of developers with different TRL, up to 9. In addition, it is one of the first centres in operation, since 2003, and it is also playing a lead role in many Projects, as FORESEA, MaRINET2, MET-CERTIFIED, SEA Wave, ITEG, Blue GIFT and many more. In recent years, EMEC has been highly active in testing and demonstrating hydrogen and energy system technologies.

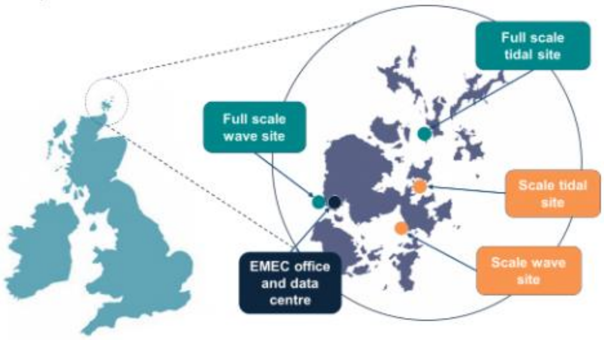


Figure 2 Overview of DMEC sites, Ref. [1]

The **Dutch Marine Energy Centre (DMEC)** has two test facilities for testing tidal energy devices of different types and maturity levels (TRL 6 – 9 at the onshore test site, all TRLs at the offshore test site). Both test sites are part of a European-wide testing infrastructure. As EMEC, it is also playing a lead role in many Projects, such as FORESEA, MaRINET2, MET-CERTIFIED, MEA, OESA, OPIN and OceanDemo. DMEC facilitates access to other test sites in the Netherlands too. With its partners IFREMER and EMEC, DMEC offers testing under protocols that comply with IEC certification.

Figure 3 DMEC Offshore Marsdiep berth, Ref. [2]

The **Perpetuus Tidal Energy Centre (PTEC)** will be operational during 2021 and is addressed to developers at an advanced stage of TRL, having previously completed prototype testing at other tidal sites. The PTEC approach – a readymade, 'live' commercial platform run in partnership with the local council and various turbine manufacturers – presents an exciting model for the tidal energy industry.

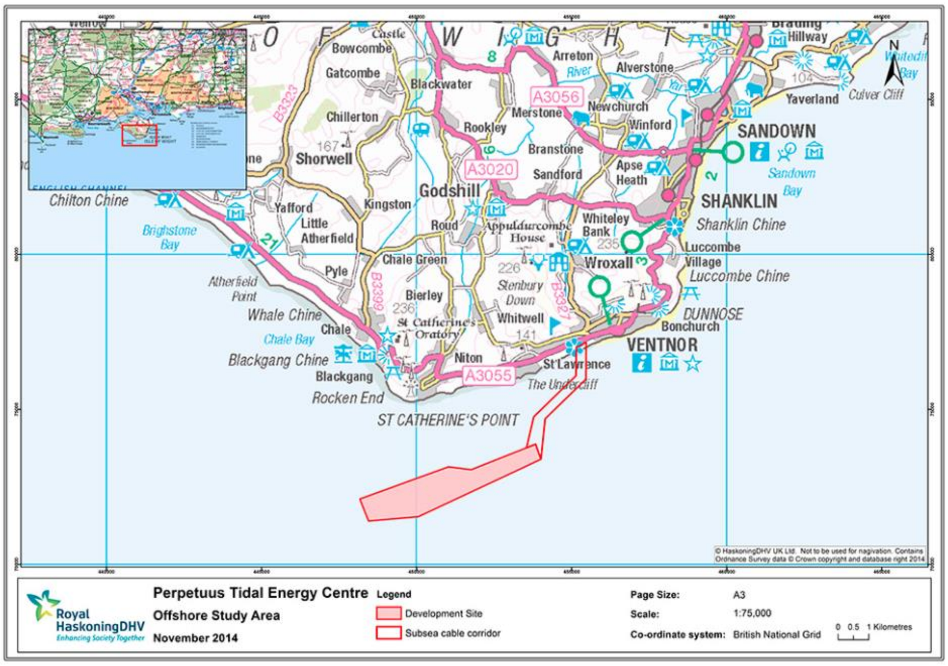


Figure 4 PTEC offshore site, 2.5 km south of St Catherine's Point, and subsea cable corridor, Ref. [3]

FORCE is Canada's leading test centre for in-stream tidal energy technology. The FORCE site is located in the Bay of Fundy, the region of the world's highest tides, hence it is ideal for developers with high TRL, up to 9. FORCE has two major roles: host to TISEC developers and steward to the site. FORCE actively supports research and development studies: for this purpose, FORCE created the Fundy Advanced Sensor Technology (FAST) program to advance efforts to monitor and characterise the FORCE site.

Figure 5 FORCE site location, Ref. [4]

FaBTest is a nursery facility enabling device developers to test components, concepts or full scale devices in a moderate wave climate. FaBTest offers WEC and TEC tests for developers at an early stage, with a TRL between 6 and 8. FaBTest's pre-consented status aims to provide a fast, flexible low risk and low cost solution, which is especially appreciated by device developers at the pre-commercial investment stage.

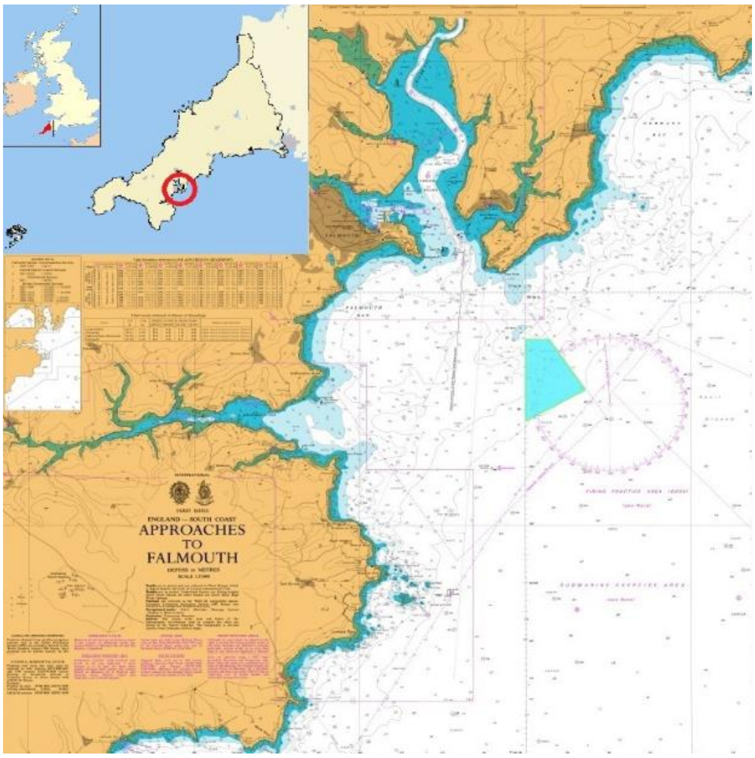
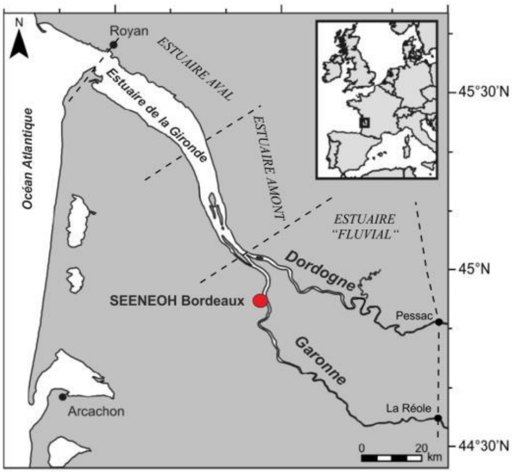


Figure 6 Overview of FaBTest site and facilities, Ref.[5]

The **SEENEOH** Test Site is mainly locally articulated, with a strong connection to Aquitaine Region economy. Located on the river part of the Gironde estuary, it offers a landmark in estuarine environment for the development of the (tidal) river turbine industry. Demonstrators may be intended on a full scale for the fluvial and estuary market, or on an intermediary scale for the ocean market.



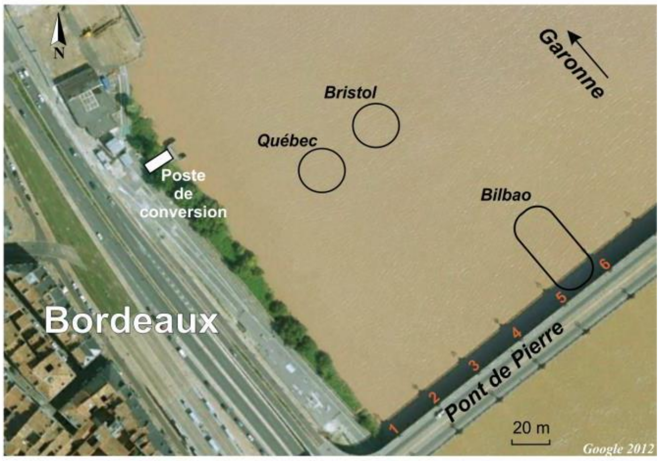


Figure 7 Location of SEENEOH Bordeaux test site and of tidal turbines slots, Ref.[6]

2.3. Questionnaire for open water test facilities

In order to answer the questions defined by the client and to capture the best practices of existing open water test facilities, a questionnaire was set up with questions grouped around 8 topics as a guideline for interviews. As preparation for the interviews, the questionnaire was sent per email to the partners and the three additionally selected facilities. The client provided a reference letter to facilitate the interviews.
The questions raised, grouped around the 8 topics were as follows:

1. Offered infrastructure and facilities
    a. Which infrastructure and facilities do you offer as test facility?
    b. What is the TRL level of the devices you test? What is the scale?
2. Offered services and certification
    a. How does typically the procedure go, when a developer approaches your test facility (different steps)?
    b. What kind of services or functions does your test facility offer? Has this evolved since the test facility became operational?
    c. Do you provide independent validation and verification of testing data, i.e. (proto)type testing reports?
    d. Do you provide the required permits? Or advice to acquire permits?
    e. Is your test facility accredited? If yes, can you describe the accreditation process, the accreditation body and specify for which standards you are accredited?
    f. If not, are you working together with a certification body? Can you share how this is organised?
    g. Are your clients interested in certification?
    h. If you offer certification or accredited test reports, please list according to which standards or specifications.
    i. Do you see accreditation, certification and adherence to recognised standards as an opportunity? Do you have any plans to become accredited in the future?
3. Site conditions
    a. Please describe the specific site conditions of your test facility: typical wave, wind and tidal characteristics, distance to shore, water depths, salinity
    b. Do you have (historical) data time series available? Numerical model results of the area? What do you do with accumulated data? Are you allowed to use it for research or transfer it to a third party?
    c. How do you deal with intellectual ownership/property?

   d. What is the average downtime due to maintenance of the test facility?
   e. What is the average monthly weather downtime for maintenance in your area?
   f. How is it your relationship with local stakeholders such as fisheries, port authorities?
4. Permitting and policy
   a. How does the test facility fit in the (inter)national policy?
   b. Which permits did it need to be build and to operate?
5. Management and business model
   a. Which parties own the test facility (private owner, academic institute, industry, government)? How is the management of the test facility organised? Are there any partnerships (with academic world, authorities, other)?
   b. How does/did the test facility get financed: % public, % EU projects, % industry, % private? Is there an evolution over the years?
   c. On what is your business model based at the moment? Has it evolved since the start of the test facility? How does/did the test facility get financed (public, EU projects, industry, private)?
   d. How is the tariff structure organised?
   e. How do you organise access and permissions for users?
   f. How is the booking of the test facility organised? One client at the time, multiple users?
   g. How has the order book evolved over time since the facility became operational?
   h. What is the typical duration of a test?
6. Marketing and promotion
   a. What are the highlights of your test facility? How does it distinguish itself from other facilities? What is the added value of your test site?
   b. Can you list why your users/clients choose for your test facility?
   c. How do you promote industry versus research projects (e.g. European…)?
   d. On a scale of 1 to 10, how do you consider your test site with regards to its capability to support small / early stage (1) to large scale deployments (10)?
   e. On a scale of 1 to 10, how do you consider your test site with regards to its capability to host innovative (1) vs. less risk tolerant developers (10)?
7. HSE
   a. How do you deal with health, safety and environmental issues? Following which standards?
8. Obstacles, opportunities and lessons learned
   a. What were/are the main frustrations when developing and managing a test facility?
   b. Where do you see opportunities in the future of test facilities in general?
   c. How do you see the role of your test facility in the future, opportunities, any wish list?
   d. What are the main risks?
   e. Can you share any lessons learned on the way, regarding above topics?
   f. Are you willing to work together with other facilities? Is there currently any collaboration (e.g. with onshore lab test centres or other open water test facilities)?

2.4. Analysis of cases

A benchmark of the existing infrastructure and the future needs of the marine energy industry was required, hence different typologies of facilities were analysed, in order to provide a wide overview of the current state of the sector, and to provide lessons learned and best practices.
The analysis was carried out reviewing project partners and selected facilities skills, in terms of competencies, services, strategies and positioning on the market.
The following sections give an overview of similarities/trends and differences at the moment, underlining for each test centre the stage of maturity, the encountered obstacles and the expected opportunities for the future.

2.4.1. Offered infrastructure and facilities

All the analysed centres, i.e. the three Partners plus FaBTest, SEENEOH and FORCE, offer TEC testing facilities, whilst only two centres, i.e. EMEC and FaBTest, also provide facilities for WEC testing. More details are given in the overview table, Annex A.

EMEC offers one scale wave site and one scaled tidal site, both not connected to the grid. EMEC has 5 grid connected berths at its full scale wave site, and 7 grid-connected berths at its full scale tidal site. Both export to the grid via onshore substations at 11kV with fibre-optic communications cables. Wave buoys are deployed at both wave sites (scaled and full scale) and a met-station at the full scale site. A test support buoy can be deployed at either scale site. On the tidal site, an ADCP can be deployed, including a met station and radar. EMEC also provides dedicated office facilities to its clients.
DMEC has two test facilities, one integrated in a dam (sluice gate, 'inshore') and one offshore berth (400 m offshore), connected by umbilical (currently removed) to NIOZ research institute on the island Texel.
FABTest has a licence for 3 berths, marked by 4 wave buoys. There is no cable connection to shore, power output can be measured as a 'dump-load' at one of the buoys.
PTEC develops tidal stream facilities at commercial scale, from grid connection, substation and control room up to subsea cables for long term deployments (at least 15 years).
SEENEOH is an estuarine tidal test site for full-scale river devices and intermediate-scale ocean devices. It offers 3 grid-connected (100 kW each) locations for floating tidal devices that includes moorings. One of them also includes a large floating platform that can accommodate different types of turbines. A new anchoring system is now available, however not grid connected, in the form of a pile fixed on the seabed.
FORCE can accommodate a number of turbines throughout the demonstration site. These turbine "berths" are supported by four 34.5kV subsea power cables (each 2 to 3 km in length) and designed to transfer power to the shore and on to the Nova Scotia electricity grid.

The selected centres cover the **full TRL spectrum**, ranging from developments at early up to advanced stage. For example, SEENEOH offers four different testing areas, for different TRLs, starting from TRL 4-5. FaBTest, with its nursery site, clearly addresses pre-commercial investment stage, with technologies at a TRL between 6 and 8 who aim to test their devices in moderate wave conditions.
The DMEC sluice gate site offers test facilities for tidal stream turbines of TRL between 6 and 9, while tidal energy devices of all types and maturity levels can be tested at its offshore test site. All the other facilities are suitable for most advanced prototype testing: FORCE, located in the region of the world's highest tidal range, PTEC, is addressing only to developers with TRL of 8-9, having previously completed prototype testing at other tidal sites and also EMEC receives most offers from mature developers with high TRL (up to TRL 9).

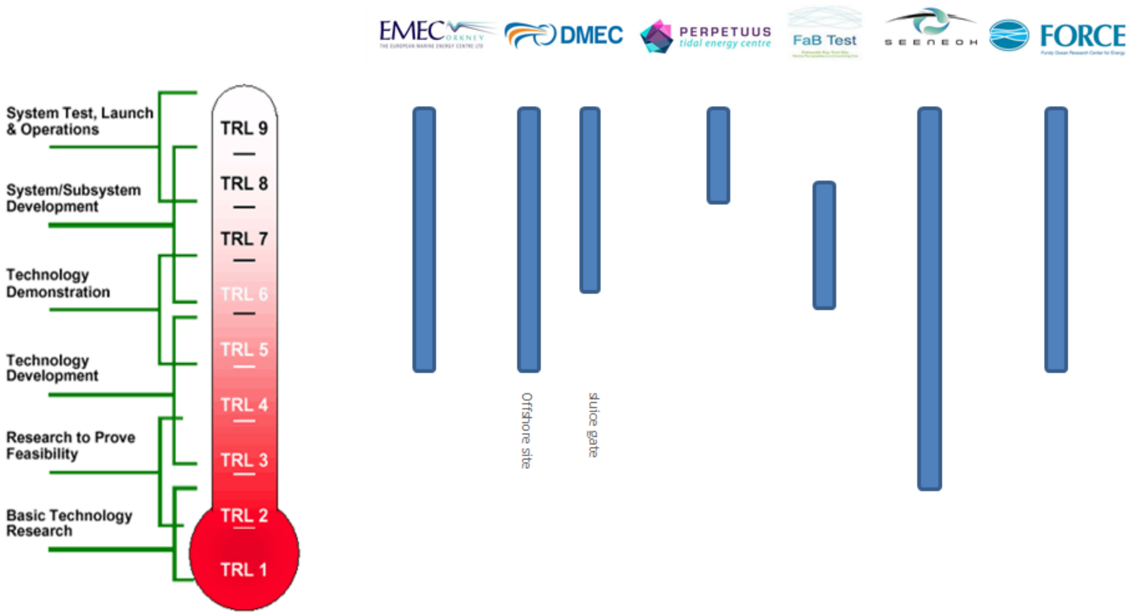


Figure 8 Overview of TRL offered by the centres

EMEC is the most experienced test centre, having been in operation since 2003, followed by FORCE (2009) and FaBTest (2011).
SEENEOH has only been in operation since 2017, but it has already gained valuable experience, due to its strong connection with local stakeholder, partners and investors, accurately planned before entering in operation.
PTEC is currently on hold, pending a suitable revenue support mechanism from the UK Government. However, the project could be operational during 2021 if development was to recommence this year.
With the exception of FaBTest, all the test sites are connected to onshore by export cables. For the time being, DMEC's export cable is out of service, but the connection can be restored if requested by a client.

A **typical test duration** is 6 to 12 months, except for PTEC which is specifically intended for long-term 'commercial demonstration' of up to 15 years.
At EMEC several test locations are available, hence several devices can be **tested at the same time**, for example, on the full-scale tidal test site, 7 developers can work at the same time. For the wave energy test site, up to 7. Usually 2 to 4 technologies are on site at the same time.
FaBTEst and SEENEOH each have 3 berths available, hence they allow for up to three devices to be deployed concurrently; PTEC has up to 6 berths of 5 MW each or 3 berths of 10 MW each, while DMEC can test only two devices at a time, one at each facility.

2.4.2. Offered services and certification

Offered services

EMEC has the largest team and offers the most services of all the studied test facilities. Apart from making the above described infrastructure available, EMEC assists clients with the planning (2 years ahead) and getting licences in place if needed, as parts of EMEC sites are pre-consented. EMEC has a Quality Management System which is certified to EN ISO 9001:2015 and provides guidance to developers with emergency response plans, relevant standard operating procedures and safe systems of work such as permitting. EMEC monitors the generated electricity, manages data acquisition and provision from instruments on site, supports development of test programmes and offers accredited Performance Testing. EMEC assists technology developers to access funding for demonstration programmes. This support can range from helping with funding applications, and providing intelligence and contacts, to setting up open access schemes such as FORESEA and Blue GIFT which technology developers can apply to.

DMEC consists of a team of 11 people. Apart from the facilities, DEMEC develops and provides technical and commercial support and services to clients via DEMEC's network, they offer monitoring of environmental impact and act as consultant. Together with Certification Bodies and other Test Facilities, DMEC is developing certification services for technology developers on performance assessment, loads measurements, power quality, acoustic measurements and support services such as technology qualification and mooring assessment.

FaBTest is regulated by a body of representatives from the University of Exeter and Falmouth Harbour Commissioners including the facility manager. They have 3 berths available, with access to data and data measurement equipment. They offer guidance in the lead up to a deployment, and have a rigorous application procedure for the permit, including third party verification of the device moorings (see Annex C.3. FabTest – Application request form). FaBTest informs marine authorities of a new deployment, but do not assist the operations. Developers have open access to the berths. The developer is responsible for contracting its own installers, and operators. FaBTest can provide testing reports if required by the client to verify performance. The University of Exeter Offshore Renewable Energy Group can host and process data if required, with the client responsible for its own data collection (telemetry, VHF receiver, etc.) with facilities and support with equipment for transmission made available by the University. FaBTest is proactive and instrumental in pointing developers to funding like Marinet2, and Marine-i.

PTEC will not only offer test facilities to external developers, but will in fact also be the project developer partnering with selected turbine manufacturers. A third party will be involved for independent validation and verification of test data (Type Testing).

SEENEOH offers apart from its facilities, monthly or occasional monitoring reports (ADCP, bathymetry, acoustic, fish compatibility), mechanical and reliability testing, electrical performance including power performance measurements, which are certified by BV if required. In addition, SEENEOH brings clients to their platform with their own boat, so that they can supervise and assist with onsite activities.

All of the test centres are able to provide test reports, but only EMEC has a licence to offer accredited test reports. It is the responsibility of the developer to contact an external Certification Body to get a conformity statement of the Type Test Reports.

CERTIFICATION

All the interviewed partners of the MET-CERTIFIED project were familiar with the **IECRE certification** scheme, [7], created in part with the support of the MET-CERTIFIED project (more details in section 2.5). With regards to the other contacted test sites, **FaBTest** showed strong interest in the scheme, aiming for a strong collaboration among the test centres, pointing out the accreditation of the test centre and providing certification services as an opportunity.

On the other side, **SEENEOH** has not yet engaged in an accreditation process, due to the time and resources needed, and also because it does not yet feel a crucial need to gain accreditation, as most of its clients are still at an early stage, and therefore not yet interested in accredited test reports. It must also be highlighted that SEENEOH is an estuarine tidal test site; the existing IEC technical specification for open water tidal resource assessment or river resource assessment still needs further development. For this reason, SEENEOH invested in a partnership with BV, offering a power performance certification, based on IEC, but adapted for the particular bi-directional current conditions of the SEENEOH estuarine river site.

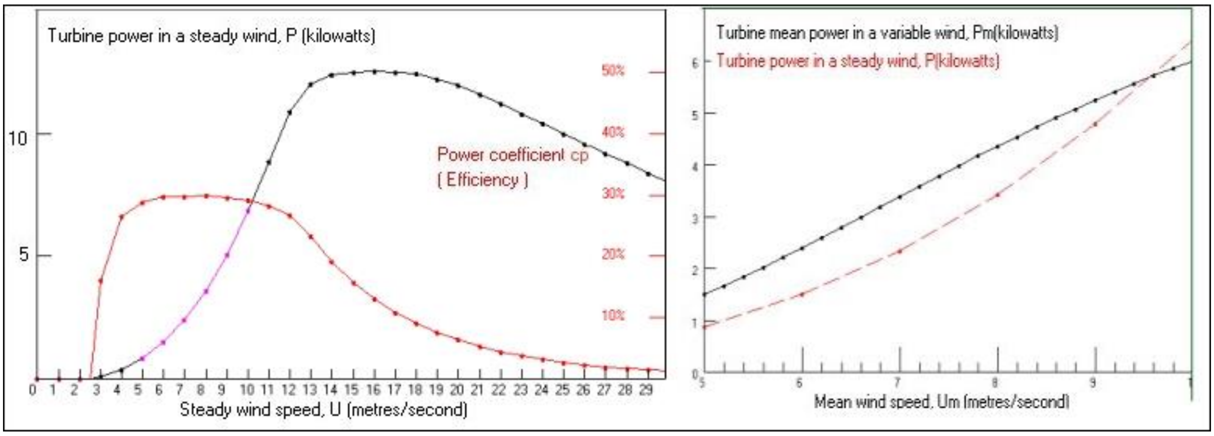


Figure 9 Example of Power Curve for Wind

EMEC offers testing under protocols that comply with IEC technical specifications. Their test reports are therefore independent and globally recognised. EMEC is the only of two test facilities in the world that is accredited to ISO/IEC 17020 for marine energy and offers independent technology inspection of marine energy converters and their sub-systems. EMEC is also accredited to test laboratory standards (ISO 17025) enabling the centre to provide independently measured performance assessments against IEC Technical specifications. EMEC's schedule of accreditation including the methods used in ISO/IEC Accredited Performance Assessment can be found in Annex C.1.EMEC Schedule of Accreditation.
DMEC is planning to issue a report according to the IEC TC-114 templates for reporting on resource and performance assessment of tidal stream energy convertors (-200 and -201) in collaboration with EMEC.
Also **PTEC** is aiming at getting accredited, perhaps in collaboration with EMEC. Their clients are very much interested in certification as it is important from an insurance and financing perspective.

2.4.3. Site conditions

All the test sites are well connected to the shore, with a maximum distance of 5 km.
SEENEOH is an estuarine tidal test site located upstream on the Gironde estuary, therefore is based only few hundred meters from shore, with a water depth at the test area ranging from 5 m to 17 m.

Figure 10 Overview of Seeneoh site, Ref. [8]

DMEC offers an inshore site integrated in a dam and an offshore site, located 400 m from shore, in a water depth of 25 m. FaBTest test facilities are located at a water depth ranging from 15 up to 50 m, with a distance of 4.5 km from Falmouth Harbour entrance. The water depth at the FORCE site, at a distance of less than 3 km to shore, ranges between 30 and 45 m. Relative deep water conditions exist at EMEC and PTEC test sites (20-70 m and 80 m water depth respectively).

Figure 11 Overview of water depth range at the test sites

The maximum current velocity at the test locations ranges from a moderate value of 1.4 m/s at FaBTest to higher values at SEENEOH (3.5 m/s), EMEC (4 m/s) and FORCE (5 m/s). At DMEC inshore and offshore site, flow velocities up to 4.5 m/s and 1.8 m/s are available respectively.

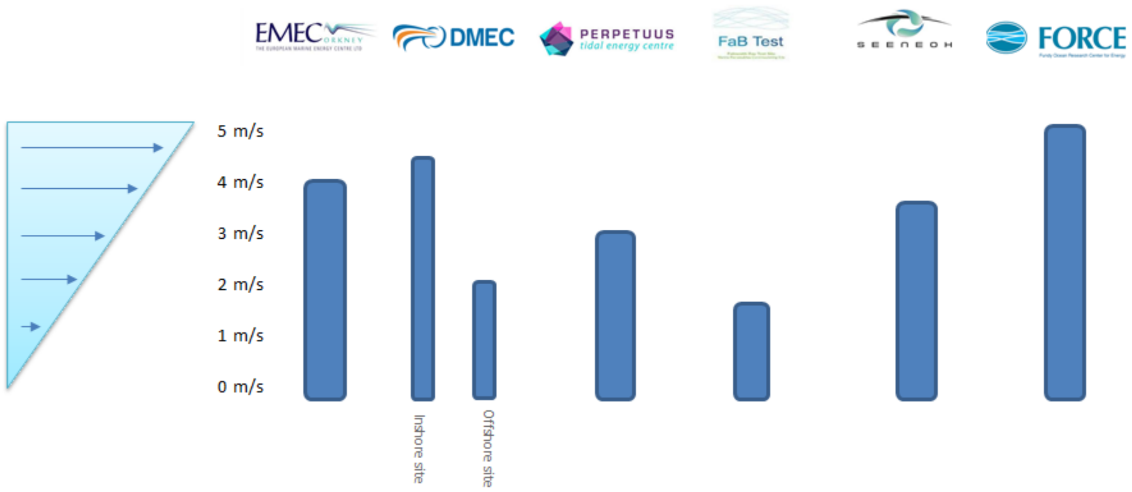


Figure 12 Overview of maximum current speed at the test sites

Average significant wave height, relevant only for the WEC test facilities, ranges from 0.6 m at FaBTest to 3 m at EMEC. More details are provided in the overview table in Annex A.

2.4.4. Permitting and policy

In terms of permits required to operate, all facilities had to face several administrative issues when opening the facility. The main **permit issues** arise from the scarce knowledge from the relevant authorities about this new technology and its potential impact.

The **FaBTest** site is leased from The Crown Estate and has consent for testing, subject to permits issued by Falmouth Harbour Commissioners. It also has a license from Marine Management Organisation. Every tester needs its own permit issued by Falmouth Harbour Commissioners and Marine License from Marine Management Organisation.

For **DMEC** the duration was quite long (3 years, including monitoring) to gain the permit; as the technology was new to everyone, they had to explain their plans to each stakeholder separately and resolve each of their concerns: province, municipality, authorities, navy, water police, water bodies etc.

Since the beginning, **SEENEOH** has gathered all the relevant stakeholders including the authority responsible for licensing – in their case, the Port of Bordeaux. Since the process to set up the project in terms of funding and in terms of management was quite lengthy, the permit timing was not really an issue for SEENEOH. The process was significantly eased considering the nature of the project: temporary, innovative, and R&D-supportive.

PTEC centre is for the time being on hold pending a suitable revenue support mechanism from the UK Government. They state that consenting was one of the longest and most complex tasks. Their intention of the project is to be pre-consented so that turbine manufacturers will only need to ensure compliance with the consent conditions.

The same problem was encountered by **FORCE**, which also had to face several concerns about TEC from representatives from fishery associations, First Nations bands, and some members of the public.
Hence, it is very important to ensure proximity to authorities and stakeholders to understand their concerns and 'educate' them on potential impacts.

Figure 13 FORCE visitor centre overlooks test area in the Minas Passage, Bay of Fundy, Ref. [9]

It must be noted that, in terms of **international policy**, most developers report a lack of support at national level, with no clear long term vision. In particular, the UK appears more focused on nuclear and offshore wind (EMEC, PTEC and FaBTest) and also in the Netherlands (DMEC) and France (SEENEOH), the government is more supportive towards the wind and solar industry, since the main target is to avoid CO_2 emissions at the lowest cost and thus invest in large impact technologies.
All the test centres experienced more interest from local scale/regional level, not national, since WEC and TEC are viewed as enhancers of local economy.
At the European level, there is a strong vision for marine energy (Blue Growth), with several commissions and Directorates-General (DGs) encouraging marine renewable energy initiatives (notably DG MARE, DG Energy).

Faster consenting is seen as one of the most attractive features of a test facility by developers. This tendency was encountered during the interviews and is also reported in previous studies, see Refs. [10] and [11].

For example, **DMEC** reported that sometimes clients are only looking for 'permitted seabed area where anchors can be deployed', to avoid the permitting time. In such cases, only 8 weeks are required to get a technology specific permit.
FaBTest also has in its pre-consented status one of its strength. Also for FaBTest the application process is relatively straight forward, with an average duration of 8 weeks. Every developer needs its own permit issued by Falmouth Harbour Commissioners to ensure compliance with the Marine License from Marine Management Organisation and the Crown Estate lease (FaBTest Operating Policy can be found in Annex C.5. FabTest – Operating Policy 2012). A developer shall complete an application process, reported in Annex C.3. FabTest – Application request form, and be compliant with its requirements. The application requires evidence of engineering due diligence, environmental and other risk

assessments (see Annex C.4. FabTest – Engineering Risk Assessment), as well as deployment and decommissioning plans and evidence of required insurance and financial bonds.

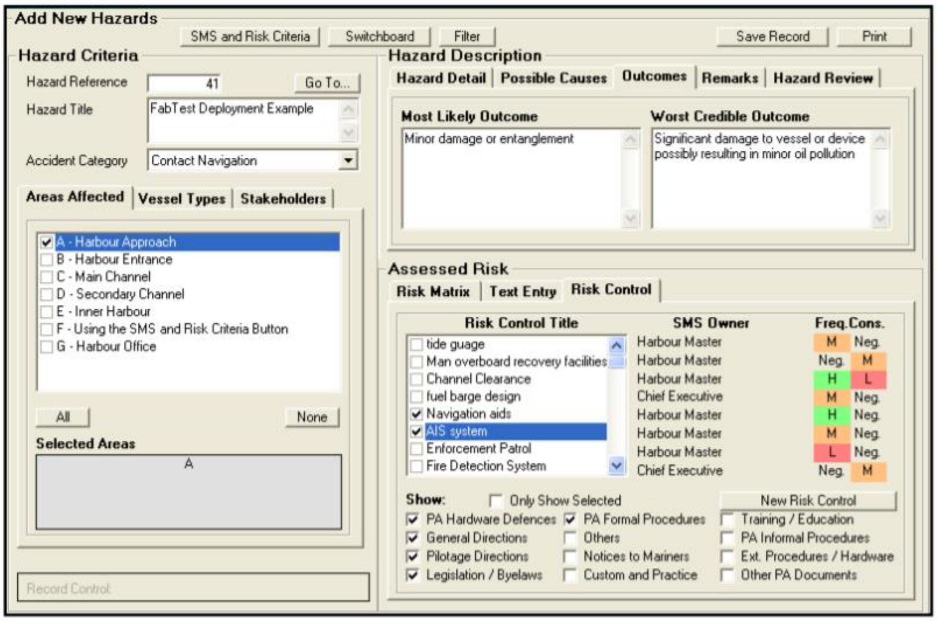


Figure 14 Hazman software (navigation risk assessments used by FaBTest) hazard outcome page, Ref. [5]

The site of **SEENEOH** is fully consented, so users do not have to submit any application for permits, as everything is already in place.
PTEC site will also be pre-consented (under a Rochdale Envelope), so turbine manufacturers will only need to worry about complying with the consent conditions.
EMEC site is pre-permitted, Ref. [10]. EMEC is also in contact with developers approximately 2 years ahead of time, in order to assist the developer in planning and gaining the relevant permits. See Annex C.2. EMEC – Consenting guidance for developers.

Note that in France, most developers tested offshore in open water, not in test facilities. Basically, if developers have a vessel available (due to prior involvement in offshore wind) and marine permits are already in place, there is no need to address a test facility. In addition, development of test facilities in France came late in contrast to, for example, Scotland where EMEC gained many clients at the moment developers needed them.

2.4.5. Management and business model

Business model

All the test facilities rely upon public **funding**, although in different form and/or share. Most of them are no-profit companies, supported by both public and private partners.

EMEC became financially self-sufficient in 2011, 8 years after its establishment in 2003. EMEC started with 100% public funding, and once it became independent, it was funded through commercial activities and competitive public funding. Today many of EMEC's clients acquire public funding to access EMEC's facilities. In addition, the EMEC facility provides electrical infrastructure by subsea power cables connecting the test facilities to the onshore national grid. The generated electricity inserted into the grid can be sold by EMEC's PPAs.

EMEC is also looking at non-utility scale markets as an increasingly large opportunity for marine energy. This includes applications such as providing power to aquaculture farms, desalination or powering islands. They are also evaluating the opportunity to couple marine energy with storage and energy systems to provide stable power, grid services, or renewable fuels such as hydrogen. EMEC can assist other test facilities to become and stay accredited as a service or to provide shared certification services (share experiences, have a dedicated person, calibration of tidal tests). EMEC is also strongly involved in development of guidelines and is working closely with other test facilities, within the MET-Certified Project, and IEC for the establishment of common standards for the sector.

Figure 15 Cable laying at EMEC site, Ref.[1].

DMEC was formed through a project funded by the European Regional Development Fund of the European Union, the 'Kansen voor West II' program and the Province of the North of Holland. It is engaged with several commercial clients and wishes to expand its commercial services.
DMEC cannot rely on developers alone, with the main income resulting from funded projects (e.g. project for standardisation and certification without focus on a single technology, OESA project with 5 pilots, Marine Energy Alliance for early stage technology support).
In particular, DMEC can offer free-of-charge access to its clients for testing, through MARINET2, FORESEA and OCEANDEMO programmes. In order to not depend on publicly funded projects only, DMEC is developing commercial income from their services like providing technical and commercial support, offering monitoring of environmental impact and acting as consultant.
In fact, DMEC develops and provides technical and commercial support and services to developers via DMEC's network (for TRL3-4/5), acting as consultant to developers. DMEC offers also environmental monitoring services. DMEC is planning to provide certification services, such as power performance assessment and delivering verified test reports, complying with IECRE via the accredited status of EMEC. DMEC is in for partnerships, helping clients to get access to any test facility, not only DMEC's.

SEENEOH is a 'Société par actions simplifiée' or joint stock company, locally articulated, supported by public and private partners, established as a private company and managed by 4 different operating companies in charge of:

1. environmental monitoring,
2. performance assessment studies,
3. legal, administrative, financial
4. mechanical/nautical aspects.

To date, 65% of the start investment was from France government and two Regional / Local Authorities; 35% has been charged to several private companies. More details can be found in Annex C.8. Seeneoh – Advisory Committees, extracted from Ref. [6].
The current economic model, i.e. sell SEENEOH services to users who come with their own budget from EU or regional funding, is not resulting successful enough, due to developer scarce budget availability. The plan is to increase public funding, mainly from the EU, to cover their own costs, so that users can access the site without paying any fees. The business model is based on providing power curve assessments as a key aspect for tidal energy.

Site authorisation is in place until 2022. The decision will then be made as to whether to extend the permit for another 7 years or to transform their business and become a real energy producer.

SEEENOH SAS SHARE CAPITAL	in %
ENERGIE DE LA LUNE	40,0%
CERENIS	22,0%
VALOREM	13,0%
SEML RDL	25,0%
TOTAL	100,0%

Figure 16 Seeneoh share capital, Ref. [6]

The **FaBTest** site is administered by Falmouth Harbour Commissioners supported by a steering group with representatives from industry, academia, agencies and other stake holders. The core group has two permanent members, Falmouth Harbour Commissioners (FHC) and the University of Exeter (UoE). The main cost to be covered is the salary of the facility manager.
The initiation of FaBTest was supported by Regional Growth Fund. The site is leased from The Crown Estate and has consent for testing, subject to permits issued by Falmouth Harbour Commissioners. FaBTest aims to diversify its activities into other aspects, mainly from a technical point of view. FaBTest tries to point developers to funding too, e.g. Marinet2, which gives free access to test facility. The primary cost of the facility is the payment of the facility manager, with other costs including maintaining telemetry, developing assets and support staff.

PTEC is majority owned and funded by Perpetuus Energy Limited, in joint venture with the Isle of Wight Council. It is mainly private, with £1m from Isle of Wight Council and a very small proportion from grant funding. Business model will be revised once the project is restarted. Two options are considered:
- to enter into joint ventures with each turbine manufacturer;
- to 'rent' the infrastructure on a long term basis.

FORCE is a private, non-profit corporation administered by a board of directors and staff, aided by independent environmental monitoring and community liaison advisory committees. FORCE has two major roles: host to TISEC developers and steward to the site.
FORCE, in its public available Annual Report 2016, [9], provides some information about the received support, quantified in $36.2M of total public investment. Each participating developer is expected to spend up to $20 million to build and install their project at a berth (comprising several turbines), contribute $1 million towards FORCE's common costs, and support ongoing operations and monitoring. Hence, a total of $203.4M from private investment is expected (projected estimate). Further details are provided in Annex C.6. FORCE– Financial Highlights, extracted from Force Annual Report 2016, [9]

Intellectual Ownership

With regards to intellectual ownership, a non-disclosure agreement is usually signed between the test facility and the developer. Data is generally classified in: open access data, controlled data, and commercial sensitive data. No private data may be stored by any facilities. They use clients data (mainly related to produced electricity) to provide them with monthly reports (SEENEOH) or real-time data (EMEC).
However sharing of data, autonomously measured by the test centre, is strongly encouraged, with a view to strengthening the collaboration between test facilities.
Some of the analysed test facilities are strongly involved in data monitoring too.
For example, environmental monitoring of the area is regularly performed, for the site characterisation, and provided to developers by SEENEOH.
EMEC has conducted extensive environmental monitoring programmes on its sites since its creation, and has also built a numerical model of the waters surrounding the Orkney Islands, including water level, complex tidal currents, wave heights etc.

DMEC also offers environmental monitoring services, and data on environment impact is published and shared with knowledge institutes.
FaBTest has an ocean database with wave buoy data from 2008-2019 and hindcast model data from 1989-2019, constructed using SWAN.

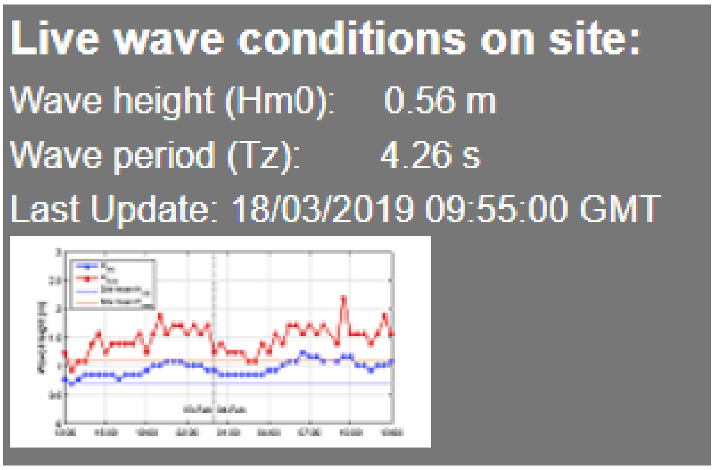


Figure 17 Example of real-time environmental monitoring on Fabtest web site, Ref. [5]

FORCE is also involved in environmental monitoring, i.e. FORCE created the Fundy Advanced Sensor Technology (FAST) program to advance efforts to monitor and characterise the FORCE site. A focus of FAST has been the development of two underwater monitoring platforms, Ref. [4].

Tariff structure

Very little information about prices for the use of the test facilities was shared. Testing a tidal device could cost anything between 0.5 to 10 million euro or more, all inclusive. The use of the test facility is only part of it. Bespoke prices are made per client depending on the requested services. The FORESEA's skill plan report [10], mentions that some services, such as access to site specific data (bathymetry, geomorphology, environmental data), are free at some facilities while paid in other facilities.
An indication of daily price can be deduced from the budgets that MaRINET2 awarded in the past for the number of days of testing in facilities. Note that no distinction is made between labs, tanks or open-see testing and that mainly lab testing is promoted. The awarded budgets for the different calls ranged between 1.1 million and 1.3 million euro for 583 days and nearly 500 days of testing respectively, i.e. ca. 1890 to 2600 euro/day.

2.4.6. Marketing, promotion and strengths

Depending on the test centre characteristics, offered services and budget, marketing and promotion receive specific attention from the different centres.
All the analysed centres are well known in the marine energy sector, nevertheless most of them, especially EMEC, DMEC and SEENEOH, invest a lot of time and effort to communicate their activities and updates on social media. An active promotion is in place via website, twitter, conferences, workshops, international events, organisation of seminars. On the other side, for small centres such as FaBTest, marketing and promotion do not have a prominent role within the centre activities.

Each test facility has its own **highlights and advantages** (further details are given in the overview table, Annex A, under 'Strengths'):
One of the strengths of the sites of **DMEC and SEENEOH** lies in their accessibility. SEENEOH site, located in the Gironde estuary in the city of Bordeaux, can be reached in 10 minutes by SEENEOH's own boat, while DMEC's offshore site is reachable under 2 hours from the international airport Schiphol. **FaBTest** is also easily accessible, being located within Falmouth Port limits, and having use of the University research vessel.

The strength of **FORCE, EMEC and PTEC** lies in the extreme conditions of their sites; as a consequence, these sites are not as easily accessed as the previous mentioned centres, being located quite far from an international airport.

EMEC has a leading role in the sector, being one of the first operative test facilities for tidal and wave energy converters. It runs, and is involved in, many European funded projects. EMEC has an experienced team and can offer about 15 years of experience and collected data to clients. EMEC has an in-house marketing team, which provides marketing support and outreach for EMEC's clients, on behalf of the marine energy industry.

EMEC has been active in promoting international cooperation and has assisted other countries in establishing their own marine energy centres. For example, EMEC established cooperation with the Northwest National Marine Renewable Energy Center (NNMREC), based in Oregon, Washington, and Alaska in the USA, to encourage knowledge exchange and joint research activities. The two organisations originally began working together in 2012, with EMEC providing support on the design, set up and operation of NNMREC's Pacific Marine Energy Center (PMEC) - a grid-connected marine energy test centre proposed for development off the Pacific Northwest coast of the United States. Moreover, it has been recently announced that EMEC will support Qingdao Pilot National Laboratory for Marine Science and Technology (QNLM) to develop the first wave and tidal test centre for marine energy converters (MECs) in China. EMEC has more than 15 years of experience in the design, build and operation of its marine energy test facilities. As a result, EMEC is now exporting its wealth of marine energy knowledge and expertise to assist other countries in establishing their own marine energy centres.

DMEC provides test facilities for tidal devices only, and works in partnership with EMEC in many projects and programmes. DMEC plays a relevant role in the sector: it is an active member of Industry groups, coordinates the MET-CERTIFIED project and created the DMEC Innovation Accelerator. They offer a benign open water offshore test facility with lower tidal flow velocities and are attractive as a partner to receive funding for tests due to their experience in testing. The facility serves as showcase for easy access in the Netherlands and to trial all offshore operations.

PTEC has the potential to be operational during 2021 and is addressing developers at an advanced stage of TRL. It has already put in place major partnerships with global turbine manufacturers, Tocardo Tidal Power BV and SCHOTTEL Hydro GmbH. PTEC will bring together a range of different tidal turbine technologies in one setting, aiming to provide a blueprint for low cost, low risk tidal energy production in the UK. A key objective of PTEC will be to commercially demonstrate the long term running, management and monitoring of arrays of proven tidal devices. PTEC is the step between EMEC and pure commercial. It is the enabler, the springboard to commercialisation.

PTEC has a unique design and business model, perfect for the current requirements of the industry. It is also at an advanced stage of development. Furthermore, the site characteristics are more representative of the majority of global sites than 'extreme' sites such as EMEC and FORCE

SEENEOH has a strong connection to the Aquitaine regional economy. The scientific support is provided by the independent research firm Énergie de la Lune (SAS). A scientific Committee is established and composed by several members, as CEREMA, Université de Bordeaux, IFREMER, IRSTEA. SEENEOH is member of International WaTERS and partner in the INTERREG BlueGift project. SEENEOH test facility has very particular conditions with bi-directional currents in an estuary, it is a sheltered site but with high currents, it is full consented, easy accessible and close to shore, with mooring and grid connection in place. It is a step in between tidal and ocean applications. Testing at SEENEOH helps developers decide which pathway to go: river or ocean tidal energy (or both).

FaBTest is a sheltered test site, well-known in the marine energy sector for providing fast, flexible low-risk and low-cost solutions and located close to port facilities and wharf space. Thanks to its pre-consented status, the application process for deployment on FaBTest is relatively straight forward, which is especially appreciated by developers at an early stage. FaBTest is not connected to the grid by export cables, as it is an unnecessary cost at this TRL stage. Sea-surface infrastructure can monitor and regulate power output.

FORCE is Canada's leading test centre for in-stream tidal energy technology. Thanks to its location in the region of the world's highest tidal range and to its growing base of monitoring and site data, it is ideal for developers with high TRL, up to 9.

2.4.7. HSE

All the test centres consider health, safety and environment as key values. All of them are compliant with both local and international regulations and have a detailed quality system in-place. Further details are given hereafter.

Health and safety is one of the 8 key values of **EMEC**. They provide developers with emergency response procedures and relevant standard operating procedure. EMEC Integrated Management System (IMS) approach is adopted, integrating HSE and Quality Assurance Management. EMEC has produced guidelines for the marine energy industry on H&S too. All testers shall comply with the EMEC procedures and Quality System.

DMEC is in line with local/national and marine regulations, they oblige clients to adhere to permit regulations. Responsibility for or health, safety and environmental issues is deferred to the sub-contractors who work on the sites.

SEENEOH developed a risk prevention plan which is yearly updated, and clients must comply with it. It is continuously supervising the activities and access to the site is via SEENEOH's own boat.

FaBTest defines clear requirements to be fulfilled by the developers in the application process.
The FHC-FaBTest Operating Policy (FHC/FT/102) document is available on the website and provided in Annex C.5. FabTest – Operating Policy 2012. FaBTest, 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 works at the test site and will ensure that any developer wishing to use the FaBTest site will be fully compliant with their responsibilities as defined by the Health and Safety at Work Act (1974), the Marine and Coastal Access Act 2009 and all other pertinent legislation or regulation.

PTEC has all the requirements in place, especially as a tenant of The Crown Estate and as part of their consenting requirements. Further consent compliance and development will continue towards construction and operation.

With regards to **FORCE**, all contractors must adhere to "FORCE Safety and Environmental Expectations" (Ref. [12], Annex C.7. FORCE– Project health, safety and environmental expectations) while users shall adhere to the Nova Scotia "Occupational Health and Safety Act" and "Technical Safety Act". Access Permits (Safety, Onshore Access, Offshore Work) are required and issued on-site by FORCE staffs.

2.4.8. Obstacles, opportunities and lessons learned

LACK OF BUDGET

The main reported frustration is related to developers' lack of budget. All the interviewed test centres reported lack of money and low budget. To overcome this issue, different strategies were put in place by the test sites. For example, EMEC and DMEC are Marinet2 and FORESEA partners.
EMEC has created and leads the €11m FORESEA programme and €12m OCEANDEMO programme specifically to fund open sea testing at its facilities, and partner facilities (DMEC, SmartBay and SEM REV).
DMEC, supports clients with their application to Marinet2/Foresea to receive funding for free access to their site. In particular, DMEC helps to prepare a budget and supports the application under funding programs.
SEENEOH also plans to increase public funding, mainly from EU, to cover their own costs, so that users can access the site without paying any berth or access fees.
Basically, all the test centres desire an **increase of public funding and government support to the marine energy industry, rather for developers than for the test facility itself**. Most of the funding support is intended for the test phase, ex. Marinet2, nevertheless help to the industry should be addressed somewhere else, since the test itself has marginal impact on the total costs sustained by a developer. More specifically, all the interviewed test facilities point out that marine operations are where the greater costs are, so developers would rather spend money there than on testing.
An important lesson gained during this desktop study is that most developers have historically underestimated what is involved in open water testing and marine operations in their design and in their

cost plan, or underestimated the cost, with the consequence of a market getting stuck at pre-commercial phase and with a significant number of failures occurring during marine operations.

Lack of experience of developers

Another reported frustration arises from the **lack of experience** of the marine energy sector. All the test facilities report a **lack of pathway** of the sector.
Leading centres see that most developers get stuck at pre-commercial phase because they cannot compete with offshore wind.
Particularly for the small/early stage developers, it is quite common that all the efforts are focused on the design phase, while costs for testing and for the operations on-site are not initially taken into account. Hence, it may happen that the device is ready, but there is no economical possibility to test it, even though execution and testing is as important as design.

Need for good standards regime

The test facilities emphasise the **need for a good standards regime** for the sector.
The test facility accreditation and the adoption of standards widely recognised by the marine energy industry represent the main expectations for the future of the sector. They are deemed to be the key elements to make the marine energy sector a huge forward step, leading the industry to a more mature level. The expectation is that using standards will improve quality and will help to find insurance and finance. Also, the more the specifications are used, the more they will improve, so continuous development and collaboration will gain more and more importance inside the sector. [7]

The ocean energy industry is now at the stage of only beginning to gain experience and to ensure a repeatable approach. In addition, the high level of uncertainty makes the certification process very complicated for new technologies.
The same consideration applies to standards, with an evident lack of a good standards regime: it is not clear to most developers which **Technical specifications and Standards** to use. There are no 'international standards' yet in tidal energy, although we mention 'technical specifications', which are a precursor to international standards where there is a lack of consensus, as technology has not been tested enough against it.
For tidal energy, 11 international industry guidelines (technical specifications) exist as starting point for the first international standards for marine energy, but have not yet been used very much. After developers/facilities start using it, feedback should be sent to IEC TC114 to improve, but such process is not a common practise yet. The more tests are done and feedback is shared with the team developing the standards, the better the 'standard' will become. The more parties that state that they have started using the 'technical specification', the more likely it is that other parties will use it as well.
DMEC and EMEC are strongly involved in the coordination and cooperation processes between international test centres for the establishment of common global standards.
Bureau Veritas and DNV-GL developed their own rules for Type Certification from their experience in Oil&Gas and maritime industries. While Lloyd's Register has developed guidelines for certification schemes for Technology Qualification. Bureau Veritas, DNV-GL and Lloyds's Register are all part of IEC Technical Committee for marine energy (TC 114) and engaged in developing the conformity assessment scheme for marine energy under the IEC Renewable Energy scheme.

Small/early stage test sites, such as FaBTest and SEENEOH, do not perceive certification and standards as an urgent need, but they aim for a major collaboration among the test centres and see the accreditation of the facility as an opportunity too.

Collaboration with other test facilities

The key word arising from the desktop study is certainly **collaboration**, intended with respect to all the potential stakeholders, i.e. authorities, regulators, public institutions, certification bodies, universities, manufacturers, developers, and especially other test facilities (lab and open marine).

Through knowledge/data sharing, effective communication and analysis of potential impacts of the ocean energy sector, policy makers will be able to define measures in a more informed and effective manner. Sharing the gained knowledge about operations, maintenance, business development and other key aspects of test centres will lead to better standardisation internationally. Furthermore, understanding the capabilities of other wave and tidal testing facilities will help to provide the industry best guidance of where to test their technologies.

EMEC has taken an active lead in trying to improve the coordination between international test centres, notably by the creation of the International Wave and Tidal Energy Research Sites (International WATERS) that seeks to enable test centres to liaise and synchronise activities. EMEC already created programmes for test centres such as FORESEA, OceanDEMO and Blue GIFT. EMEC provides support services to other test sites in terms of procedure and advice too.

The idea of being part of a chain of test facilities at different levels of development (from lab to nearshore, to offshore), which a client can go through, is well perceived by the test facilities. However there are some restraints: there is a lot of time in between the different development steps, it is not a continuous chain in time, and developers like to come back to facilities known to them and had good experiences with.

Similarly for IECRE system to be sustainable, it is paramount to have many partners/users instead of only one, as the current system depends on income from fees from several accredited and paying members.

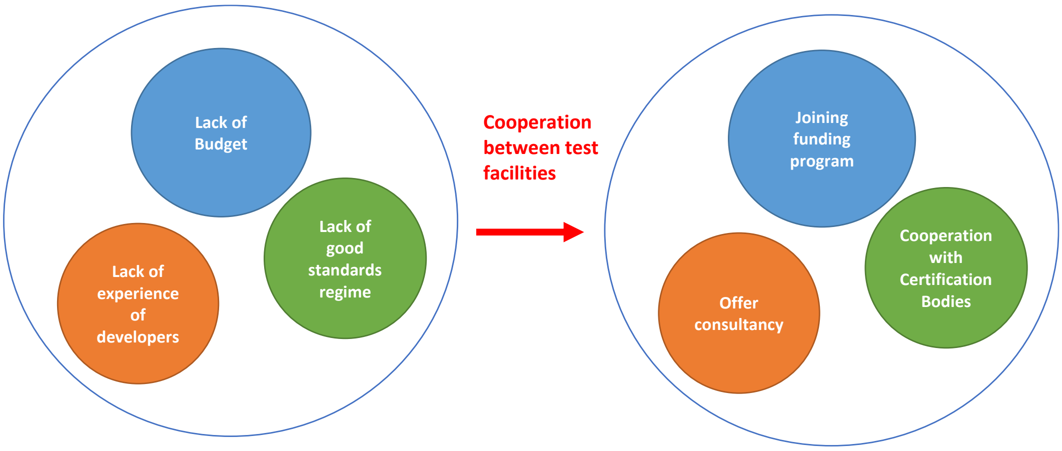


Figure 18 Cooperation between test facilities can convert frustrations in opportunities

Involvement of stakeholders and regulators

Maintaining good relations and keeping the various involved **stakeholders** updated is one of the most recurrent lessons learned shared by the test facilities during this desktop study.

The consenting process took quite some time for all the interviewed test centres, FaBTest and SEENEOH excluded, as per Section 2.4.4. Obtaining the right permits can be a lengthy and expensive process. Therefore it is crucial to try to involve all the different actors, i.e. authorities and stakeholder, at the outset, trying to understand their requirements and their concerns. Good practices include consultation during the Environmental Impact Assessment and organising stakeholder and community engagement exercises during the development of the test facility

For example, FORCE stepped up efforts in 2016 to meet with over 45 different groups, with a focus on fishing and First Nations communities, to understand and overcome concerns about tidal devices impact. It is vital that the broader marine community be engaged regularly and comprehensively during all stages of the project, both to share project-specific information, as well as hear their concerns.

EMEC has invested considerable resources in making the consenting procedure at its site as simple as possible, and as a result helped advance the consenting regime in Scotland in general to the benefit of the Scottish industry.

Also, by keeping close contact and by building relations, regulators can gain confidence in the new technology and be informed of possible (limited) impacts. There is a role for the test facilities to break down possible knowledge barriers between facilities and regulators.

Data monitoring

A further relevant point that came out of the desktop study, is the importance of site **data monitoring** and/or modelling, which is fundamental for a correct definition of the testing conditions, to optimise the layout and design of the facility and to provide device manufacturers with the required data to undertake performance/yield assessments. A desirable outcome would be the establishment of a concerted effort to collect, interpret, and share data related to any environmental effects. While the work done to date has been encouraging, far more needs to be collected. The public and regulators will need convincing evidence that any effects are both known and acceptable if the technology is to move to larger-scale.
Data monitoring resulted in an important part of test centre schedule, to be run in parallel to the standard testing activities, as shown by the experiences of DMEC, FaBTest and SEENEOH (see Section 2.4.5).

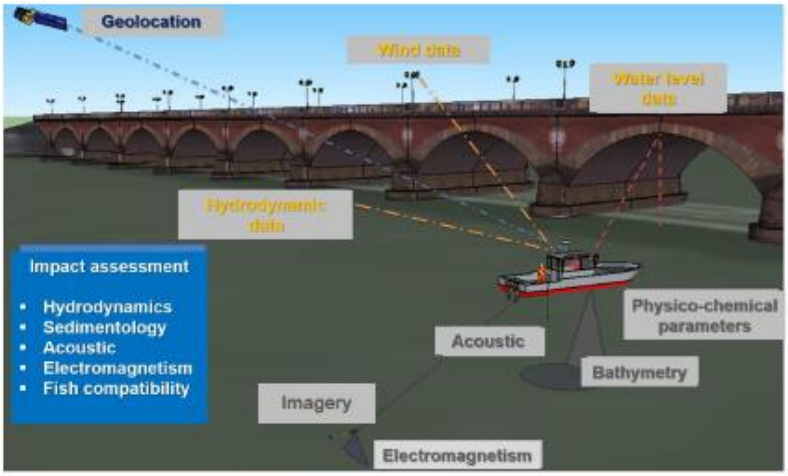


Figure 19 Scientific exploitation from environmental monitoring at Seeneoh site, Ref. [6]

Management

In terms of delivering the infrastructure, a valuable lesson learned is to continuously manage the evolution of the test centre. This should be achieved through careful planning, project management and consciously having one eye on the future to anticipate the needs of the industry.

2.5. Certification and involvement of Certification Bodies

In contrast to the Oil&Gas industry, where many standards and certification exist due to high risks and danger to equipment and personnel, in the Renewable Energy (RE) industry, standardisation is intended rather to make technology viable in specific environmental conditions and to assure that components operate reliably and can be shared. Due to the more performance and reliability-driven standardisation rather than safety-driven, developers in RE seem to be reluctant to involve certification bodies from the beginning and often take the risks themselves.

Nevertheless, certification in ocean RE starts to exist. Clients want to have their technology tested to prove that the equipment is safe and available at all times in specific conditions and meet certain performance levels. In addition, there is a need to have an international recognised and consensus based certification system for developers that want to market their technology internationally. For example, a developer from Japan, who wants to market his technology in Europe and US, does not want to invest in multiple certifications to get a proof of conformity in different countries.
Certification bodies (CBs) have developed 'in-house' protocols and certification schemes, but these are often only nationally valid and have limited acceptance in different countries (e.g. certification schemes of Lloyd' Register are recognised in Canada and UK, but not world-wide).

The IEC (International Electrotechnical Commission) is developing a third party Conformity Assessment System based on International Standards and technical specifications for equipment used in renewable energy (RE). The system aims to facilitate international trade in marine, solar photovoltaic and wind energy by verifying the safety, performance and reliability of equipment and services. The IECRE system, explained in Figure below and extracted from Ref. [7], shows the typical steps taken to reach a type certificate. Both test facilities and CBs are needed to perform the tests and to issue conformity statements. Accredited test facilities perform Type Testing and produce Test Reports and Certification Bodies deliver Type certification by issuing a conformity statement at the end of each certification step. Some steps are optional to reach type certification and based on the client's wishes.

The added value of certification and involving a Certification Body is bringing out issues of concern that were not previously seen. Certification looks into other issues than the technology itself: looking at interfaces with other technology, identifying risks to other technology, or risks of other nearby technology for the development.

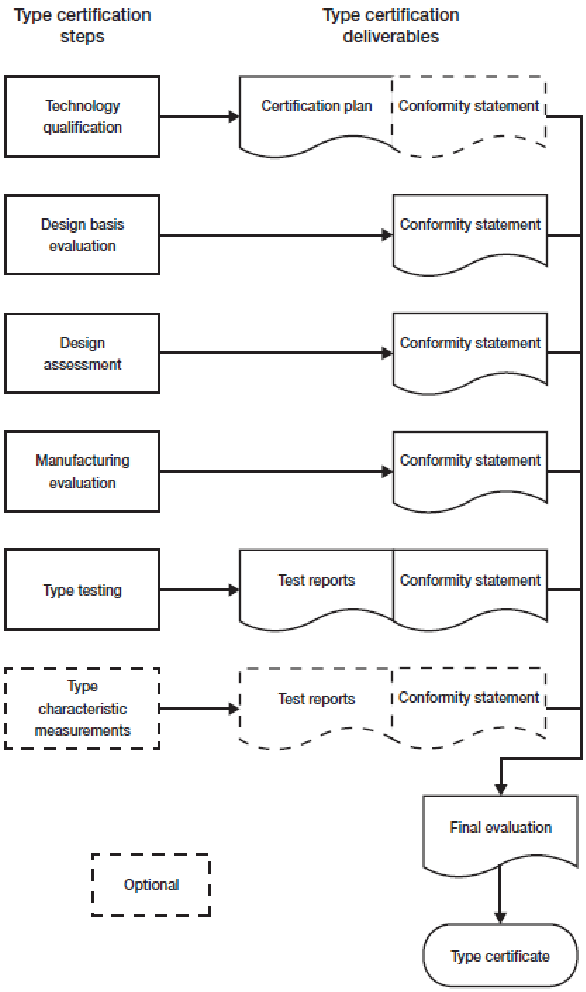


Figure 20 [IECRE Marine Certification Process - Ref. [7]]

Lloyd's Register (LR) has developed guidelines for certification schemes for Technology Qualification (certification of new technology which cannot be certified against an existing standard).

LR follows three stages in the Technology Qualification (TQ) process (very alike the IECRE scheme in Figure 20, Ref. [7]), they encourage clients to start the TQ process at TRL level 2-3 as they know from experience that certain issues are overlooked and will pop up at a later stage:

- Stage 1: TQ workshop and risk analysis, for which LR encourages its client to gather all their experts, not only technical but also business people, to come to the most viable product in the market. The outcome of this stage is a technical and risk assessment report, which lists issues of concerns and recommendations of LR and how they can be implemented;

- Stage 2: based on the report, the client writes a TQ plan (similar to the Certification plan of the IECRE scheme, Ref. [7]) as a roadmap, describing what passes/fails, management of change, etc. The plan is sent to LR who checks if everything is in accordance to their recommendations, when accepted, the client receives a statement of endorsement (similar to the conformity statement of the IECRE scheme, Ref. [7])
- Stage 3: Design basis evaluation & design assessment and final 'Type testing', which is rather a 'technology review' as it is not yet tested against official standards. At the end of this stage, the client receives a Technology Qualification Certificate, stating that the technology is viable in a specific environment under certain conditions.

LR's type approval certification schemes are accepted in Canada and UK coast for marine related equipment, mainly for shipping, not for marine renewable energy.

LR's idea is that what can help to mature and develop wave and tidal energy industry, is not the certification process itself, but rather the research. 'Certification' is, first of all, testing if the equipment meets certain environmental conditions, and secondly, to prove that technology is commercially viable.

Bureau Veritas offers dedicated MRE guidelines: NI 631 Certification Scheme for Marine Renewable Energy Technologies, based on IEC guidelines. The certification scheme covers: floating offshore wind turbines, current and tidal turbines, including sea and river turbines, wave energy converters and ocean thermal energy conversion (OTECs). Certification follows a step process below, according to the maturity of the technology, which has some similarities with IECRE scheme.

- Approval in principle;
- Prototype certification;
- Component and type certification;
- Project certification.

Project certification is related to a specific item, evaluated for the specific external conditions at a specific installation site. For project certification, test centres are not involved, developers contact directly the CB, in order to verify that the device can be installed offshore. It is something common in a pre-commercial phase.

Type certification is often asked by developers; it is related to common design, materials and major components and common manufacturing process, certified according to selected design parameters and conditions. Type certification is also covered by IECRE scheme and it can be related to test facilities activity. BV is contacted for Type Certification of devices, get approval principle, check if device is suitable to install offshore and provides design review. Similarly for ocean energy, clients are starting to ask for type certification as past research and R&D is starting to pay off.

BV reported a lack of internationally recognised standards too: IEC developed technical specifications, not standards. BV developed its own rules for Type Certification from their experience in Oil&Gas industry inspired by IEC.
BV lets the client decide if they want BV's own protocols or the international IECRE. BV recognises that IECRE has several advantages, when comparing the technology internationally and the reciprocal acceptance of the system (see Ref. [7]) is a key factor.

Developers are still not confident about using standards. It is not clear if IEC will become the most recognised International Standard or a Certification Body will take the lead, as for example DNV-GL in offshore oil & gas. For the time being, the adoption of one or the other, IEC or CB protocols, depends on the developer's needs/requests only.

As pointed out by LR as well, standardisation and certification will help increase the confidence of investors and insurers in the ocean energy technology, but will always follow the developments and not lead; to get the industry more mature, strong commitment on R&D is required.

BV has an on-going partnership with SEENEOH for the power curve certification, see Section 2.4.2. BV developed specific protocols based on IEC TC114 for tidal power curve certification in order to adapt these for the particular area of the SEENEOH site.
The procedure followed by BV when SEENEOH has a client who asks for a certified power curve is:

- first an instrumentation check,
- then data collection;
- and finally power curve verification.

Certification for power curves is done at a later stage of development, as the power curve changes when the device is modified, so the certification would not be valid anymore.

Test facilities are not seen as competitor by BV, but as potential partner, and several advises were collected during the interview.

- One of the most sensible advantages offered by a test facility is deemed to be the grid connection. With the grid connection in place, even the developer with a vessel available and marine permits already in place, as mentioned in the paragraph above, would prefer to test in a facility rather than offshore.
- It can be useful to combine the testing with other activities, such as hydrogen production. As detailed in Section 2.4.5, many test facilities are actually integrating in their business model other activities, but mainly limited to data and environmental monitoring. EMEC has integrated hydrogen production facilities and energy system technologies at its tidal test site.
- Increase the collaboration between test facilities, also for the testing activities themselves. For example, a client can test in two different test centres with the same team, so he can check if the resulting power curve is the same when checked following the same technical specification, to get more trust. Then, he is able to go offshore for commercialisation.
- Also, it is suggested to get technology developers involved as part of the working groups on developing standards. Now their experiences are not reflected while they could help to improve the standards.

CEB-BEC (Comité Electrotechnicque Belge - Belgisch Elektrotechnisch Comité) is a neutral and independent standardisation platform for electrotechnics and electronics in Belgium. It is the Belgian national body for IEC-membership and as such represents the Belgian industry towards IEC. Both ISO and IEC make standards. If a test site wants to become accredited, the application must be submitted via CEB-BEC, by requesting membership.

The dormant membership of Belgium in IEC TC-114 was recently activated, and prior to this, no requests had been received from Belgian industry.

The advantages of using the IECRE scheme and being part of the IEC working groups were discussed in detail.

- Certification is internationally recognised. Although also reputable Certification Bodies, e.g. BV and LR, with their international offices and network, can make sure that the certification is internationally recognised, thanks to their internal tests and rules (e.g. certain LR protocols are accepted in Canada and UK). Also, a CB can do this at a reduced cost instead of using the IECRE. Nevertheless, for developers who want to sell worldwide and who have limited international connections, IECRE is worth working with, as it will save costs and time.
- By engaging in IECRE working groups there is a sensitive gain in terms of international visibility too, such that it is easier to attract players from abroad;
- Collaboration with IECRE gives the possibility to a developer to be aware of the evolution of the market and the standards which will be published and reach the market in advance (usually developing a standard requires 3 years).

The advantages of certification were reiterated too:

- Easier to get technology insured;
- Proves that it is the latest state of the art;

- Part of network with other equipment, makes sure that it interconnects (e.g. USB fits all PCs worldwide).

3. Best practices in other sectors

3.1. Context and case study selection

In order to complement the previous analyses of the open water test facilities from the marine energy sector, other sectors' test facilities are analysed in this chapter, to collect best practices and lessons learned from these other sectors as well. The following chapter first provides an overview of the sectors and test facilities selected for this study, followed by the five case studies in Sections 3.2-3.6.

Based on a long list of potential sectors and cases, five cases have been selected for detailed analysis. The following criteria were taken into account to ensure the relevance of the case studies:

- High quality innovation
- Initial investment costs are high
- Testing in phases (TRL's)
- Operational conditions difficult to control
- Disruptive technology
- Public support needed
- Testing/ certification comparable to test centres from MET-certified project (type testing stage)
- Representation of different sectors, site conditions and stages of development
- Available information and/or contacts

Based on these criteria, five sectors have been identified that best meet these requirements (although not all criteria may apply to all cases). The table below provides an overview of the five case studies.

Sector	Test facility	Description
Seaweed production	ECN/TNO Seaweed processing laboratory	Pilot seaweed processing laboratory that can produce the raw materials for fuels, sustainable plastics, textiles, sweeteners, antioxidants and minerals. They bring together different parties and transfer know-how to businesses so they can innovate with seaweed.
Space	NLR Netherlands Aerospace Centre	NLR is a technical research institute that offers a wide range of testing facilities that are relevant to the space, civil aviation and military aviation sectors. They cover the support of the entire development chain, from concept development to qualification.
Automotive	Helmond Automotive Campus	The Helmond Automotive Campus houses various mobility test facilities as well as research laboratories, offering the opportunity to use modern test and research facilities to research new smart mobility and green mobility technologies.
Smart grids	Smart Grid Test Centre ACRRES	The need to develop electricity grids and systems than can cope with the fluctuations in renewable energy generation lead to the development of the smart grid test centre in the Application Centre for Renewable Resources (ACRRES). This test centre with an semi-off grid network can be used for testing new concepts to discharge renewable energy in a more efficient and cost-effective way to the national grid.
Wind energy	OWI-lab	The 'Offshore Wind Infrastructure Application Lab' (OWI-Lab) is a R&D initiative which aims to initiate and support innovation projects concerning offshore wind energy. The project itself aims to increase the reliability and efficiency of offshore wind farms by investing in

		testing and monitoring equipment that can help the industry in reaching these goals.

The five cases have been analysed in detail by means of desk research and interviews. Desk research focused on gaining a broad understanding of testing and standardisation within the sector and identifying relevant information on the test facilities and their ongoing projects. Subsequently, interviews with test facility owners or managers and sometimes other relevant stakeholders or experts on the subjects were performed.

The case study analysis focuses on:

- Evolution in used business models and ownership structures
- Offered services and evolution over time
- Testing to commercialisation in the sector
- Role in development of standards for the sector
- Evolution and added value of accreditation
- Role in life cycle testing
- Conclusions and lessons learned

3.2. Case study Seaweed production

3.2.1. Context of the sector

Although several Asian countries like China, Japan and Korea have been cultivating seaweed for centuries, within the EU cultivated seaweed production is a relatively new sector. *Seaweed* is an important resource for food and feed ingredients, biochemicals and the *production* of biofuels. It is regarded as a promising resource for the energy transition, bio-based economy and as alternative protein source for meat.

Seaweed farming

In the Netherlands, the first seaweed farming test location the 'Wierderij'[1] was opened in 2011 in the sheltered waters of the Oosterschelde. Researchers are using this site to test the performance of several seaweed species and different materials for the seaweed to grow on. A second initiative called 'Noordzeeboerderij'[2] has two test sites approximately 15 km off the coast, one near Texel and one near Scheveningen. In addition to their research activities, they aim to promote and accelerate seaweed production in the Netherlands by functioning as a platform for the sector. A third initiative is the commercial seaweed farm run by a company called 'ZeeWaar'[3], which has a small scale sheltered location in the Jacobahaven in the Oosterschelde. They have developed a line of products, including the Dutch Weedburger[4] that uses their seaweed as one of the ingredients.[5]

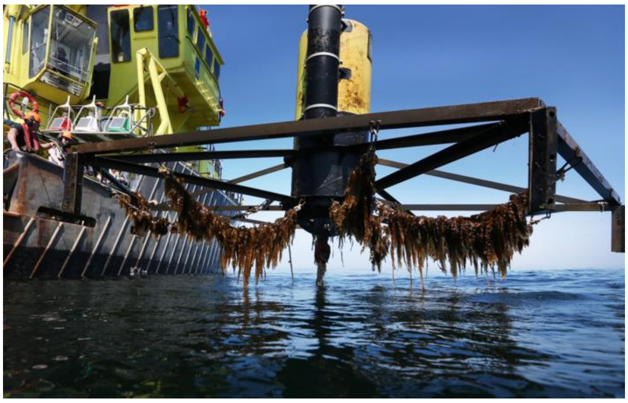


Figure 21 Seaweed harvesting at the Noordzeeboerderij

Seaweed processing and applications

After harvest and transportation, the seaweed can be used for a wide range of applications. The fresh seaweed can be used for human or animal consumption, or the seaweed can be processed to extract products that can be used in e.g. food, feed, cosmetics and pharmaceuticals, or for the production of energy carriers. Examples of products that can be extracted from seaweeds are agars (gelatine like substance used in e.g. food products), sea weed extracts for cosmetics or platform chemicals for the biochemical industry can be produced by fermentation (e.g. ethanol or succinic acid). The seaweed can also be used for the production of biofuels such as ethanol or butanol.[6]

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1 Wierderij: https://seaweedharvestholland.nl/

2 Noordzeeboerderij: https://www.noordzeeboerderij.nl/

3 ZeeWaar: https://www.zeewaar.nl/

4 Dutch Weedburger: https://dutchweedburger.com/ons-eten/dutch-weed-burger/

5 ECN et al. (2016), North-Sea-Weed-Chain Sustainable seaweed from the North Sea; an exploration of the value chain

6 ECN et al. (2005), Grootschalige teelt van zeewieren in combinatie met offshore windparken in de Noordzee

3.2.2. Test facility: ECN part of TNO seaweed processing lab

In order to meet the growing demand for seaweed research and processing facilities, ECN part of TNO has upgraded its seaweed processing laboratory from bench to pilot scale. The lab can produce the raw materials for fuels, sustainable plastics, textiles, sweeteners, antioxidants and minerals. They bring together different parties and transfer know-how to businesses so they can innovate with seaweed.

FIGURE 22 SEAWEED PROCESSING AT THE ECN PART OF TNO PROCESSING LAB

The Seaweed processing laboratory offers:

- the entire processing chain for the conversion of (fresh) seaweed into products such as carbohydrates, platform chemicals, plant stimulants or proteins;
- characterisation and screening of seaweed composition;
- realistic processing conditions for producing samples so users can carry out relevant product tests;
- the flexibility to perform processing steps separately as well as in sequence;
- a unique combination of extensive seaweed refinery experience and lab infrastructure.[7]

3.2.3. Business model and ownership structure

The processing laboratory was opened only recently in November 2018 and is owned by ECN part of TNO. ECN is the Energy Research Centre of the Netherlands, which has the ambition to accelerate the energy transition. In 2018, ECN merged with TNO (the Netherlands Organisation for Applied Scientific Research) and since then is using the name 'ECN part of TNO'.

ECN part of TNO has strong collaborations with institutes and companies in academic, research and industrial sectors of the Netherlands and Europe, including Stichting Noordzeeboerderij, Wageningen University & Research, Deltares, the Maritime Research Institute of the Netherlands (MARIN), the Royal Netherlands Institute for Sea Research (NIOZ), SIOEN Industries, and Avantium.

The Province of North Holland is helping to fund projects in this field, and support is also being given by the top sectors and the Dutch Ministry of Economic Affairs and Climate (EZK). Early 2017, EZK set up the ProSeaweed programme to further professionalise and scale up seaweed research and development amongst knowledge institutes and businesses. In seaweed chain research, ECN part of TNO has directed itself chiefly towards sustainable energy carriers, while Wageningen UR is looking at seaweed applications in food, feed, raw materials and chemicals. In this collaboration with knowledge institutes, governments and businesses they have formed a seaweed chain that facilitates making more effective use of each other's expertise. This has accelerated development.[8]

The seaweed lab is cooperating in several EU and Dutch research projects:

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[7] ECN: Leaflet Stimulating a biobased economy by optimising the seaweed processing train

[8] TNO: https://www.tno.nl/en/tno-insights/articles/the-seaweed-lab-a-symbiosis-between-knowledge-and-industry/

- MacroFuels aims to produce advanced biofuels, including ethanol, butanol, furanics and biogas, from seaweed or macro-algae. MacroFuels will develop technology for the production of fuels which are suitable as liquid fuels or precursor thereof for the heavy transport and aviation sectors. The seaweed lab will be used for producing sugar syrups from seaweed to be converted into biofuels.

- MACRO CASCADE will prove the concept of the cascading marine macroalgal biorefinery i.e. a production platform that covers the whole technological chain for processing sustainable cultivated macro-algae biomass to highly processed value added products. Algae based products for food, feed, cosmetics, pharmaceutical will be tested and documented for their bio-activities and health properties. The lab will be used to provide essential feedback for developing realistic process schemes.

- PORT4INNOVATION brings together the several Dutch institutions and SMEs to develop new and sustainable biorefining concepts for the production of seaweed and high-value seaweed-derived products in the region of North Holland. The lab will be used to produce samples to perform realistic product tests by our collaborators.

3.2.4. Commercialisation of the sector

The seaweed sector is still relatively new in Europe and working towards standardisation and commercialisation. There has been considerable European research effort on the development of a seaweed value chain including support structures the past years. Examples are found on low TRL projects like European projects AT~SEA and Mermaid. Local initiatives are mostly pilot testing sites, but also small scale commercial production for food or medical applications. Biofuel production from seaweed is still in early stages of testing, and not currently being commercially produced.

The European Committee for Standardization (CEN) is currently working on the development of standards for aquatic biomass, which includes seaweed (technical committee 454). This will focus on specification, classification, terminology and determination methods for algae and algae-based products. In addition, guidance on the specific application of algae products as feedstock or intermediates for energy and non-energy products may be developed.[9] The first year of this process has focused on what needs for standards currently exist, e.g. a standardised method for measuring the content of one kg of seaweed (in terms of energy or fat content). Standardising such methods can support further development of the market for seaweed.

Another aspect where standardisation or certification may be needed in the future is the seaworthiness of the seaweed cultivation systems. If seaweed cultivation will be executed on a large scale, the seaworthiness of the seaweed infrastructure may need to be guaranteed, in terms of the structures staying in place to prevent accidents with vessels. Especially if the seaweed cultivation will be co-located with offshore wind farms, this will be important.

For seaweed food products there are certifications available in terms of sustainable food production. The ASC/MSC and EU Organic labels are now available to guarantee sustainable cultivation and production of seaweed products. In January 2019, the first seaweed company in the world was certified (euglena co. from Japan) with the ASC/MSC Seaweed Standard. This ASC/MSC Standard puts forward demands for seaweed cultivation and harvesting related to five basic principles: sustaining wild populations, environmental effects, effective management, social responsibility, and community involvement.[10]

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[9] CEN:https://standards.cen.eu/dyn/www/f?p=204:7:0::::FSP_ORG_ID:2278882&cs=1F20FCBCD6123B309AAB0F52C8CDEF169

[10] MSC: https://www.msc.org/nl/media-pers/opinie-en-blogs/2019/01/23/waarom-u-enthousiast-mag-zijn-over-gecertificeerd-zeewier

3.2.5. Conclusions and lessons learned

The seaweed sector is still partially in the phase of pilot testing with novel technologies, but also partially commercialising. Particularly for food applications, seaweed products are commercially available. However, within the EU market, this is only small scale production. The technologies for biofuel production from seaweed are being developed and tested, but are not commercially available at this point.

Standardisation offers the opportunity for the market to further develop, by having agreement on methods for measurement of seaweed content or and determination of the seaweed species. Certification offers the opportunity to market seaweed as a sustainable product, and also could also provide assurance of the safety and seaworthiness aspects in the long term, if the seaweed production will be performed on a large scale. The first step towards standardisation is for the CEN to determine together with the sector for which type of standardisation there is a need. Standardisation and certification offer the opportunity of market growth on the one hand, and (perceived) administrative burden on the other hand.

Close collaboration between companies, research institutions and governments is very beneficial for the development of the seaweed sector. The Dutch seaweed programme brings together the important stakeholders from the sector to further professionalise and scale up the seaweed research and developments. This development aligns well with the government ambitions to reduce carbon footprint in both the energy and food sectors. Individual initiatives such as the Noordzeeboerderij are also taking up a role as a platform for knowledge sharing and storytelling to the general public.

3.3. Case study Space

3.3.1. Context of the sector

Since it is only 50 years ago that the first person landed on the moon, the Space industry is still considered a relatively young sector. Test facilities within the space sector are often operated by research institutes supported by government funding. Certification is not so relevant for the space sector, unlike in the aviation sector, where certification is important guarantee passenger safety. However the Space industry does work with quality standards that the technologies have to meet. Type certification like in the automotive industry (when the type of car is tested and approved, production is unlimited) does not exist in the space sector, where each individual product has to be tested and approved.

3.3.2. Test facility: NLR – Netherlands Aerospace Centre

NLR is a technical research institute focusing on aviation and space. NLR offers a wide range of testing facilities that are relevant to the space, civil aviation and military aviation sectors. They cover the support of the entire development chain, from concept development to qualification. Their services include:

- assisting in the design and development of space systems like satellite, payload or launcher, and subsystems like thermal control systems, electronics or antennas.
- unique capabilities in the area of light-weight composite structures and multi-metal additive manufacturing.
- a wide range of test facilities to test, verify and validate a product. This includes environmental and structural testing, but also wind tunnel testing up to (zero-gravity) flight testing.[11]

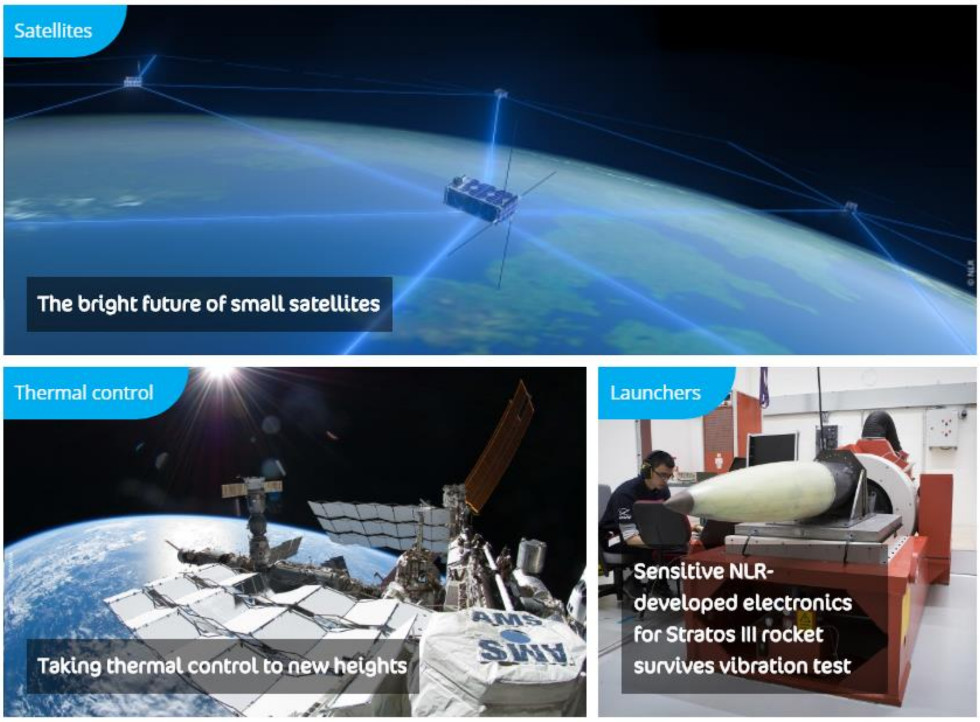

FIGURE 23 VARIOUS NLR TESTING ACTIVITIES

Environmental testing

[11] NLR: https://www.nlr.org/space/

Environmental testing is used to test the equipment in different environmental conditions, to qualify or validate the model or equipment. NLR has over 20 different facilities for environmental testing, covering the following tests:

- Climatic (temperature, humidity, salt spray, fluid contamination, altitude, thermal vacuum, fungus, pressure);
- Mechanical (vibration, shock, acceleration, static load);
- Electric (emi/emc, esd, hirf, lightning);
- Radiation (total dose, proton, heavy ion, californium Cf-252);
- Acoustics (acoustic noise, transmission loss) [12].

Structural testing

Structural testing is used for the testing, inspection or evaluation of materials, coupons, components or full structures. NLR offers inspection, testing, characterisation and failure analysis. They can perform standardised tests, material qualification, tests made fit for purpose, of mechanical and/or environmental nature. The test articles can be made of ceramic, composite and/or metal, and can be small up to full scale. They can help to set up a test plan which satisfies the requirements or use the results to improve the product. [13]

Low gravity flight testing

Low gravity flight testing is used for exposure of the application to in-flight zero or low gravity conditions (e.g. to the Moon or Mars). NLR offers the following facilities and services:

- A modified and instrumented Cessna Citation II research aircraft capable of performing zero or partial gravity flight manoeuvres
- A relatively small aircraft which allows for favourable cost, yet provides enough cabin space for many low gravity applications
- Flight operations that are dedicated to a single customer or project, which allows for:
- Performing of only those parabolic manoeuvres that are required by the customer (saving time and cost)
- Aborting a flight whenever your application requires so (saving flight time)
- Confidentiality and protection of intellectual property rights
- A flight test organisation which offers flexible (re)scheduling of flights and a short time between project request and flight test execution
- A Part 21 based design organisation to support installation of your application onboard our aircraft
- A flexible and affordable flight test facility representing almost one century of experience [14]

3.3.3. Business model and ownership structure

NLR started out as the Government Service for Aeronautical Studies (RSL) in 1919 to increase air safety for military aviation. The rapid emergence of civil aviation, however, caused the RSL to focus on that sector too. In 1937 the RSL was turned into a foundation (the NLL and subsequently the NLR), which created a better basis for conducting scientific research for the national aircraft industry.

The test facilities are owned by NLR, but supported with governmental funding. Because these testing facilities are expensive, it is necessary to have a central testing location like NLR supported by the government. If it would be a profitable business, companies would be exploiting this. But this is currently not the case. For NLR it is also feasible because they are able to make their test facilities available to a wider market that includes space, civil aviation and military aviation.

NLR serves as an intermediary between universities and businesses, as it translates scientific knowledge into technological ideas based upon which the industry can develop concrete and competitive products. NLR also

[12] NLR: https://www.nlr.org/capabilities/environmental-testing/

[13] NLR: https://www.nlr.org/capabilities/structures-testing-and-evaluation/

[14] NLR: https://www.nlr.org/capabilities/low-gravity-flight-testing/

provides materials for policy development by the ministries that are responsible for the safety and environmental aspects of air transport. NLR generates 75% of its turnover from paid contracts from the Netherlands and other countries, from governments to aircraft manufacturers, and from civilian to military clients. Around half of NLR's industrial activities are carried out on behalf of small and medium-sized businesses.

The institute also carries out numerous projects with national and international collaborations, such as European aviation projects regarding e.g. passenger safety or capacity improvements. NLR participates in the European programme Clean Sky for instance, which is focussed on developing breakthrough technologies to increase the environmental performance of airplanes and air transport, contributing to achieving the Single European Sky environmental objectives. NLR works closely together with other research institutes such as TNO, MARIN, ESA (European Space Agency) and the German DLR. [15]

3.3.4. Offered services and accreditation

NLR does not offer certification services themselves, this is done by large certification bodies (e.g. Lloyd's Register). NLR does provide the testing required for certification in the aviation sector, in order to comply with norms for civil or military aviation. These include the following Aerospace standards[16]:

- Military standards - DoD MIL-STD-461 (C to F) and DoD MIL-STD-704 (D)
- Standards environmental testing for the design of avionics electronic hardware in airborne systems - RTCA DO-160 (C to G) and EUROCAE ED-14 (D to G)
- Aircraft specific standards: AIRBUS ABD0100.1.2 (E and G) and Boeing D6-16050-5 Rev. C and D6-16050-4 Rev. D
- Other standards like FCC (Federal Communications Commission), IEC (International Electrotechnical Commission) or DEF-STAN (UK Defence Standard).

The NLR test facilities are accredited by the Dutch Accreditation Council RVA, to demonstrate compliance of NLR with the minimum standards for the testing equipment

3.3.5. Commercialisation of the sector

The first satellites were very much based on trial and error, and since then, standards have been developing constantly. A major role in this development was played by the European Cooperation for Space Standardization (ECSS), an initiative established to develop a coherent, single set of user-friendly standards for all European space activities. The ECSS has a steering board that consists of members from the European Space Agency (ESA). Other voting representatives are members from other Space agencies, e.g. Netherlands Space Office or UK Space Agency.[17] The ultimate goal of building such a standardization system, at European level, is to minimise life-cycle cost, while continually improving the quality, functional integrity, and compatibility of all elements of a space project. For this purpose ECSS develops common standards for project management and for the development and testing of hardware and software.

To reach its goal, ECSS standards have to be known and applied. Therefore the ECSS website is used as a mechanism to promote, disseminate the information, and involve the space community in the development of standards. The website aims to make important information available, including the most recent versions of the standards, procedures, and policies. Furthermore, it is also used to share ideas among the space community:

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[15] NLR: https://www.nlr.org/about-us/customers-and-partners/

[16] NLR: https://www.nlr.org/capabilities/environmental-testing/

[17] European Cooperation for Space Standardization: https://ecss.nl/

using discussion forums to help in prioritising the needs for new standards and improving existing ones, and creating a common understanding and interpretation of standards.[18]

Recently, the active sustainability standards have been developed, aimed at mitigation of space debris. This debris originates from the satellites being sent into space, but are often not cleaned up after use. The new standards will ensure that objects that are launched into space will also be cleaned up afterwards.

3.3.6. Conclusions and lessons learned

The space sector is a relatively young and small sector where certification is not so relevant, but standardisation has matured over the last 50 years. In particular the ECSS played an essential role in the development of coherent standards for European space activities, contributing to lowering life-cycle costs, while improving quality. The initiative also provides a platform for the space community to discuss the interpretation of current standards and the need for new standards.

NLR provides test facilities for the space and aviation industries, including facilities for environmental testing, structural testing and low gravity flight testing. For the space industry, testing is an essential part of production, as type certification like in the automotive industry (when the type of car is tested and approved, production is unlimited) does not exist. In the space sector, each individual product (e.g. every satellite) has to be tested and approved.

Despite this large demand for testing, running a test facility for the space industry is not a profitable business. The sector is small and the testing facilities are expensive. Therefore governmental support is needed for a testing location like NLR. For NLR, this business is also feasible as they are able to make their test facilities available to a wider market that includes space, civil aviation and military aviation.

[18] European Space Agency: https://www.esa.int/Our_Activities/Space_Engineering_Technology/Requirements_and_standards

3.4. Case study Automotive

3.4.1. Context of the sector

The International Automotive Task Force (IATF) is responsible for the certification of the automotive industry and her supply industry[19]. The main quality certification standard in the automotive industry is IATF 16949. This is a document formulated by the IATF containing the quality management standards guaranteeing a safe production of vehicles. The IATF has outsourced the granting of certifications to a large number of certification bodies (41)[20]. These certification bodies operate world-wide certifying the industry. The amount of test facilities in the industry is countless, every car brand has multiple test sites and there are also a large number of independent test sites, including the independent test facilities at the Helmond Automotive Campus. The Helmond Automotive Campus is unique having its own living lab the A270. This is a regular motorway equipped with high-tech that transposes all data to a high-end control room located at the campus. Making use of real-life situations in the living-lab of the motorway A270 makes the Helmond Automotive Campus unique. The Helmond Automotive Campus also contains one of the largest rolling road in Europe[21].

3.4.2. Test facility: Helmond Automotive Campus

The Helmond Automotive Campus houses various mobility test facilities as well as research laboratories. The campus and organization such as TNO, TASS International, VDL, WaterstofNet, Altran, and Rijkswaterstaat have the opportunity to use the modern test and research facilities to research new smart mobility and green mobility technologies[21.]

FIGURE 24 OVERVIEW OF HELMOND AUTOMOTIVE CAMPUS

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[19] https://www.iatfglobaloversight.org/iatf-169492016/about/

[20] https://www.iatfglobaloversight.org/certification-bodies/under-contract/

[21] https://www.automotivecampus.com/en/about-the-campus/test-facilities

The following test facilities are located on the campus:

- Rolling Road Testbench
  With its weight of 800 tons and outskirts of 7 by 22 meters Automotive Campus in Helmond has one of the largest rolling roads of Europe on site. Busses, trailers and trucks up to 30 tons can be tested. The following tests can be conducted:
  - Engine performance tests;
  - Specific speed profile test;
  - Suspension fatigue tests;
  - Fuel consumption tests;
  - Road load simulation;
  - Ambient temperature test.

- European Electric Mobility Centre
  The European Electric Mobility Center (a TNO test facility) focuses on supporting developers and manufacturers of electric vehicles and components. With a wide range of facilities the EEMC provides development, engineering and testing of battery safety & performance and vehicle performance & efficiency[22].

- Powertrain Test Centre
  In the powertrain test centre TNO focuses on control systems that optimize overall system performance of platooning. Platooning is a technology in where vehicles drive cooperatively following each other autonomously on a very short distance with the help of high-tech. TNO's technical developments concentrate on truck and bus applications for city distribution as well as long haul transportation.

- TASS International Testing Site
  TASS offers fully equipped facilities to perform tests on a whole range of automotive applications, both indoor and outdoor. TASS has its own crash sled that can be used for full scale impact testing. This way TASS provides the final and independent verification of your product's compliance against worldwide standards. The TASS safety centre is also accredited to test road furniture like lighting columns and guardrails. TASS International is also fully accredited to assess the performance of Advanced Driver Assistant Systems (ADAS) according to the globally recognised testing procedures.

- TASS uses a combination between computer simulation and physical experiments to validate cooperative and automated driving systems. The testing contains three components: virtual testing (using simulation platform), mixed reality testing (mix between computer simulation and physical testing) and real world testing (road test site). On campus TASS also makes use of the International Mobility Centre facilitates testing, evaluation, and validation of cooperative systems from desktop simulation to indoor laboratory testing as well as outdoor testing on public roads.

- Altran's Test Facilities
  The Altran location at the Automotive Campus offers special automotive engineering expertise in the areas of e-Mobility, ADAS, vehicle armouring and durability testing. The facilities offer testing vehicles under low frequency vibration, high frequency vibration, different climate conditions and testing on potential corrosion. Altran has a final inspection lab in where microscopic research can be done on failure-modes, cracks, tears and malfunctions. The inspections are compliant with the NEN-EN ISO 17025 certification.

- Hydrogen Fuelling Station
  The refuelling station on the Automotive Campus comprise a hydrogen generator (using electrolysis) and consume water and (100% green) electricity generated by wind and solar power. This innovative fuelling

[22] Overzicht test faciliteiten Automotive Campus

station is owned by WaterstofNet and can fuel vehicles 100% green. The fuelling station is one of the first site in the Netherlands to offer H2O as a fuel for private vehicles.

- Traffic Innovation Centre (Ministry I&W)
  The Traffic Innovation Centre is an experimental area where national, regional and local road authorities test intelligent mobility solutions. Experiments occur in real-life-setting: on a real road, in a real network, in live traffic. That way, impact on traffic and traffic management becomes visible immediately.

3.4.3. Business model and ownership structure

The automotive campus has its own governing body (“stichting Automotive Campus”). This administration is chaired by Lex Boon. The idea behind institutionalising the campus was the desire to professionalise the campus structure. This enabled to increase the cooperation between the multiple parties at the campus on land acquisition and create a solid preposition towards the outside world. As the test facility is located near a real motorway, which is unique in the Netherlands, it is attractive for companies that provide or need to carry out tests to settle themselves in this region. Moreover, due to a variety of offered tests, the facility functions as a magnet for companies that are offering test facilities.

The campus is a foundation with multiple participants. The municipality of Helmond, the province of North-Brabant and the real-estate developers Hurks and Van der Ven participate in the campus. Real-estate developer Kadans is present on the automotive campus, however it does not participate in the foundation. The land and real estate ownership on campus is split up amongst multiple parties; the municipality, the province and the real estate developers and also TNO and TASS possess their own real estate. The business model of the participants in the campus is to rent out land and real estate to firms, this is the main source of income. The ownership of the test site is changing with the participants of the foundation (actual campus) acquiring increasingly more land on the conceptual campus. The participants aim to possess all land on campus in order to create one harmonious campus. In being a harmonious campus, the participants invest together in becoming a knowledge-intensive campus in order to attract high-end automotive firms.

The campus receives funding from all layers of the government in order to become a knowledge-intensive campus (from the municipality to the EU). Local and regional government participate in land transaction, but they also fund new technologies/machinery. The Helmond Automotive Campus is very active in attracting EU projects to the campus, where EU funding innovative solutions are tested and implemented on the campus.

3.4.4. Offered services and accreditation

The test facility at the Automotive Campus includes tests that are certified by external companies as well as tests that function as certification procedure itself. The “Rollerbank” is an example of a test that is certified by another organisation. This test is used to measure the power of breaks and maximum speed. This certification is required to assure clients that the outputs of the rollerbank are accurate within certain defined thresholds. Certification of tests is regarded crucial for tests that require certainty regarding outputs. An example of a test that is a part of a certification procedure itself is the “crash test”. The crash test is used to assess whether cars and trucks meet certain safety standards in case of accidents. The crash test will show whether those requirements are met.

Another variant of certification is that developers of tests define their own standards. This method is used by for example knowledge institutes who design both the test and criteria of test. When knowledge institutes are large enough and/or have enough members, the organization is regarded reliable. For those entities, external certification is not required to assure quality outputs of tests.

The automotive campus in Helmond is owned by several parties. The area itself including the motorway belongs to governmental organisations (municipality of Helmond and provincial government of Noord-Brabant). The buildings on the campus are owned by several construction companies. Knowledge institutes and companies which wish to use the test facility own the equipment that they use for testing and may rent or buy buildings from the construction companies to facilitate their testing activities.

FIGURE 25 ROLLERBANK AT HELMOND AUTOMOTIVE CAMPUS

3.4.5. Commercialisation of the sector

The automotive industry came to Helmond in 1975 when Volvo started a production site at what is now called the Helmond Automotive Campus. An important step towards a high-end campus was made with TNO opening a location at the campus in 2003. TNO opened the VEHIL-lab for testing active safety systems. The campus was officially established in 2008 and named Helmond Automotive Campus. When the automotive industry came to Helmond, the industry was already a mature industry. The automotive sector commercialised in the early 1900s and boomed in the 1950s. The sector is thoroughly driven to balance innovation and safety. As a result, the automotive sector has high safety standards, embedded in quality management certification. The International Automotive Task Force (IATF) has created ISO certification in 1999 with the aim to harmonise the different assessment and certification systems worldwide in the supply chain for the automotive sector[19]. The certification was lastly updated in 2016 when the quality standard ISO/TS 16949 was replaced by IATF 16949, decoupling from general ISO 9001 certification, making the certification exclusive for the automotive industry[23].

Parts of the test facilities that are owned by private companies are also open for shared usage. The government in the Netherlands is stimulating shared usage of the test through providing a discount on usage tariff. This is beneficial for both owner of the test facility (through a source of income) as well as for smaller companies who are able to test their products for a reduced price. Every company is able to use the test facility on a booking-basis. Companies may also collaborate to perform a joint test. In those cases, costs are split between the participants on an equal basis. The stimulation of testing leads into higher quality products from Dutch companies and is therefore beneficial for the Netherlands as a whole.

[23] https://www.qualitydigest.com/inside/standards-article/automotive-quality-standard-sees-major-update-031517.html

3.4.6. Conclusions and lessons learned

The automotive campus has learned lessons from certification. The earlier mentioned rollerbank was initially not certified by an external company. Later on, it proved to be necessary to certify the rollerbank as this was demanded by the market. It proved to be difficult and time consuming to adjust the rollerbank into a test facility that met the requirements of the certifying company. The main lesson learned is to identify the necessity of certification of test sites at an early stage. If regarded necessary, the certification criteria can be included in the design phase of the test facility. The main advantage is a reduced chance of making adjustments to meet certification standards. The effect is a more efficient construction and thus a shorter construction and development phase of the test site. This can save both time and money. Another lesson learned is that the integration of several test facilities around one location generate opportunities for cooperation as it becomes an enabling environment for innovation and new ideas.

3.5. Case study Smart grids

3.5.1. Context of the sector

Energy generation in the Netherlands is increasingly shifting from conventional coal and gas fuelled power stations (fossil fuels) to a mix of fossil sources with renewable energy sources from wind turbines and solar panels. An important difference between conventional and renewable energy generation is the fluctuation in energy generation. While conventional fossil fuel driven power plants deliver electricity on a continuous basis, based on a specific demand in time, the renewable energy sources are dependent on local environmental conditions (such as wind speed/availability and hours of sunshine). Both wind and solar energy fluctuate significantly over time both on daily and seasonal level. It is obvious that the fluctuations are not in-line with electricity demand from customers causing issues in matching supply and demand. There is therefore a need to develop electricity grids and systems that can cope with the fluctuations in energy generation and to develop concepts to discharge renewable energy on a more efficient and cost-effective to the Dutch national grid. In this context, the Wageningen University in the Netherlands developed a test centre with an semi-off grid network that can be used for testing new “smart grid” concepts.

3.5.2. Test facility: ACRRES Smart Grid Test Centre

The smart grid test centre is located at the Application Centre for Renewable Resources (ACRRES) in Lelystad, the Netherlands. This test centre is an initiative of the Wageningen University in the Netherlands but is working intensively via partnerships with the private sector and energy companies. While the ACRRES test centre was developed 15 years ago, although the test facility for smart grids was developed 3 – 4 years ago. The concept for developing a smart grid test site was born from market developments and interest from society to increase the share of renewable energy from total energy generation. At the same time, the sector realised that this shift would become challenging for the existing national grid and that solutions are required. In response, this shift stimulated the development of new innovative concepts, smart grids, which need testing prior to (potential) implementation.

FIGURE 26 ACRRES TEST FACILITY

A couple of examples illustrate the kind of test associated with smart grids on the test site are:

- Installation of solar, wind and thermal energy (biogas plant) to a semi-off grid and connect various users (such as loading docks) to assess potential options to create a stable grid from fluctuating and diverse energy sources.
- Connectivity possibilities of various food-related industries to a grid with renewable energy sources.
- Storage of excess energy (during peak production) in freezing, cooling and cooking processes.
- Installation of various battery technologies to store energy in case of peak production and deliver energy to grid during hours with low energy generation to stabilise and control the electricity supply in the grid.

- The ACRRES test centre is not working together with other test centres, as the facility is rather unique in the Netherlands.

3.5.3. Business model and ownership structure

Although the ACRRES test centre is an initiative of the Wageningen University, it collaborates with several private partners via partnerships (these include several battery producing companies, energy companies, food industry). The business model is based on these partnerships. In many cases, the costs for operating the test site are born by EU-funded projects. However, the test site is also funded by governmental resources and own resources from the Wageningen University.

As there is a continuous and large usage demand for the smart grid test facilities, ACRRES maintains a list and an order book for partners who request to use the test facility. It can therefore be concluded that the Wageningen University is responsible for the test site management. Only one company / organisation is able to make use of the smart grid test facility at the same time. Due to the various testing possibilities and variances as mentioned in the examples above, it is not possible to facilitate multiple tests simultaneously.

The outcomes of tests are of relevance for the companies that make use of the test facility. Based on the tests, it can be decided whether new techniques can proceed, are cancelled or adjusted. Wageningen University is using the collected data for research purposes.

3.5.4. Offered services and accreditation

The smart grid test facility is focused on practical research. Due to this characteristic, the site facility is flexible and can be adjusted to meet the requirement of various users. There is no need to develop pre-defined procedures and tests that require certain standards that should be covered in a certification. Thus, ACRRES considers certification of the smart grid test facility not as a requirement. Due to flexibility of the test site, companies have their own specific preferences and, in this stage, are only interested in the functionality of new concepts. In case a new concept proves to be commercially viable (after test results are completed), certification of new techniques and services are arranged by specialised certification companies such as KEMA. However, ACRRES does not cooperate with certifying agencies like KEMA.
However for other innovational tests, ACRRES uses external certification agencies such as Navigant, which are specialised in certification and advice of energy-related innovational tests.
Neither the ACRRES test centre nor the smart grid test facility are accredited. ACRRES mentions that accreditation of test sites is only relevant in case of start-ups from unknown or new companies (unknown to the market). In those cases, accreditation helps to attract interested clients and partners. Since ACRRES is initiated by Wageningen University, there is already trust within the market that the test facilities meet high quality standards.

3.5.5. Commercialization of the sector

The ACRRES test facility is owned by a research organization and is not aiming for profit. The fees associated with usage of test facilities are cost-based and are used to maintain the test site. However, another benefit is that the Wageningen University has access to the collected data which can be used for research purposes.
Due to the shift in conventional electricity generation from fossil sources to a mix with alternative sustainable energy sources, questions are raised regarding the effects of these shifts on the national electricity grid. As such, there was a need for a test centre to assess these effects which is currently intensively used. The demand for this test facility is growing as the shifts towards renewable energy sources is increasing in the Netherlands. The test facility consists of a test-grid and is used for a diverse variety of assignments including, wind energy sector, electricity supplying agencies as well as battery manufacturers (for storage).

3.5.6. Conclusions and lessons learned

The ACRRES test site and the smart grid test facility did not face serious start-up problems. However, during the start-up it was challenging to attract sufficient funding. During the start-up phase of the test site, risks were mapped and addressed accordingly to prevent issues occurring during the operation phase. Firstly, an extensive location exploration was carried out for installing the test site. This was based on the interest of provincial and regional governments. Some provincial governments are sceptic and concerned about site sites, while other governments stimulate innovative test facilities on renewable energy issues. A mapping of these government and political interests was the basis for location selection and helped the test centre to acquire the necessary permits. Moreover, the organization of the test site was embedded within an existing and well respected organisation with the required experience and capacity to organise good implementation of required processes. For example, Wageningen University has in-house experts on environmental legislation which helps to prevent issues with environmental legislation.

3.6. Case study Wind energy

3.6.1. Test facility: OWI-lab

The OWI-Lab test facility on wind energy consists of a climate room where several climatic conditions can be simulated. The climate room can have temperatures from -60 to +60 degrees Celsius and is able to simulate other extreme weather events to test the functioning of (parts) of wind turbines.

FIGURE 27 OWI LAB TESTING FACILITIES

The test facility has a main focus on testing prototypes. As an example, the test facility investigates whether new gear systems and warning light are still functioning under extreme climatologic conditions. However, in some cases (*ad-hoc*), existing parts of wind turbines are tested in the climate room as well. This may occur when some parts are facing difficulties during operation and the test facility is used to investigate the modes and causes of the failure. In general, the test facility is testing equipment in the range of TRL 6 – 9 level although occasionally TRL 3 equipment is tested as well.
The duration of tests varies from client to client. However, in most cases the tests last from a couple of days to two months. Long-duration tests of multiple months are not done due to extensive costs.
The test facility is not focussed on life-time tests, such as corrosion of materials. In potential, the test facility is capable of doing certain tests, however it is too expensive for this relative young market.

OWI-Lab is cooperating with Belgian Universities including the University of Gent and Antwerp. The cooperation is a win-win situation as these organisations strengthen each other with their specialised capacities and testing facilities. For example, Antwerp University has a smaller climate room than OWI-Lab and is thus cheaper in operation. This climate room can be used during testing of small equipment by OWI-Lab. On the other hand, OWI-Lab can assist Antwerp in business intelligence which is limited at the University.

3.6.2. Business model and ownership structure

OWI-Lab is a privately owned research facility by SIRRIS. It functions on a similar way as TNO in the Netherlands. During the start-up phase, the test facility received a subsidy from the government. Currently, the test facility has industrial members who are paying an annual contribution. As such, the test facility must be available for the industry.

The driving factor for developing the test facility came from the wind industry itself. Two large wind energy companies active in Belgium felt the need of having a test facility for testing equipment and parts of wind turbines in a climate room. As such, there was a market momentum to develop this test facility. During the years, the test facility was able to build a track-record by carrying out test which helped to attract new clients.

The test facility is evolving in time as new market requirements arise. For example, the market required the testing of icing (for wind turbines in extreme cold climates) which is now included as a test in the climate room. The climate room can also be used for testing equipment from other sectors such as from the oil- and gas industry and solar energy.

In some cases, the test are carried out by personnel from SIRRIS itself. However, large companies usually have their own staff which can carry out tests and prefer this option. Both cases are applied.
Companies that wish to make use of the test facility are required to pay a usage tariff. As SIRRIS is a non-for-profit organisation, the tariff only includes the operational costs of the test facility.
The order book of the test facility is volatile. Some periods are fully booked, while at other periods in time the test facility is not used. In general, the target for using the test facility is 70% over a year.

3.6.3. Commercialisation of the sector

The commercialisation of the test facility came mainly through a market demand for testing wind turbine equipment. Later, through building a track record and open acquisition, SIRRIS was able to expand their client base and tests.
Certification and accreditation did not play a major role in the commercialisation of the test facility. However, as the sector matures, it becomes increasingly important (for e.g. insurance reasons). Certification and accreditation is considered more relevant for sectors that deal with safety issues such as the automotive sector.

3.6.4. Conclusions and lessons learned

- The tests are done a short basis. Failures that may arise on long-term usage still are not fully understood yet.
- Most of the equipment is still in the warranty phase. As a result, data sharing is limited and should be improved. For the tidal energy sector there is already a significant amount of data. It is important that this data will be shared.
- OWI-Lab may be interested to cooperate with the MET-Certified project. Involvement in workshops to explore cooperation opportunities.

4. Strategic recommendations for future development open water test facilities

4.1. General recommendations

Ocean energy will play a part in the global energy transition in the medium to long term.
“Key actors in the sector need to engage with technologies and with each other over the coming years and there are indications that this is happening in countries with an active role in ocean energy development. ‘..it is worth restating that Ocean Energy development is taking place because there is an urgent need to replace fossil fuel as a source of electricity generation, the oceans contain a massive source of potential energy, and that the development and deployment of the technologies associated with ocean energy, will support and synergise with wider moves to harness and protect ocean resources.”[13]

Marine energy is a sector with significant long-term potential but not operating at commercial scale for some time to come, several obstacles stand in the way of its development to full potential. Indeed, ocean energy technologies are still in an early demonstration phase of single units, largely involving short to medium-duration testing deployments (few months to few years), with only a few prototypes demonstrating a route towards the commercialisation phase. Research efforts and funding are spread over many different wave and marine current energy concepts, and there is no clear technology convergence, in contrast to wind energy. Investment costs are high, and the cost of energy is high compared to conventional and other renewable energy grid-scale power generation.
Game-changing technological breakthroughs, however, could lead to rapid increases in gigawatt capacity thereafter.
In this respect, test facilities can play a very important role [14], in terms of:

- Connecting with organisations and individuals working in the marine energy sector to accelerate development and enhance economic and environmental outcomes;
- Educating people globally on the nature of marine energy systems, the current status on development and deployment, and the beneficial impacts of such systems, improve skills and enhance research;
- Motivating governments, agencies, corporate and individuals to become involved with the development and deployment of marine energy systems;
- Facilitating research, development and deployment of ocean energy systems in a manner that is beneficial for the environment and provides an economic return for those involved.

In parallel with the study at hand, another questionnaire was launched querying the offshore energy market and their interest in wave and tidal energy, how they see the added value of test facilities, where the industry can use help from the test facilities. It is recommended to include the results of that questionnaire with this study to refine the strategic recommendations.

4.2. Market and Business models

4.2.1. Market

The market for test facilities could be restricted in the initial phases of development, however there is always potential to grow subject to a long term development strategy. Apart from testing services, the non-utility scale markets (i.e. autonomous power application, niche markets) provide an opportunity for marine energy, because of the different value proposition. This includes applications such as providing autonomous power to aquaculture farms, oil & gas infrastructure, desalination (power to drinking water) or powering islands or remote sensor and data monitoring equipment. There are also opportunities to couple marine energy with storage and energy systems to provide stable power, (mini) grid services, or renewable fuels such as hydrogen.

Within the other sectors studied in the case studies, expanding to a wider market was identified as a successful strategy. For example, for NLR it is feasible to run expensive aerospace test facilities amongst others, as they are able to make their test facilities available to a wide market that includes space, civil aviation and military aviation.

In certain cases, a combination of services has proven successful at improving the success rate of testing facilities, leveraging private capital, and catalysing on public-private partnerships. Some marine centres are developing commercial income not only from testing facilities but also from additional services like providing technical and commercial support, offering monitoring of environmental impact and acting as consultant. Having strong national experience allows testing facilities to expand their business opportunities to international markets.

Collaboration of testing facilities at national and international levels offers stronger opportunities for the private sector to engage in collaborative research and development, user facilities, and other technical assistance across the national borders.

EMEC has been active in promoting international cooperation and has assisted other countries in establishing their own marine energy centres. Expanding market opportunities through cooperation of test facilities at international level could be further developed. Table 1 presents some of blue energy test facilities that could be potential partners for cooperation. It is of particular interest that there are several test facilities under development in South Korea and China.

TABLE 1 BLUE ENERGY TEST FACILITIES OF DIFFERENT COUNTRIES

Country	Type of facilities			
		Wind	Wave	Tidal
China	National Ocean Technology Center (NOTC)		✓	✓
	China Three Gorges Corporation (CTGC)		✓	
	Guangzhou Institute of Energy Conversion			✓
	CGN Rudong Demonstration Offshore Wind Farm	✓		
	Qingdao Pilot National Laboratory for Marine Science and Technology (QNLM) (under development)		✓	
	National Small Scale Test Site in Weihai, Shandong (under development)		✓	
	Tidal Current Energy Test and Demonstration Site in Zhoushan, Zhejiang (under development)			✓
	Wave Energy Test And Demonstration Site in Wanshan, Guangdong		✓	
Canada	Fundy Ocean Research Centre for Energy (FORCE)			✓
	Wave Energy Research Centre (WERC)		✓	
	Ocean, Coastal and River Engineering Research Centre		✓	✓
	Aquatron Laboratory		✓	
Japan	Awashima	✓	✓	✓
	Kabeshima	✓	✓	
	Kabashima	✓		
	Hisakajima		✓	
	EjimaHirasima		✓	
	Kamaishi	✓		✓
South Korea	Korea Research Institute of Ships & Ocean engineering (KRISO), new facility Jeju Island (under development)		✓	✓
	Korea Institute of Ocean Science and Technology (KIOST), new facility – Uldolmok (under development)		✓	✓
	Ulsan Metropolitan City	✓		
	Ulsan Metropolitan City – Ulsan floating new demonstration site (under development)	✓		
	Aquanet Power		✓	
	National Taiwan University			✓

Taiwan	National Cheng Kung University, Tainan Hydraulics Laboratory	✓	✓	✓
USA	U.S. Navy's Wave Energy			✓
	OTEC Test Site			✓
	Southeast National Marine Renewable Energy Center (SNMREC)		✓	
	Field Research Facility (FRF)		✓	✓
	Jennette's Pier Wave Energy Test Facility			✓
	Center for Ocean Renewable Energy (CORE)		✓	✓
	Bourne Tidal Test Site (BTTS)		✓	
	UMaine Deepwater Offshore Wind Test Site	✓		✓

The global market for offshore testing services at international level is only emerging but shall not be ignored. There are countries around the world that are interested to open and further develop existing marine testing centres in order to accommodate a growing pipeline of marine technology projects.

Review of best practises show that collaboration with prospective clients through MARINET2, FORESEA, OCEANDEMO and other programmes that provide funding for testing could be beneficial. Establishment of similar funding programmes at international level could help in expanding cooperation of European test facilities and partner organisations from countries beyond Europe.

The following factors will influence the ability of test facilities to outreach and establish cooperation with technology developers and partner test centres from global market: marketing efforts, number of sales professionals, various distribution channels, and the ability to disrupt a market with dramatically better services and products.

Subject to resource availability, test facilities could use different tools to inform markets about their capabilities including training sessions, branding toolkits, study visits, newsletters, innovation clubs, matchmaking missions, and B2B events.

Speed of technological development of marine technologies would also play an important role on the opening of new market opportunities for testing facilities. Further reducing cost of blue energy technologies would open up the market for large scale commercial projects in the future. Continued technological innovation will be needed in the future to achieve a successful clean energy transition. Test facilities are well positioned to assist in innovation process aiming to address full life cycle, including demonstration, deployment and commercialisation. Delivering the innovations needed for the clean energy transition will require increased, intensive, focused and coordinated action by national governments, international actors and the private sector.

4.2.1. Business model and services

The study has shown that the business models of testing facilities have been evolving over the time. The existing services range from simply providing access to testing facilities to providing a whole range of support services including support for software and hardware development, and the scale-up from prototype to commercial scale through manufacturing partnerships and services. The successful business model of a test facility shall address the needs of clients from an early R&D development phase through testing to final launch of the product to the market. The below Figure 28 represents a typical value chain from R&D efforts up to commercial deployment with different challenges and recommendations for specific project phases.

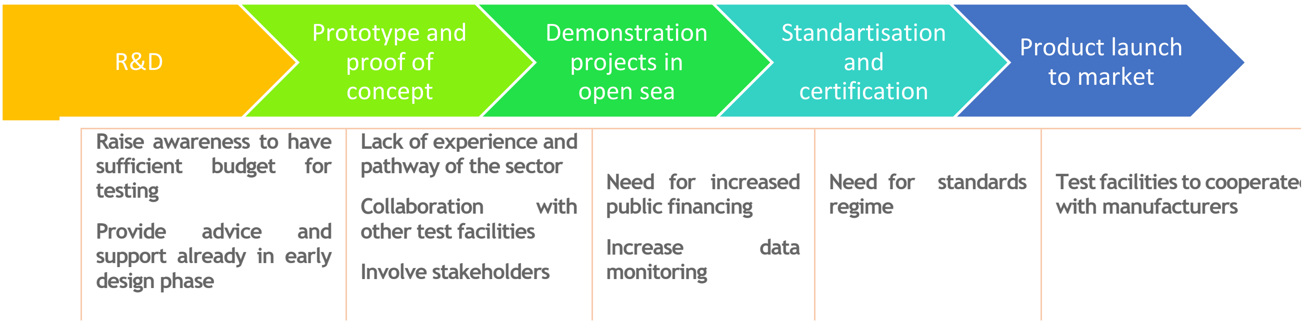

Figure 28 Typical project value chain and its challenges

Within the other sectors that were explored in this study, services cover various parts of the chain. For example, NLR can cover the support of the entire development chain, from concept development to qualification. One of their services is also to help set up a test plan which satisfies relevant requirements or to use the results to improve the product.

It is reported that prototype testing is not always planned by project developers but it is essential to gather critical performance data, address technical challenges, lower costs, and improve technological solutions to accelerate the commercialisation and deployment of renewable energy technologies. While the need for demonstration projects is increasing across the markets, there is less demand for standardisation and certification services which are widely accepted in offshore wind, although less in demand by wave and tidal technology developers.

Testing facilities could have different ownership structures including non-profit, for-profit, corporate, university, and state-led centres. The conducted review has shown that usually test facilities need a significant early state funding support and they could be fully or partially owned by a state. Once the major facility is established its operations and further development could be based on a combination of the EU, states and private sector funds. The ownership structure could also change over the time.

In the other sectors studied, various ownership structures and business models were identified. The Helmond Automotive Campus is a foundation existing of multiple participants, including local governments and real estate companies. Their business model is based on renting out land or real estate to companies who want to be part of the campus. The ACRRES test centre for renewable energy collaborates with several private partners via partnerships (including several battery producing companies, energy companies, food industry). The OWI-lab has industrial members who are paying an annual amount to be able to use the test facilities. Additionally, all test facilities studied in the other sectors were in one way or another supported by government funding, ranging from local or regional government support to funding via EU projects.

Particularly in the marine industry, the pre-permitted sites are the best way to effectively address the needs of industry and allow project developers to save time and focus on the technological challenges instead of tackling complex permitting and regulatory matters. The most advanced test facilities provide access to grid-connection where researchers and project developers can test full-scale energy conversion device concepts. Assistance and reports provided by testing facilities can help secure future finance and investment to move technology towards commercialisation, aiding certification and helping to reduce insurance costs too.

In order to develop a specific business model, each testing facility shall define its market positioning. If a testing facility provides services to resolve a potential need not yet expressed by users, the market positioning is category “new” which is mostly related to certification services. If offered services help to improve (e.g. by increasing features, reducing costs), the positioning of testing facility is in the “existing market” category. Interviewed test centres fall into different market positioning but a common trend is to increase capabilities and terms of service and support.

Figure 29 Typical market positioning of test facilities

		Test Facilities Services		
		Existing	Incremental	New
Markets	Testing	*testing, reports*	*data collection*	*data processing*
	Consultancy	*testing methods*	*EIA*	*technology aspects*
	Certification	*methodologies*	*consenting*	*conformity statements*

4.2.2. Recommendations

The study shows that marine test facilities face challenges in securing both public and private financing for early phase projects, especially those with significant technology risk and capital intensity. An early-stage clean energy company may be able to secure funding for initial pilot or bench-scale demonstrations, however, finance for larger scale testing campaign is often available only for proven technologies with a low-risk profile. This gap in commercial-scale financing limits the ability of test facilities to take project developers from TRL 4 to TRL9 and effectively commercialise advanced energy technologies. In order to address the challenge it is recommended to:

- Raise awareness and educate technology developers to foresee sufficient budgets for testing in early design phase.
- Facilitate public investment in new test facilities and simplify permit procedures.
- Unlock new sources of capital and foster more effective investment models to scale innovative clean energy companies.
- Catalyse the formation of long-term marine funds for technology testing and development. Standardisation and certification offer both the opportunity of further market development and the threat of additional administrative work for the companies within the sector.
- Facilitate matchmaking between early-stage companies and potential investors and marine test facilities.
- Address the needs of customers from early R&D development phase followed by marine testing and even assisting to launch developed technology to the market. The business model of a test facility shall be initially positioned towards the specific target market but gradually expanded to serviceable and total available market at an international level.
- Increase the level of service from testing to consultancy and even certification.
- Make test facilities available to a wider market of blue economy sector.

4.3. Best practices and lessons learned

- One specific lesson learned which all open marine test facilities mention is to start on good terms with governments and local stakeholders by informing, educating and communicating transparently. It is vital that the broader marine community is engaged regularly and comprehensively during all stages of the project, both to share project-specific information, as well as hear their concerns.

  In addition, by keeping close contact and building relations, regulators can gain confidence in the new technology and be informed of possible (limited) impacts. There is a role for the test facilities to break down possible knowledge barriers between facilities and regulators. In case of new technologies, regulators often impose very strict measures or thresholds in permit requirements, out of precaution or lack of knowledge, not knowing the potential economic effect (of lengthy permit procedures) on test facilities. Test facilities can help regulators to define reasonable measures (e.g. noise thresholds), based on monitoring results and taking into account economic consequences. Test sites can act as showcases to attract attention, raise awareness, engage stakeholders, promote the industry, get government support, raise finance for clients.

  Also for the other sector cases the good relationships with government and other local stakeholders was described as an important best practice. For example, the seaweed sector is being strongly supported by multiple government bodies, enabling further development of the sector. The Province of North Holland is helping to fund seaweed projects, and support is also being given by the top sectors and the Dutch Ministry of Economic Affairs and Climate (EZK). The ProSeaweed programme was set up by EZK to further professionalise and scale up seaweed research and development amongst knowledge institutes and businesses. Local government support can even provide a motivation for selection of location of the test site, as indicated in the case of the ACRRES test centre.

- Ensure an easy permitting procedure for developers, invest in acquiring a permit for the test facility that covers all types of tests and technologies, i.e. full consented under Rochdale Envelope allows a project description to be broadly defined, within a number of agreed parameters, for the purposes of a consent application. This means that the technologies and alternatives described in an Environmental Impact Assessment (EIA) cover a certain range (e.g. range of sizes and diameters, different types of mooring, range of number of devices and cables, etc.) to make sure that the potential worst case impact is covered and described. So that the potential impact of new technologies of clients falls within the described impacts and mitigating measures. When the test facility is full consented, developers do not require lengthy permit applications and only need to worry about complying with the consent conditions (this is the case for PTEC, SEENEOH, FaBTest). This will lead to faster permitting and saves valuable time and costs for the developers. Note that the use of a Rochdale envelope in an EIA is not allowed in all countries, it is in Belgium and the Netherlands, not in France (in case of offshore wind farms).

  Often developers are only looking for a permitted offshore area where they can freely test their technology on seaworthiness.

  However, note that developers who already have an offshore permit and vessels around (e.g. for an offshore wind farm), will test themselves offshore and don’t need test facilities.

- It was reported that it is quite common that all the efforts of developers are focused on the design phase, while costs for testing and for the operations on-site are not taken into account since the beginning. Hence, it may happen that the device is ready, but there is not the economical possibility to test it. While execution and testing is as important as design.

  Educate technology developers to foresee not only budget for design, but also for testing and for operations on site. Recommend developers to start the technology qualification and risk analysis in an early stage at TRL 2-3 and to gather not only technical expertise but also from business experts, to come to the most viable product on the market. Certification Bodies can play a role in this awareness process.

  What helps is pointing developers to funding to get free access to facilities, mostly including operational costs such as vessels, installation and operations, as the main cost is hiring of vessels and operations at sea. Having own vessels available for deployment and/or access (e.g. SEENEOH) is an added value.

  A specific lesson learned from the automotive sector, is that is important to identify a potential need for certification at an early stage. Helmond Automotive Campus experienced this with their rollerbank test, which was initially not certified by an external company. Later on, it proved to be necessary to certify the rollerbank as this was demanded by the market. It proved to be difficult and time consuming to adjust the rollerbank into a test facility that met the requirements of the certifying company. The main lesson here is to identify the (potential) necessity of certification at an early stage, so that the certification criteria can be included in the design phase of the test facility. This reduces the chance of having to make adjustments later on to meet certification standards, ensuring a more efficient construction and development phase of the test site.

4.4. Potential collaboration between facilities

Each consulted open marine test facility has its own specialism, regional relevance and market positioning. From elementary, fast, low risk and low cost solutions like FabTest for early stage developers in search of a permitted area for launching their technology, over facilities providing grid connections, mooring, assistance and accredited testing like EMEC, to full grown facilities that target manufacturers to commercially demonstrate long term running of proven devices like PTEC. Also, the full range of site conditions is covered: from estuarine conditions, over dam constructions and marine sheltered conditions, to offshore extreme conditions. From water depths of 5 m, over 50 m to test sites with 80 m water depth. From moderate current velocities of 1.4 m/s to extreme values of 5 m/s.

The European Commission, national governments and local authorities have heavily invested in and continue supporting marine test facilities across the EU. Nevertheless, the conducted assessment shows that the marine test facilities face great common challenges in developing new infrastructure and upgrading existing to meet the requirements of the technology developers. Expanding towards the new markets is attractive but requires strong commercial and marketing efforts that are hard to achieve on an individual basis. The development of marine testing industry like many other emerging industries is driven by cross-cutting technologies, creativity and service innovation, and societal challenges such as the need for eco-innovative and resource-efficient solutions. The industry development can particularly benefit from the collaborative opportunities provided by clustering. Close cooperation at EU level is necessary to assist the existing and emerging test facilities in their development.

A structured way to set up the desired collaboration could be realised via the European Cluster Collaboration Platform (ECCP) which is a service facility aiming to provide cluster organisations with modern tools to:

- make efficient use of networking instruments (search/find potential partners and opportunities)
- develop collaboration trans-nationally (within Europe) and internationally (beyond Europe)
- support the emergence of new value chains through cross-sectorial cooperation
- access the latest quality information on cluster development
- improve their performance and increase their – as well as their members' - competitiveness.

Other sectors such as space, aviation and automotive have already taken advantage of the ECCP and established different cooperation clusters. It is high time to marine testing facilities to capitalise lessons learned and take further joint steps towards the market opportunities.

4.4.1. Recommendations

- In this uniqueness of each facility and full coverage of development stages and site conditions lies the potential to form a 'chain' of test facilities which a developer can go through. Adding collaboration with onshore lab test facilities, a client can pass through each stage of technology testing: from lab testing, to nearshore sheltered conditions to offshore extreme conditions. Lessons learned from later stages can already be taken into account in early stages.

  To realise this, close collaboration and coordination between test facilities and guidance of the developers through the process is essential. It was noted that collaboration between facilities can only work if you have real users, to do the effort to keep in touch. Another obstacle that needs to be overcome: there is a lot of time between the different development stages, it is not a continuous chain in time. Developers also like to come back to facilities known to them and had good experiences with. The FORESEA stakeholder requirements survey even mentions that partnerships with other testing facilities is in general the lowest attraction for developers [10].

- Initiatives as International WaTERS, which is an informal network of open-water test centres that cooperate on barriers and bottlenecks, and Marinerg-i, which is developing a plan for an integrated European Research Infrastructure, as an independent legal entity, designed to facilitate the future growth and development of the Offshore Renewable Energy sector, can assist in overcoming these issues.

Another example is the initiative 'France Energies marines', but then on national level which intends to create 'a technological platform for marine renewable energies, acting as a catalyst for partnership-based research and coordinating the setting up of test sites at sea'. A similar set up, but on international level and including also lab test sites might work. Note, however that the initial idea that this centre would also manage all French test sites did not work out for all facilities because of the complexness from an administrative point of view.

A good practice from another sector in this respects, is in the seaweed research chain, in which different parties have taken up different parts of the chain. ECN part of TNO has directed itself mainly towards sustainable energy carriers, while Wageningen UR is looking at seaweed applications in food, feed, raw materials and chemicals. In this collaboration with knowledge institutes, governments and businesses they have formed a seaweed chain that facilitates making more effective use of each other's expertise. This has accelerated development.

- Sharing the gained knowledge about operations, maintenance, business development and other key aspects of test centres will lead to better standardisation internationally. Further, understanding the capabilities of other wave and tidal testing facilities will help to provide the industry on best guidance of where to test their technologies.
- Collaborations with test centres from other marine sectors also provides an interesting opportunity for ocean energy test centres. For example, the offshore wind infrastructure (OWI) Lab may be interested in cooperation.
- Another opportunity to set collaboration could be realised via cluster approach by taking advantage of the ECCP. The marine test facilities could commit to work on a joint cooperation agenda with the aim to support the internationalisation of the European members towards targeted third countries beyond Europe. It is recommended to consider setting up a new collaboration cluster initiative among marine test facilities which could be done as part of the MET-Certified partnership. Having inspiration from other sectors a European Marine Test Cluster (EMTC) could be established and based on following principles:

  Being European, meaning

  - composed of partners, all established in EU Member States and participating in MET-Certified partnership;

  Being Strategic, meaning by

  - developing and implementing a joint marine testing development programme with common goals and fostering complementarities between partners;
  - promoting cooperation across marine testing facilities which support development of blue energy technologies regardless of size and technical capabilities

  Representing EMTC through

  - a new complete profile and regularly information on the Partnership activities on the ECCP platform;

  Forming EMTC with the aim

  - to set-up a partnership agreement engaging the partners to develop common development programme and actions and setting out the modalities of cooperation between them;
  - to develop a roadmap (action plan) for implementation with a long-term cooperation agenda to foster the sustainability of the partnership;

  Working towards going international by

  - developing and implementing a joint marketing strategy for going international beyond Europe; and
  - striving to successfully support the internationalisation of EMTC members towards specific third countries that have great potential for blue energy development and favourable national policies.

Moreover, the MET-Certified partnership could attract funding for a common databased of the EMTC. The purpose of the common digital database platform would be to disseminate data and information concerning the testing methodologies, equipment used public datasets. Having the database, the testing facilities could improve the interoperability of data and associated metadata, through the implementation of specific actions to:

- optimise the information flow among testing facilities
- give access to more user-friendly data
- improve the data representation
- increase the amount of data available for users.

Sharing knowledge and engaging in collaborations between test facilities would strongly help in development of this emerging sector that is fundamental to achieving common renewable energy technologies and greenhouse gas reduction targets, not only in the EU but at a global scale.

4.5. Accreditation and certification

The Belgian standardisation platform for IEC CEB-BEC is confident that in due time, when ocean industry grows, the certification needs will also grow and eventually test houses will generate new income from selling certification services.

Note that there is a major difference between standards in Oil&Gas and Renewable Energy market. In O&G, many standards and certification exist due to high risk and danger for equipment and personal; while in Renewable Energy (RE), the standardisation is more to ensure that technology is able to survive in a specific environment, leading to developers often taking the risks themselves, without involving an accredited test facility or Certification Body.

'Certification' is, first of all, testing to ensure that the equipment meets a certain standard for operating and surviving in the environmental conditions it is designed for, and secondly, to assess its power performance and thus to prove its commercial viability.

From the case studies in other sectors, it was also identified that certification was often related to safety and/or environmental conditions. For example, in the automotive and aviation sectors, certification systems are in place to guarantee passenger safety. Whereas in the space industry certification is much less relevant, since e.g. satellites don't carry any passengers (although quality standards still apply). Standards related to the environment or sustainability appear to be increasingly important in several case study sectors, as many recent developments have taken place in that respect. In the space industry, the active sustainability standards have been developed recently, aimed at mitigation of space debris from satellites being sent into space, but often not cleaned up after use. For seaweed food products, certifications have become available in terms of sustainable food production. The ASC/MSC and EU Organic labels are now available to guarantee sustainable cultivation and production of seaweed products. In January 2019, the first seaweed company in the world was certified (euglena co. from Japan) with the ASC/MSC Seaweed Standard.

Certification Bodies noted that certification always follows the maturing of the industry, and is never the driver. Standardisation and certification help the confidence of investors and insurers, but will always follow the developments and not lead. To get the industry more mature, strong commitment on R&D is required. When the industry is growing and developments are maturing, needs arise to have standards, to make sure components fit, to look at interfaces with other technology, to have technology valid all over the world, than development of certification scheme follows according to these standards. Still, there is a place and reason to have certification in an emerging (not fully mature) market:

1. To reduce uncertainty and risk in higher TRLs, Technology Qualification in early stage (TRL 3-5) is advised
2. For credibility to regulators, investors, project financiers and insurers
3. To demonstrate maturity to governments and utilities
4. To enable export, also of niche-market applications

5. To provide single terminology and (test) methods across the globe

About 10 years ago, one group (IEC TC 114) started developing standards, since 2014 another group (IEC RE) is developing the certification against these standards. There is a call from different countries to have an international recognised and consensus based system that is more widely agreed than in-house standards developed by Certification Bodies.

The IECRE conformity assessment system intends to combine the technical experience of the test facilities and the certification process experience of a Certification Body. Test facilities can perform accredited tests to assess the performance, power quality, acoustics and load in marine energy converters according to technical specifications published by IEC TC 114, while the Certification Body issues a conformity statement after each step of the system.

4.5.1. Recommendations

- In order for Technical Specifications to become standards, they need to be used by many and feedback should flow back to the IEC TC114 project teams and maintenance teams to improve the specifications. When technology has been tested enough against specifications they become 'standard'. The more tests which are carried out, the more robust and accepted the 'standard' will be. It is recommended to have such process of improvement in place (examples: H2020 OPERA project and INTERREG MET-CERTIFIED project).
- Also for the IECRE certification system to be sustainable, it is paramount to have a market of many partners/users. The system depends on income from fees from several accredited and paying members (Test Facilities and Certification Bodies) and clients (technology developers) paying for test reports or conformity statements for their technologies. If there would be only one accredited test facility assisting other facilities to deliver certified Type Testing reports, the IECRE system funding structure for the marine sector would need revision.
- Promote with developers the added value of certification and including a certification body: i.e. bringing out issues of concern that were not seen before. Certification looks into other issues than the technology itself: looking at interfaces with other technology, identifying risks to other technology, or risks of other nearby technology for the development.
- Promote with developers to join the IEC TC114 teams and IECREME OMC working groups to develop technical specifications and certification respectively. Instead of following the standards, developers can act pro-actively and assure their technology becomes the standard. Engaging with IEC TC114 and IECRE increases international visibility, so that it is easier to attract players from abroad. Being member gives the possibility to a developer to be aware of the standards which will be published and reach the market in advance and a view on the evolution of the market.
- Good practices from other sectors in this regard are the seaweed and space industry. Within the seaweed sector the European Committee for Standardization (CEN) is currently working on the development of standards for aquatic biomass, which includes seaweed (technical committee 454). The first year of this process has focused on what needs for standards currently exist, e.g. a standardised method for measuring the content of one kg of seaweed (in terms of energy or fat content). Standardising such methods can support further development of the market for seaweed.

  Within the space industry, a major role in the development of standardisation was played by the European Cooperation for Space Standardization (ECSS), an initiative established to develop a coherent, single set of user-friendly standards for all European space activities. The ECSS website is used as a mechanism to disseminate the most important information and it involves the space community in the development of standards.

4.6. Anticipation of requirements for test facilities in the near future

- Certification of the power curve assessment & design is necessary for commercial and financial purpose. The power curve certification is also fundamental to compare technologies.
- Non-utility scale markets are an increasing opportunity for marine energy. This includes applications like providing power to aquaculture farms, desalination, renewable fuels such as hydrogen or powering islands. Test facilities should be prepared to tackle the challenges of energy storage and needs for stable power.
- In marine spatial planning, the tendency is to encourage multiple-use of available space, by e.g. including wave or tidal energy devices in offshore wind farms. The interaction between devices and foundations needs exploring, e.g. by performing tests in a multi-user environment.
- In offshore wind industry, the tendency exist to go for deep water realisations with floating foundations. However, dynamic cables and mooring are still an issue. The wind industry is also looking for a limited number of 'standard' floating foundations for a number of classes of metocean conditions, instead of having to design site specific foundations as is the case for non-floating offshore windfarms. Marine Test facilities are best suitable to help to mature the floating foundations market as well.

4.7. Recommendations for investments and other opportunities

- An opportunity for testing facilities is to assist project developers from early stage, even design phase providing their expertise in wave and tidal conditions.
- As already mentioned in 4.2.1, in addition to testing services, the non-utility scale markets provide an increasing opportunity for marine energy. This includes applications such as providing power to aquaculture farms, desalination or powering islands. There are opportunities to couple marine energy with storage and energy systems to provide stable power, grid services, or renewable fuels such as hydrogen.
- Facilities can decide to allow developers to have open access to the facilities without the facility itself being too much involved, or they can choose to offer supporting services during operations and even bring the developers to the sites with own vessels. Both approaches exist. As the main cost for the developers is the hiring of vessels for the offshore operations, and the weather standby, investing as facility in having a vessel (available) for operations, will definitely attract developers. Results of the stakeholder requirements survey of FORESEA [11] showed that availability of support vessels and proximity to shipyard are key priority and a must-haves (were ranked first and second resp. in developer's priorities).

  This does not necessarily have to be a facility owned vessel, having an agreement in place with nearby harbour users (e.g. maintenance vessels for offshore windfarms, vessels from harbour authorities) can be a solution.
- In the FORESEA stakeholder requirements survey [11], also 'grid connection' is mentioned by about 70% of the respondents as critical for their deployment, so worthwhile to invest in. Communication cables was the third priority and considered a must-have and very important.
- From the survey [11] was concluded that 'pre-installed anchor points and moorings' were considered not important and even the least important infrastructure requirement for the developers. As testing the dynamic response of WECs and their mooring system is key [15], most likely the reason for not wanting it foreseen, is because mooring and anchor points are considered technology specific and better not pre-installed.

5. Contact details

5.1. Open marine test facilities

Contact - email	Centre	Country	Main References
info@emec.org.uk	EMEC	UK	[1]
info@fabtest.com	FaBTest	UK	[5], [16]
contact form on web site	SEENEOH	France	[8], [6]
info@fundyforce.ca	FORCE	Canada	[4], [9]
office@dutchmarineenergy.com	DMEC	Nederland	[2]
contact form on web site	PTEC	UK	[3]
contact form on web site	BV	France	
contact form on web site	LR	UK	
centraloffice@ceb-bec.be	CEB - BEC	Belgium	

5.2. Other sectors

Case	Organisation	Website
Seaweed	ECN part of TNO	www.tno.nl/en/tno-insights/articles/the-seaweed-lab-a-symbiosis-between-knowledge-and-industry/
Seaweed	Wageningen Economic Research	www.wur.nl/nl/Dossiers/dossier/Dossier-Zeewier.htm
Space	NLR	www.nlr.org
Automotive	Helmond Automotive Campus	www.automotivecampus.com
Smart Grids	ACRRES	www.acrres.nl
Wind	OWI-lab	www.owi-lab.be

6. References

[1] EMEC, "http://www.emec.org.uk/." .
[2] DMEC, "https://www.dutchmarineenergy.com/." .
[3] PTEC, "https://perpetuustidal.com/." .
[4] FORCE, "http://fundyforce.ca/." .
[5] Falmouth Bay Test (FaBTest) Site, "http://fabtest.com/." .
[6] Seeneoh, "Seeneoh Spec Part 1- General Information." 2016.
[7] IECRE, "A guide to conformity assessment for renewable energy test labs in the marine energy sector." Sep-2018.
[8] Seeneoh, "http://seeneoh.com/index.html." .
[9] FORCE, "FORCE Annual Report 2016," 2016.
[10] ECN, "FORESEA'S SKILL PLAN." Interreg -FORESEA, 2018.
[11] ECN, "FORESEA'S INFRASTRUCTURE PLAN." Interreg -FORESEA, 2018.
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[13] OECD (2016), "The Ocean Economy in 2030." OECD Publishing, Paris.
[14] Ocean Energy System, "Ocean Energy System Annual Report 2016," 2016.
[15] R. E. Harris, L. Johanning, and J. Wolfram, "Mooring systems for wave energy converters: a review of design issues and choices," presented at the Marec 2004, 2004.
[16] FaBTest, "FaBTest - Appendix_3_Application_Form." .

7. Glossary

Accreditation	The process in which certification of competency, authority, or credibility is presented. Organizations that issue credentials or certify third parties against official standards are themselves formally accredited by accreditation bodies; hence they are sometimes known as "accredited certification bodies". The accreditation process ensures that their certification practices are acceptable, typically meaning that they are competent to test and certify third parties, behave ethically and employ suitable quality assurance.
ADCP	Acoustic Doppler Current Profiler
Certification	The process or action performed by a Certification Body to attest that specific Renewable Energy equipment was fully evaluated according to a Scheme including the relevant requirements of one or more applicable Standard(s) accepted for use in e.g. the IECRE System.
Compliance	Certification or confirmation that the manufacturer or supplier of a product, meets the requirements of accepted practices or specified standards.
Conformity	If the product, service or system meets the requirements of a standard
Standardisation	The process of implementing and developing technical standards based on the consensus of different parties that include firms, users, interest groups, standards organizations and governments.[1] Standardization can help maximize compatibility, interoperability, safety, repeatability, or quality.
TEC	Tidal Energy Converter
TRL	Technology Readiness Level
WEC	Wave Energy Converter

Annex A Overview table open marine test facilities

General summary

Interview	Contact	Centre	Country	Status (since)	Type of technology	Type of scale targeted	TRL
20/02/2019	info@emec.org.uk	EMEC	UK	Operational (2003)	WEC, TEC, subcomponents	Scaled and full-scale	up to 9
1/03/2019	office@dutchmarineenergy.com	DMEC	Nederland	Operational (2008 / 2015)	TEC	Intermediate and full-scale	6 - 9 at the inshore test site; all TRLs at the offshore test site.
No interview (answers by email on 14/03/2019	contact form on web site	PTEC	UK	Not operational (planned in 2021)	TEC	Full-scale	8 / 9
21/02/2019	info@fabtest.com	FaBTest	UK	Operational (2011)	WEC, TEC	Nursery	6 / 8
21/03/2019	contact form on web site	Seeneoh	France	Operational (2017)	TEC	For full-scale river devices and intermediate-scale ocean devices	4 different areas, for different TRL: - two areas suited for TRL up to 9; - one for TRL up to 4; - one for TRL below 2
No interview (info from web)	contact form on web site	IFREMER	France	Operational (1984)	WEC, TEC	Scaled	No info
No interview (info from web)	info@fundyforce.ca	FORCE	Canada	Operational (2009)	TEC	Scaled and full-scale	9

Site conditions

Centre	Availability of Site Specific Data	Water depth	Avg significant wave heigth	Max significant wave heigth	Current velocity	Distance to shore	Support vessel	Pre installed mooring	Soil type	Communication to shore	Grid connection	Test typical duration	Avg weather downtime for weather condition
EMEC	Free / Paid Access	up to 70 m	2 - 3 m	18 m	up to 4 m/sec	max. 2 km	Available via local supply chain	Available on scale sites	Sand and areas of glacial till (wave), rock (fullscale tidal) and boulders (scale tidal)	Fibre on all full-scale sites, microwave on scale sites from test support buoy able to be sited on scale sites; VHF link available	Existing export cable; 5MW per berth; Substation capacity 35MW	6 - 12 months	For test purposes, standby can last several months, in order to get a favourable weather window for the devices to be attached. For installation of tidal technologies neap tide is awaited
DMEC	Yes, free access	25 m	Not relevant	Not relevant	up to 4.5 m/s (inshore site) and 1.8 m/s (offshore site)	800m from shore	Not planned	Yes	Sand	Wireless	Currently no. The installed export cable broke in 2015, and it has not repaired.	1 - 6 months	No statistic available
PTEC	Yes, several site data avaialble - both raw and analysed data	80 m	Not relevant	Not relevant	Mean spring peak and mean neap peak current speeds around 2.5-2.9 m/s and 1.3-1.6 m/s, respectively.	2.5 km	No info	Yes	Mostly bedrock with occasional cobbles and rock boulders and virtually no mobile surficial sediment	FOC integrated in the power cable	Yes, by dedicated export cables	15 years	Estimated 0.5% of the year – based on expected grid maintenance. Further downtime (of the manufacturers) taken into consideration separately
FaBTest	Yes, wave data from hindcast model constructed using SWAN	from 15m up to 50 m	0.6 m	9 m	up to 1.39 m/sec	4.5 km from Falmouth Harbour entrance, 7.5 km from dock area	Available via local supply chain	No	Rock, gravel and sand	Telemetry, LTE (4G) Mobile, DHF and VHF receiver available	Not planned. all generated power must be consumed on site via a dump load	12 months	For test purposes, a standby can last several months, in order to get the desired weather window
Seeneoh	Yes	Depth at the test area ranges from 5 to 17 meters	Not relevant	Not relevant	max 3.5 m/s > 1 m/s 80% of the time	200m, located upstream on the Gironde estuary	Yes	Yes	Sand and mud	FOC integrated in the power cable	The site is connected to the grid for consumption (36kVA) and injection (250 kVA)	6 - 12 months	No statistic available
IFREMER	Yes. A dedicated project, Datarmor, has been developed. Ifremer's data centre (Sismer) is accreditated by Unesco	No info	No info	No info	No info	No info	No info	No info	No info	No info	No info	No info	No info
FORCE	Yes	from 30m up to 45 m	Not relevant	Not relevant	up to 5 m/sec	< 3 km	Available via local supply chain	No	Sediment-free bedrock sea floor	FOC integrated in the power cable	Four 34.5kV subsea power cables (each 2 to 3 km in length) designed to transfer power to the shore and on to the Nova Scotia electricity grid	No info	No info

Services and Infrastructure

Centre	Available Infrastructure	Access for users	Test facility organisation	Support to monitoring	Operational support	Accreditation	Support to development		
							Independent verification	Support to certification	Resident engineering
EMEC	One scale wave site and one scaled tidal site, both not connected to the grid. The full-scale wave and tidal test sites are connected to shore with electrical cables.	Each tester needs its own specific permit for its technology. Testers shall comply with EMEC procedures and Quality System	Several test locations available, hence several devices can be tested at the same time	Yes	Planning and supervision of marine works and operations; Logistical support	It is accredited to UKAS. It is accredited to ISO/IEC 17020 and offers independent technology verification on marine energy converters and their sub-systems	Accredited to test laboratory standards (ISO17025) enabling the Centre to provide independently-verified performance assessments against IEC Technical Specifications	Test management and liaison with UKAS for certification of off-site testing. EMEC provides Type test reports (i.e. performance assessment test)	Yes, team of 25 people, incl. a metocean data engineer
DMEC	Two test facilities, one integrated in a dam and one offshore berth (400 m offshore), connected by umbilical (currently failed)	Clients test via existing funding programmes such as Marinet2 or FORESEA or OCEANDEMO. There is an access agreement that describes conditions for access and transfer of liabilities	One client at time	Yes	Yes	Not accredited.	DMEC is planning to issue a report according to the IEC TC 114 templates for reporting on resource and performance assessment of tidal stream energy convertors	DMEC works closely with BV, DNV-GL and Lloyd's Register in the MET-Certified project. However, they do not (yet) provide services to commercial clients at their site	Yes, team of 11 people
PTEC	Tidal stream facilities, from grid connection, substation and control room up to subsea cables for long term deployments	The project will be full consented (under a Rochdale Envelope), so turbine manufacturers will only need to worry about complying with the consent conditions	6 berth areas available	Yes	Yes	Not accredited.	By third parties, for example EMEC	Not at the current time – only initial conversations with risk/insurance providers and as part of the MET-CERT project	No info
FaBTest	3 berths and 4 wave buoys available. No cable connection to shore, power output is measured by the buoys.	Every tester needs its own permit issued by Falmouth Harbour Commissioners and Marine License from Marine Management Organisation. Testers shall fill an application form	Three berths, hence it allows for up to three devices to be deployed concurrently	Yes, by the OREG, UoEx	Operational support provided by the OREG, UoEx	Not accredited.	Developers must provide independent verification by suitably qualified individual or organisation to the FaBTest regulatory panel	No. FaBTest can provide type test reports, if required by the clients	Yes: Offshore Renewable Energy Group (OREG, UoEx)
Seeneoh	3 locations for tidal devices or floating tidal devices, all grid connected and equipped with moorings, generating platform if required.	Application procedure on the website. User do not have to apply for permits, everything is already in place	Applications are processed in a logic of First In First Out (FIFO)	Yes	Yes	Not accredited.	N.A.	Power performance certification by Bureau Veritas, outcome of a collaboration between Seeneoh and DNV	Yes, performed by scientific partners, mainly Energie de la Lune
IFREMER	No info	No info	No info	Yes	Yes	Accreditated to ISO 9001 and ISO 20000. Sismer, Ifremer data centre, is accredited by Unesco IODE (one of 6 centres worldwide)	Offers testing under protocols that comply with IEC certification	No info	Yes
FORCE	The turbine "berths" are supported by four 34.5kV subsea power cables (each 2 to 3 km in length) designed to transfer power to the Nova Scotia electricity grid	All contractors must adhere to "FORCE Safety and Environmental Expectations". Access Permits (Safety, Onshore Access, Offshore Work) required and issued on-site by FORCE staffs	No info	Yes	Yes	Environmental assessed under a joint federal – provincial Environmental Assessment (EA) review process	No info	No info	No info

Management

Centre	Ownership and coordination	Business model	Policy	Legal issues / Permitting	Intellectual ownership	Promotion / Collaborations	Safety & environmental issues (HSE)
EMEC	No profit, private company, limited by guarantee	Historically, EMEC started with 100% public funding. Now about 50/50 between public and private funding	Lack of UK government support, more focused on offshore wind or nuclear	No info	EMEC does not collect any data from developers test. A commercial confidence agreement is signed between EMEC and the developer	- Runs International WaTERS group; - Provides consultancy services to other test sites; - Leads FORESEA, involved in MaRINET2, METCERTFIED, Marinerg-i and many EU research projects	Provides developers with emergency response procedures and relevant standard operating procedure. EMEC has produced guidelines for the marine energy industry on H&S
DMEC	Not-for-profit network and consulting organisation	Partly financed by the European Regional Development Fund of the European Union, the Kansen voor West II program and the Province of the North of Holland	There is no clear government vision. More interest at provincial level, regional not national, that enhances local economy	Long permitting process , almost 3 years	A non-disclosure agreement is signed with the clients. Design and performance information is owned by the client/developer. Data on impact on environment is published and shared with knowledge institutes	Strongly involved in research and funding programmes:MET-CERTIFIED project, DMEC Innovation Accelerator, Marinet, Environmental Impacts Blue Energy, FORESEA	Deferred to sub-contractors who work on the sites
PTEC	It is majority owned and funded by Perpetuus Energy Limited, in joint venture with the Isle of Wight Council	Mainly private, with £1m from Isle of Wight Council and a very small proportion from grant funding.	UK Government doesn't have a long term strategy	One of the longest and most complex tasks was consenting	Under certain agreements, they can share some of their data. PTEC owns it 100% and will only share confidential information to selected parties under NDA.	Partnerships with global turbine manufacturers, Tocardo International BV and SCHOTTEL Hydro GmbH.	All the requirements in place, especially as a tenant of The Crown Estate and as part of consenting requirements.
FaBTest	Administered by Falmouth Harbour Commissioners (FHC). supported by a steering group with representatives from industry, academia, agencies and other stake holders	Mainly supported by Regional Growth Fund	No info	The FaBTest site is leased from The Crown Estate and has consent for testing, subject to permits issued by Falmouth Harbour Commissioners. No particular issues to report	No private data may be stored, all data must have direct relevance to FaBTest	- Site well-known in the marine energy sector, no active promotion; - Received Green Energy Award in 2012; - Ccollaboration with Plymouth laboratory and WaveHub test centre wave tanks, partnership with Marinet	Clear requirements to be fulfilled by the developers in the application process.
Seeneoh	Société par actions simplifiée, established as a private company and managed by 4 different operating companies	65% of the investment from France government and two Regional / Local Authorities; 35% has been charged to several private companies	French government is quite supportive with offshore tidal. Most of the support (national and from EU) is for R&D rather than for offshore operations	A lot of time to get the permit, mainly because of the time needed to get a management in place, not the permit procedure itself	Access to user data by SCADA system,to deliver monthly report. They cannot use client data for other purposes	Website and Twitter regularly updated. Presence at conferences and seminars. Collaboration with BV for the power curve certification. Member of International WaTERS and BlueGift	All the requirements in place. Client has to comply with the risk prevention plan
Ifremer	Public research institute	No info	No info	No info	No info	IFREMER is developing standard test protocols with other labs (round robin tests) and participates in European projects to develop test protocols	No info
FORCE	Private, not-for-profit corporation administered by a board of directors and staff, FORCE has two major roles: host to TISEC developers and steward to the site	FORCE receives funding support from the Government of Canada, the Province of Nova Scotia, the Atlantic Canada Opportunities Agency (ACOA), Encana Corporation and participating developers	No info	Several concerns from fishers associations, First Nations bands, and some members of the public	No info	Collaboration on-going with EMEC	Users shall adhere to the Nova Scotia"Occupational Health and Safety Act" and "Technical Safety Act"

Risk and opportunities

Centre	Main frustrations	Main risks	Strenghts	Expected opportunities	Strategy - Expectation for the future	Lessons learned
EMEC	- Lack of pathway to the market, get stuck at pre-commercial phase, - Lack of long-term vision, i.e. most developers prefer to focus on standard, not-innovative, devices; - Lack of a good standards regime; - Lack of UK government support, more focused on offshore wind or nuclear; - Low budget from developers	- Lack of clarity of the market - Health of the market (next to wind and nuclear)	- Leading role in the sector; - Its instrumentation; - About 15 years of experience; - The generated electricity can be inserted in to the grid and sold; - Integrated Management system approach; - Team of 40 people, incl. a metocean data engineer - Strong marketing side; - At the very forefront of the development of international standards	- Offering certification; - Address towards non-utility scale markets; - Coupling marine energy with storage and energy systems to provide stable power, grid services, or renewable fuels such as hydrogen	- Improving the coordination between international test centres; - Supporting wave and tidal sector; - Assisting other test facilities to become and stay accredited as service; - Providing a shop window to the industry; - Cooperating with other test centres for the establishment of common global standards	- Maintain good relations and keep updated the various involved stakeholders; - Careful planning, project management and consciously having one eye on the future to anticipate the needs of the industry
DMEC	Obtaining the right permits was a lengthly and expensive process	- Cash flow; - Keeping expertise/experience	- Benign open water test facility with lower tidal flow velocities; - Easy access in the Netherlands; - Funding for test available through MARINET2 and FORESEA programmes; - Pre-approved facility	- Providing certification services, such as power performance assessment; - Running collaborative R&D projects with industry; - Helping emerging developers from technical and commercial point of view; - Supporting offshore projects; - Monitoring environmental impact	- To help the renewable energy business to move forward; - To expand offered technical and commercial services; - To deliver verified test reports. Try to comply with ICRE via self certification and ISO certification	- It has proven to be difficult to attract a steady stream of clients for testing and clients bring little or no funding ↓ - DMEC joined MARINET2 and FORESEA programmes, providng funding for tests to developers; - anchors and grid cable have been removed
PTEC	Lack of government support	- Political; - Financial standing / balance sheet credibility of turbine manufacturers; - Technical	- Suitable for proven tidal devices at advanced stage of development; - The site characteristics are much more representative of the majority of global sites than 'extreme' sites such as EMEC and FORCE	- Becoming the step between standard test facilities and pure commercial; - Getting accredited, perhaps in collaboration with other test facilities and joining working groups	- Optimising the project; - Engaging with stakeholder and community to discuss the project; - Collaborating with other test facilities	Don't underestimate how slow consenting authorities take. Think about financing and insurance. Having the correct team (mainly external experts) and sufficient budget is paramount
FaBTest	- Frustration of the small/early stage developers: all the efforts focused on design while costs for testing and for the operations on-site are not planned since the beginning; - Lack of pathway of the sector and lack of public funding to the developers	- Low budget	- Pre-consented status, fast authorisation process; - Sheltered test site; - Port facilities closeby, 3-5 km from train and wharf space and deep harbour; - Cheap	More funding for the marine energy industry	- To diversify its activities into other aspects, mainly from a technical point of view; - Major collaboration among the test centres; - Getting accredited	Execution and testing is as important as design. Many costs of testing and operations, not properly taken into account, are much higher than expected by developers
Seeneoh	- Market still at early stage; - Lack of money; - Low budget; - Small companies	- Administrative issues for setting-up as R&D company; - time for development is very long; - Developers do not have enough money/ do not receive enough funding	- Very particular site - estuarine; - Sheltered site, but with high currents near a bridge; - No need of particular permits; - Easy access, close to shore (300 m, 10 minutes by boat); - No expensive boat needed; - 3 berths; - Mooring already in place; - Grid connection – 300 m cable, SCADA infrastructure; - Good current, bidirectional tidal flow; - Power curve certification (in collaboration with Bureau Veritas)	To increase public funding, mainly from EU, to cover their own costs, such that user can access the site without paying any fees	Authorization is in place until 2022. Then, it will be decided if extend the permit for other 7 years or to transform the business and become a real energy producer	The intention was that a 'Research Institute' would gather all French test sites and would manage them all. It was so complicated from an administrative point of view that they decide to set up as a private company and to manage the facility themselves. The R&D institute still exists, but does not manage test facilities
Ifremer	No info	No info	- strong R&D and wide experience in the marine sector; - 10 years of testing experience (more than 20 devices tested); - well known in the sector	No info	No info	No info
FORCE	No info	No info	- Its location in the region of the world's highest tides; - Strong connection with Canadian stakeholder	-Site characterisation, i.e. to identify and validate new sites suitable for development, as well as monitor the environmental conditions at already permitted sites for both social license and regulatory compliance	- To refine TISEC technology, lowering technical and financial risk; - To monitor TISEC devices, helping to understand and mitigate any potential effects	- The need for better site data has spurred development of the next generation of sensors and modeling – and the FAST program; - Educated the various stakeholders. In 2016 FORCE met over 45 different groups to understand concerns

Annex B Overview table cases other sectors

Sector	Test facility	Business model/ ownership	Offered services	Commercialization of the sector	Conclusions and lessons learned
Seaweed production	ECN/TNO Seaweed processing laboratory	-Owned by ECN/TNO -Support by Province of North Holland, top sectors, and ministry EZK (ProSeaweed Programme) -Collaborations in national and EU projects	-Pilot scale lab offers entire processing chain from seaweed into products -Characterisation and screening of seaweed composition -Producing samples for users to carry out product tests -no certification services	- CEN is working on development of standards for aquatic biomass, identifying needs for standards (e.g. measuring content) -For seaweed food products sustainability certification is available (ASC/MSC, EU Organic label) -For large scale seaweed cultivation at sea, certification of seaworthiness of the systems may become relevant	-EU seaweed food products are becoming commercially available (e.g. seaweed burger) -Seaweed biofuel production still being developed, not commerically available -Standardization offers opportunity for market to further develop, e.g. by standardizing measurement of seaweed content, marketing seaweed as sustainable product, and supporting safety and seaworthiness aspects.
Space	NLR Netherlands Aerospace Centre	-Owned by NLR (foundation) -Supported by governmental funding -Wide market: space, civil aviation and military aviation -Collaborations in national and EU projects	-Assisting in design and development of space systems -Facilities for environmental and structural testing and low gravity flight testing -Test facilities accredited by RVA -Testing required for certification in aviation (not space): complying with civil or military standards for safety	-Major role in standards development played by ECSS, providing a platform for sharing of information and discussion on standards -Recently, the active sustainability standards have been developed, aiming at mitigation of space debris	-Certification not so relevant for space industry, but standardisation is important for lowering life cycle costs while improving quality -Testing of every individual product is important for space industry (rather than type testing) -Test facility in space industry not very profitable, government support and wider aviation market necessary
Automotive	Helmond Automotive Campus	-Governing body: Automotive Campus foundation, including municipality Helmond, Province North-Brabant, real estate developers -Main income: foundation rents out land and real estate on campus to companies (who own their own equipement) -Support from all layers of government: local/regional involved in land transaction and funding new technologies, EU project funding for testing innovations	-Various mobility test facilities and labs -Some tests certified by external organization, e.g. rollerbank (to assure clients that breaks and speed live up to standards) -Other tests function as certification procedure, where the developers of the test define their own standards (for a large research institution this is often considered reliable, external certification is not needed)	-Automotive sector has high safety standards, embedded in quality management and certification -IATF created ISO certification in 1999 to harmonize systems worldwide for automotive -Certification updated in 2016, decoupling from ISO certification, making the certification exclusive for the automotive industry -Shared use of test sites is stimulated by NL government, by providing discount on usage tariff	-Rollerbank tests initially not certified by external company, it proved necessary to certify because the market demanded this -Adjusting rollerbank test facility to meet requirements of the certifying company was difficult and time consuming -Main lesson: identify necessity of certification at early stage, for design of the test facility
Smart grids	Smart Grid Test Centre ACCRES	-Initiative of Wageningen University, collaborating with private partners -Business model based on these partnerships: incl. several battery producing companies, energy companies, food industry	-Testing with semi-off grid network and connecting users -Flexibility to adjust to needs of different users, no need for standardisation -If new concept proves commercially viable, certification is done by external company -No accreditation, only relevant for new companies unknown to the market to attract clients and partners	- Smart grid test center does not provide certifications as this is not required by clients - As the test center is owned by Wageningen University, it is well trusted. Through the Wageningen University network clients know how to find the test center	-During start-up of test site it was challenging to attract sufficient funding -Mapping of government and political interest was basis for location selection -Organization of test site embedded within existing and respecte dorganization, with necessary experience and capacity to ensure good implementation
Wind energy	OWI-lab	-Private initiative, have companies as members and received start-up subsidy from government' - They look pro-actively for new clients and through building track-record they expand client base - Clients pay a usage tariff which are covering operational costs of the test facility	- testing with a climate room to test equipment functioning under different climatic conditions - Short term testing from days to two months - the facility develops test report but does not offer certification reports - test facility is equiped on such a way that certification tests (from e.g. TuV) can be executed	- Through market study that showed that two companies were interested in having a test facility - Building a track record helps to attrack new clients - Pro-active acquisition important to attract new clients	- The test facility is private driven and dependent on projects - Certification and accreditation is not always needed for new markets (like tidal wave energy, wind) as in early stages of development, testing is regarded as more important than official certification and accreditation - Data sharing is important

Annex C Specific documents of test facilities

C.1.EMEC Schedule of Accreditation

Schedule of Accreditation
issued by
United Kingdom Accreditation Service
2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

2625 **Accredited to ISO/IEC 17025:2005**	**European Marine Energy Centre Ltd** **Issue No:** 008 **Issue date:** 23 June 2016	
	The Old Academy **Back Road** **Stromness** **Orkney** **KW16 3AW**	**Contact: Mr N Kermode** **Tel: +44 (0) 1856 852060** **Fax: +44 (0) 1856 852068** **E-Mail: neil.kermode@emec.org.uk** **Website: www.emec.org.uk**
Testing performed at the above address only		

DETAIL OF ACCREDITATION

Materials/Products tested	Type of test/Properties measured/Range of measurement	Standard specifications/ Equipment/Techniques used
Wave Energy Conversion Systems	Electrical Energy Output corresponding to measured sea conditions at the stated location. Location: Billia Croo, Orkney Water depth: 50 m Distance from shore: Approx. 2 km Number of test berths: 5	11 kV [1] 3-phase 50 Hz system with power factor correction and live grid connection. In-house documented methods based on the relevant sections of the following standards: *Assessment of Performance for Wave Energy Conversion Systems ISBN 978-0-580-65549-4*. *IEC/TS 62600-100 (2012) Marine energy - Wave, tidal and other water current converters - Part 100: Electricity producing wave energy converters - Power performance assessment* *IEC/TS 62600-101: (2015) Marine energy - Wave, tidal and other water current converters - Part 101: Wave energy resource assessment and characterization.*

Testing performed at main address only

Materials/Products tested	Type of test/Properties measured/Range of measurement	Standard specifications/ Equipment/Techniques used
Tidal Energy Conversion Systems	Electrical Energy Output corresponding to measured tidal conditions at the stated location. Location: Fall of Warness, Eday, Orkney. Number of test berths: 8	11 kV [1] 3-phase 50 Hz system with live grid connection. In-house documented methods based on the relevant sections of the following standards: *Assessment of Performance of Tidal Energy Conversion Systems ISBN 978-0-580-65031-4* *IEC/TS 62600-200 (2013) Marine energy - Wave, tidal and other water current converters - Part 200: Electricity producing tidal energy converters - Power performance assessment* *IEC TS 62600-201: (2015) Marine energy - Wave, tidal and other water current converters - Part 201: Tidal energy resource assessment and characterization* [1] Other voltages can be accommodated by the use of transformers if so agreed between EMEC and the customer. [2] Excludes any criteria for reporting of local meteorological conditions.

END

C.2. EMEC – Consenting guidance for developers

CONSENTING GUIDANCE FOR DEVELOPERS AT THE EMEC FALL OF WARNESS TEST SITE

January 2015

EMEC ORKNEY
THE EUROPEAN MARINE ENERGY CENTRE LTD

UKAS TESTING
2625

CONSENTING GUIDANCE FOR DEVELOPERS AT THE EMEC FALL OF WARNESS TEST SITE

January 2015

Revision	Date	Description	Originated by	Approved by
1.0	09/01/2015	Fall of Warness site-specific consenting guidance for EMEC developers.	DC	JN

Contents

Important preliminary note – Disclaimer

These guidelines have been developed to assist developers intending to test marine energy conversion devices at EMEC. For developments of 1 MW or less, these guidelines, which have been agreed with Marine Scotland and Scottish Natural Heritage, should be used in the production of all documentation in support of licence applications. Developers wishing to test devices or arrays >1MW will also require formal Environmental Impact Assessment (EIA)[1]. These developers should also refer to the Marine Scotland guidance available at: http://www.scotland.gov.uk/Topics/marine/Licensing/marine/LicensingManual which provides specific guidance on the EIA process for wave and tidal developments.

The purpose of these guidelines is to explain the assisted process at EMEC, the range of consents-related documentation available to developers, and to encourage and assist developers to consider as fully as possible the range and scale of risks and impacts that might result from the testing of their device(s) at EMEC.

The guidelines reflect EMEC's understanding of the relevant legislation and procedures and whilst we make every effort to ensure the accuracy and reliability of the information, it is not guaranteed and EMEC will not be responsible for any errors or omissions. In particular, EMEC will not be liable for any loss, however arising, from the use of, or reliance on these guidelines. The guidelines should not be relied on as a substitute for formal advice where appropriate. It is the responsibility of individual developers to ensure that their devices and all operations that they carry out are fully compliant with all current legislative requirements.

Over time, this document is likely to be revised to reflect the growing knowledge and experience in marine energy conversion devices and environmental interactions. Developers must ensure that they refer to the most up to date version which will be available on the EMEC website (http://www.emec.org.uk).

This document should be used in conjunction with the EMEC document *Marine Operating Guidelines for Operations at EMEC Wave and Test sites GUIDE010-01*.

[1] EMEC is currently (December 2014) in the process of applying for site-wide Section 36 consent for the Fall of Warness test site, and any developers interested in testing a device with maximum rated output >1MW should speak to EMEC directly in the first instance.

1 Introduction

The European Marine Energy Centre (EMEC) is the first centre of its kind in the world and one of the leading organisations in the testing of commercial scale wave and tidal energy technologies. As such, we recognise the importance of establishing high standards of safety and environmental protection and an early understanding of the range and significance of potential environmental and navigational impacts. EMEC operates an Integrated Management System (IMS) that demonstrates a clear commitment to high standards of quality, health, safety and environmental (QHSE) management. We aim to encourage those involved in the developing marine energy industry to fully consider safety and environmental risks of projects/technologies in the early stages of design and development, thereby encouraging best practice to be carried forward into commercial scale developments.

This document provides information and guidance on the environmental and navigational safety considerations required and the licence application process for developers wishing to deploy a device at the EMEC Fall of Warness test site with maximum power output of less than or equal to 1MW.

1.1 Background and Context

EMEC has in place Crown Estate leases covering the marine test sites, together with planning consents for substations and associated lay-down areas.

Developers have full and sole responsibility for obtaining any consent[2] required for the installation and operation of their device(s) at the Fall of Warness test site (including any land planning consents that may be required).

In order to introduce efficiencies into the consenting process, EMEC has worked closely with Marine Scotland and the key statutory stakeholders to capture as much as possible of the 'generic' information pertaining to navigational safety and environmental risks at the EMEC test sites, and has undertaken site-wide risk assessments in both areas. These are available to developers and form the basis of all licence and consents applications. Section 1.5 provides more information about this documentation.

As part of this process, EMEC has also defined a 'project envelope' describing the types and characteristics of marine energy converter systems (MECS) likely to be deployed at the EMEC test site, together with the types of marine operations and activities likely to be associated with their installation, operation and maintenance. The project envelope has been prepared by EMEC using its experience of the parameters associated with existing deployments at EMEC, together with those emerging elsewhere. Section 3 of this document provides further information about the project envelope.

[2] EMEC is currently (December 2014) in the process of applying for site-wide Section 36 consent for the Fall of Warness test site, and once this is in place individual developers will not be required to apply for their own Section 36 consent.

1.2 Legislative and Consent Requirements

Legislation relevant to marine renewables can be found in the *Draft Marine Licensing Manual* published by the Scottish Government, available at:
http://www.scotland.gov.uk/Topics/marine/Licensing/marine/LicensingManual.

1.3 Assessment of Potential Risks

EMEC has initiated risk assessments for the whole of the Fall of Warness test site. These site-wide risk assessments aim to identify potential risks that are expected to potentially apply to the range of deployments anticipated at the site, as captured and expressed in the project envelope.

These risk assessments are used to support any application for a Marine Licence or Section 36 consent for deployment at any of the berths at the Fall of Warness. They are supplemented by project-specific annexes produced by the developer, as described in Section 1.6 of this document.

1.3.1 Environmental Risk Assessment

An Environmental Appraisal has been carried out by Scottish Natural Heritage (SNH) for deployments at the Fall of Warness test site, based on anticipated deployment activities and parameters as described in the project envelope. This appraisal constitutes a HRA/AA for the whole site, and supports any application for a Marine Licence or Section 36 consent for deployment at the Fall of Warness. Provided that a project falls within the parameters set out in the project envelope, it will be considered as pre-appraised in terms of its environmental impacts and no further environmental appraisal by Marine Scotland will be required. Projects falling out-with the envelope may require additional appraisal and/or consultation, and further advice should be sought from EMEC in the first instance.

1.3.2 Navigational Risk Assessment

EMEC has undertaken a site-wide Navigational Risk Assessment (NRA) for the Fall of Warness. This NRA describes the potential navigational risks and mitigation measures associated with deployment of a range of types of tidal energy devices in relation to the specific site, taking into account the latest guidance and experience available, including the Maritime Coastguard Agency's Marine Guidance Notice 371 (*Offshore Renewable Energy Installations – Guidance on UK Navigational Practice, Safety and Emergency Response Issues*). EMEC undertakes regular Vessel Traffic Surveys to assess the currency of the data used for the NRA.

1.4 Activities Out-with EMEC Test Sites

EMEC does not have responsibility for offsite activities undertaken by developers. However developers are strongly encouraged to fully consider the impacts associated with their activities out-with the EMEC test areas and to promote high standards in all aspects of their operation. Appendix 1 of this document indicates the types of activities that should be considered. EMEC would encourage developers to consult with relevant stakeholders where appropriate, and is happy to facilitate and aid these discussions.

1.5 Process and Timing

EMEC uses the following terminology when referring to the different stages of the licence application and planning process.

Initial Project Information
In order to assess the feasibility of a project for testing at the Fall of Warness test site, EMEC requires developers to submit high level information of their project prior to commencing contract negotiations. This should briefly describe the project and include full device and mooring details (including construction materials), deployment methods, installation and decommissioning timeline and key milestone dates as known. EMEC will discuss the project details with Marine Scotland, to ascertain whether or not the proposal falls within the project envelope for the test site.

If the proposal is deemed to fall out-with the project envelope, EMEC will facilitate further discussion with Marine Scotland regarding additional project-specific appraisal requirements. Even if a proposal falls within the project envelope, a meeting with Marine Scotland may still be required (e.g. to clarify aspects of the proposal).

At this stage EMEC encourages developers to meet with appropriate targeted stakeholders, with whom EMEC regularly engages. EMEC is happy to facilitate and assist in these meetings, and can utilise its experience of past discussions with the stakeholders in relation to any concerns that may be raised. This helps to ensure that a consistent approach is taken with each developer to any issues raised, and that all other relevant potential developments (of which an individual developer may be unaware) are taken into account.

Marine Licence Application
This is the process by which a developer applies to the Regulator (Marine Scotland) for a Marine Licence to deploy a device at EMEC. Developers use the Environmental Appraisal and Navigational Risk Assessment documentation described in Section 1.3 as the basis for their own project-specific risk assessments. These documents are submitted by developers in support of their licence application.

The Marine Licence application should be accompanied by a Project Information Summary (see Section 2), any additional project-specific impact appraisals which may be required[3] (as advised by Marine Scotland), a Project-specific Environmental Monitoring Programme (PEMP), a project-specific Navigational Risk Assessment (NRA), and a Third Party Verification (TPV) report that verifyies the suitability of the device and its moorings for deployment at the EMEC test site.

The turnaround time for processing Marine Licence applications, from receipt of completed application form and supporting documentation to issue of a licence, is typically about 3 months (assuming that the project falls within the defined project envelope and all submitted documentation is in order), although this period is significantly shorter for projects that fall within the project envelope. The consenting process for the Fall of Warness test site is shown as a flow chart in Figure 1 below (please note that timescales shown for each stage are indicative and will depend on individual projects). It is important that developers are aware that late submission of their Marine Licence application may lead to delays in installation.

[3] If the project falls out-with the project envelope, Marine Scotland may possibly require developers to undertake further impact appraisal.

For projects with a device power output >1MW, consent under Section 36 of the Electricity Act 1989 is required in addition to a Marine Licence. This involves submission of a full EIA by the applicant. At the time of writing, EMEC is in the process of obtaining a site-wide Section 36 consent for the whole site, so developers intending to generate >1MW are advised to speak to EMEC directly to discuss the status of this application.

Full details of the process for Marine Licensing in Scotland can be found on the Marine Scotland website (http://www.scotland.gov.uk/Topics/marine/Licensing/marine).

1.6 Other Supporting Documentation

In addition to the site-wide risk assessments (see Sections 1.3.1 and 1.3.2), the following supporting documentation should also accompany the Marine Licence application.

Project-specific Environmental Monitoring Programme (PEMP)
All developers are required to submit a (draft) PEMP as part of their Marine Licence application. This is essentially a project-specific annex to the Environmental Appraisal, in which developers propose methods for monitoring their device in respect of the issues of concern identified in the main document. The framework and principles of the PEMP should be agreed with the Regulator, and commitments made therein are very likely to be incorporated into licence conditions (see also Section 3.3).

Navigational Risk Assessment (NRA)
Developers are also required to submit a project-specific NRA in support of their Marine Licence application. This NRA should be based on the EMEC Fall of Warness site NRA described in Section 1.3.2, which is available to all EMEC developers, and should form an annex to it. This project-specific annex should incorporate all aspects of MGN 371 (Marine Guidance Notes, produced by the MCA: please check online for the latest version). The water depth and overall height from the seabed of the proposed device should also be considered in the NRA, to demonstrate that the developer can ensure adequate under keel clearance at Lowest Astronomical Tide (LAT). Where appropriate, developers should also take account of MGN 372 and IALA Recommendations O-139 (International Association of Marine Aids to Navigation and Lighthouse Authorities) regarding marking and lighting of their devices.

Third Party Verification (TPV)
Developers are required by the Regulator and its statutory consultees to produce an independent structural verification report for their device. It is also a requirement stated within the EMEC-Developer Agreement that a report be provided which verifies the integrity of the structural design of the device and its foundation, including any moorings, for the conditions likely to be experienced at the site. The report must be provided by an independent body with sufficient experience, standing, and reputation.

Decommissioning Programme
Decommissioning of devices capable of generating power is governed by the Energy Act (2004). Responsibility for decommissioning under the Energy Act has not been devolved to the Scottish Government and thus lies with the UK Department of Energy and Climate Change (DECC). When a developer has been granted a Marine Licence to test at EMEC, a Notice to Decommission is issued by DECC to the project developer. This places a requirement on the developer to produce a

Decommissioning Programme. DECC[4] has produced a standard set of guidelines for the preparation of this document, available from the DECC website at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/80786/orei_guide.pdf.

The Decommissioning Programme is submitted for two rounds of consultation. The first is for 30 days around a range of stakeholders specified by DECC, and EMEC can assist with this. Following the incorporation of any feedback, the Decommissioning Programme is then submitted to DECC for a second 30 day circulation around Whitehall before finally being submitted to the Secretary of State for approval. During this second consultation stage the developer is likely to have to produce evidence independently to DECC, showing their ability to finance the decommissioning of the proposed project.

DECC recognises that, through the course of testing prototype devices, changes may arise to the Decommissioning Programme and developers are required to notified them of any significant alterations prior to commencing decommissioning operations. EMEC is in continuing discussion with DECC on this process and will be able to update developers as to any streamlined approaches available.

[4] EMEC is currently (January 2015) in discussion with DECC about potentially introducing efficiencies to decommissioning at EMEC sites.

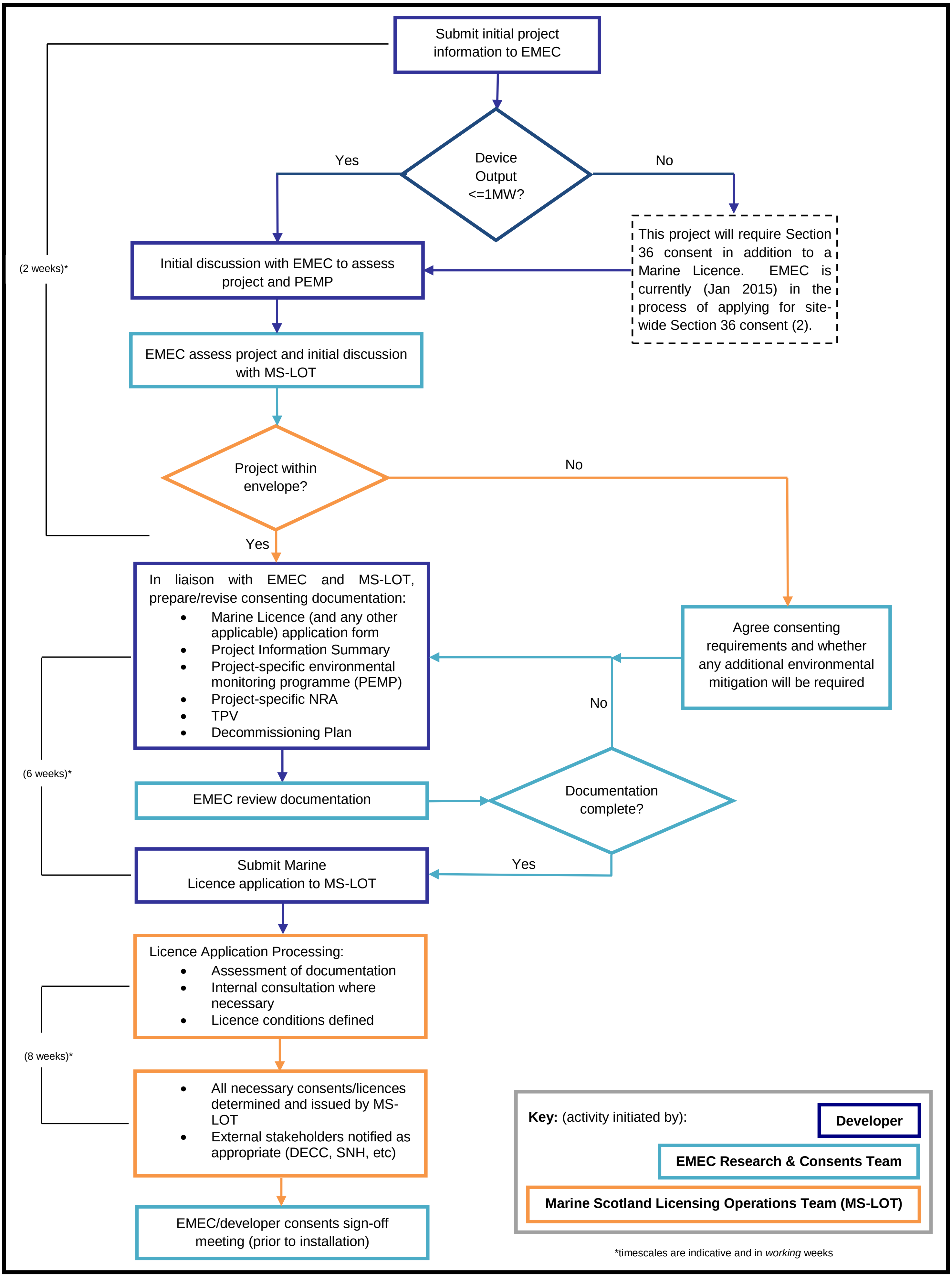


Figure 1: Consenting process for the EMEC Fall of Warness test site

2 Project Information Summary

2.1 Introduction

The Project Information Summary should be submitted to EMEC soon after contract signing. EMEC will review the document and advise any amendments required before submitting to the Regulator in support of the Marine Licence application.

2.2 Content of the Project Information Summary

The Project Information Summary should be around 10 pages in length and provide brief details of the proposed project, organised in the following sections:

- **Introduction** (no more than one page giving a brief background to the company, the technology, and the project plan; should include brief details of any testing undertaken to date)
- **Device Description** (three to four pages, including any relevant diagrams/photos, details of scale of device, dimensions, position in water column, nominal power rating, how the device works, description of moorings, and list of materials to be used in construction of device & moorings)
- **Project Description** (no more than three pages, including any relevant diagrams, details of deployment location, installation method, device monitoring systems to be used, and proposed decommissioning/removal method)
- **Environmental & Navigational Risk Considerations** (one or two pages providing a brief summary of any potential environmental and navigational issues identified and proposed mitigation; should make reference to project-specific PEMP and project-specific NRA documents)
- **Proposed Timescales** (provide details of proposed installation and maintenance, testing, and decommissioning schedule together with key project dates; can be provided as a Gantt chart)

3 Environmental Appraisal and the Project Envelope Description

3.1 Introduction

An Environmental Appraisal for the Fall of Warness test site has been undertaken by SNH to assist both EMEC and Marine Scotland in streamlining the appraisal process required to support the Marine Licence application for deployments at EMEC. To this end, the Environmental Appraisal aims to pre-appraise potential deployments within the context of the wider test site using an EMEC project envelope description. This project envelope describes the types and characteristics of Marine Energy Convertor Systems (MECS) likely to be deployed for testing at the Fall of Warness site. It also describes the types of marine operations and other activities likely to be associated with the installation, operation and maintenance of these devices.

The Environmental Appraisal document does not remove the requirement for each developer to apply for an individual Marine Licence, rather it is provided to help inform the assessment process. Consequently, most potential impacts from the installation, operation and maintenance of anticipated types of tidal turbine devices at the Fall of Warness test site have been appraised and conclusions reached, provided the proposal fits within the project envelope. The Environmental Appraisal document contains comprehensive receptor appraisals that satisfy the requirements of legislation relating to designated sites and protected species. Some potential effect pathways may require project-specific appraisal, depending on their relevance to the proposal, and therefore developers should ensure that they are familiar with this documentation. The appraisal process has also identified potential mitigation and / or monitoring requirements and suggestions, to be used in the formation of a PEMP (as described in Section 1.6).

It is the initial responsibility of the developer to ensure that their proposal fits within the project envelope description. If this is confirmed by EMEC and the Regulator, then the potential impacts of the proposal will be considered to be pre-appraised.

3.2 Project-specific Environmental Appraisal

Whilst the Environmental Appraisal has pre-appraised many of the potential impacts at the Fall of Warness using the project envelope description, there will be some elements of some developer projects for which this was not possible. This will be the case where some or all of the following apply: aspects of the proposal are not within the project envelope; specific information was unknown or unavailable; the range of options to be used was too large to be assessed. In such instances it will be necessary for the developer to provide additional project-specific information with their Marine Licence application documentation. This will enable the Regulator to assess the project and, if necessary, undertake an Appropriate Assessment. Marine Scotland and SNH will advise on the approach to any additional appraisals and will be consulted on their outcomes. Any mitigation and/or monitoring identified through this process will also need to be integrated into a PEMP.

In addition to the few specific effect-pathways not appraised, there are a number of broad aspects that the Environmental Appraisal and or project envelope description do not cover but for which the Regulator may require further information or assessment, namely:

- Environmental topics typically referred to the Scottish Environmental Protection Agency (SEPA) are **not** addressed in these appraisals. This includes issues relating to the use or release of pollutants and contaminants, such hydraulic fluids, oils or antifouling paints. The competent authority should therefore continue to consult SEPA on such topics.

- Onshore (including intertidal) ancillary developments and infrastructure are not addressed in these appraisals (including the landfall of cables). Any such proposals require consultation under the Town and Country Planning (Scotland) Act 1997.
- The documentation does not seek to review or appraise any of the other aspects that require consideration for device deployment, such as navigational safety (see Section 1.3.2) or third party verification (Section 1.6).
- The documentation does not appraise decommissioning which will be dealt with separately through the DECC process (see Section 1.6 for further details on the decommissioning process).

3.3 Environmental Mitigation and Monitoring

The Environmental Appraisal has already identified some of the mitigation and/or monitoring requirements likely to be necessary for deployment at the Fall of Warness. This information is provided to help assist individual developers to prepare a PEMP. The PEMP should contain a Construction Method Statement (CMS) specific to the individual developer's project. Further information and guidance is provided in the Environmental Appraisal document. A first draft of the PEMP should be submitted with the Marine Licence application. The project-specific PEMP will be an iterative document, the framework, principles and details of which will be agreed as part of any consent from the Regulator. **The results of mitigation and monitoring carried out in accordance with the PEMP must be submitted to the Regulator in fulfilment of any licence conditions.**

3.4 Other Licence/Consent Requirements

There may be instances where additional licences/consents are required in relation to particular species or surveys. These have been identified where possible in the Environmental Appraisal and may include:

- Licence to disturb European Protected Species (EPS) under the Habitats Regulations 1994 (as amended in Scotland)
- Licence to disturb basking sharks under the Wildlife and Natural Environment (Scotland) Act 2011

EMEC/Marine Scotland will advise if any of these licences and any associated mitigation will be required. Such mitigation is likely to be limited to undertaking marine mammal observations during key activities, although it could extend beyond this, depending on the project details.

3.5 List of Commitments

There are likely to be some issues of environmental concern, in relation to which the Regulator wishes to see some mitigation (which may be monitoring of the device in operation). These will be discussed during the preparation of the PEMP. Developers should summarise all realistic and tangible commitments made in the Marine Licence application submission documentation in a

Commitments Table/Register to be included within the PEMP. The format for this is provided in Appendix 2 of this document.

Some of the commitments made by the developer may affect the final device design. If a material change to the design is subsequently made, then the impacts and list of commitments will need to be reviewed before work can proceed.

Developers should ensure that they discuss appropriate commitments with EMEC, as well as with Marine Scotland, as there may be operational implications to be considered.

The issues shown in Appendix 2 are by way of example only and should not be considered as an exhaustive list. Any other issues/commitments which may be important from an environmental perspective should also be included in the Commitment Register.

Appendix 1: Considerations for Activities Out-with EMEC Facilities

Orkney has a wide range of resources and services available to support developer test activities and wherever possible developers are encouraged to make use of these.

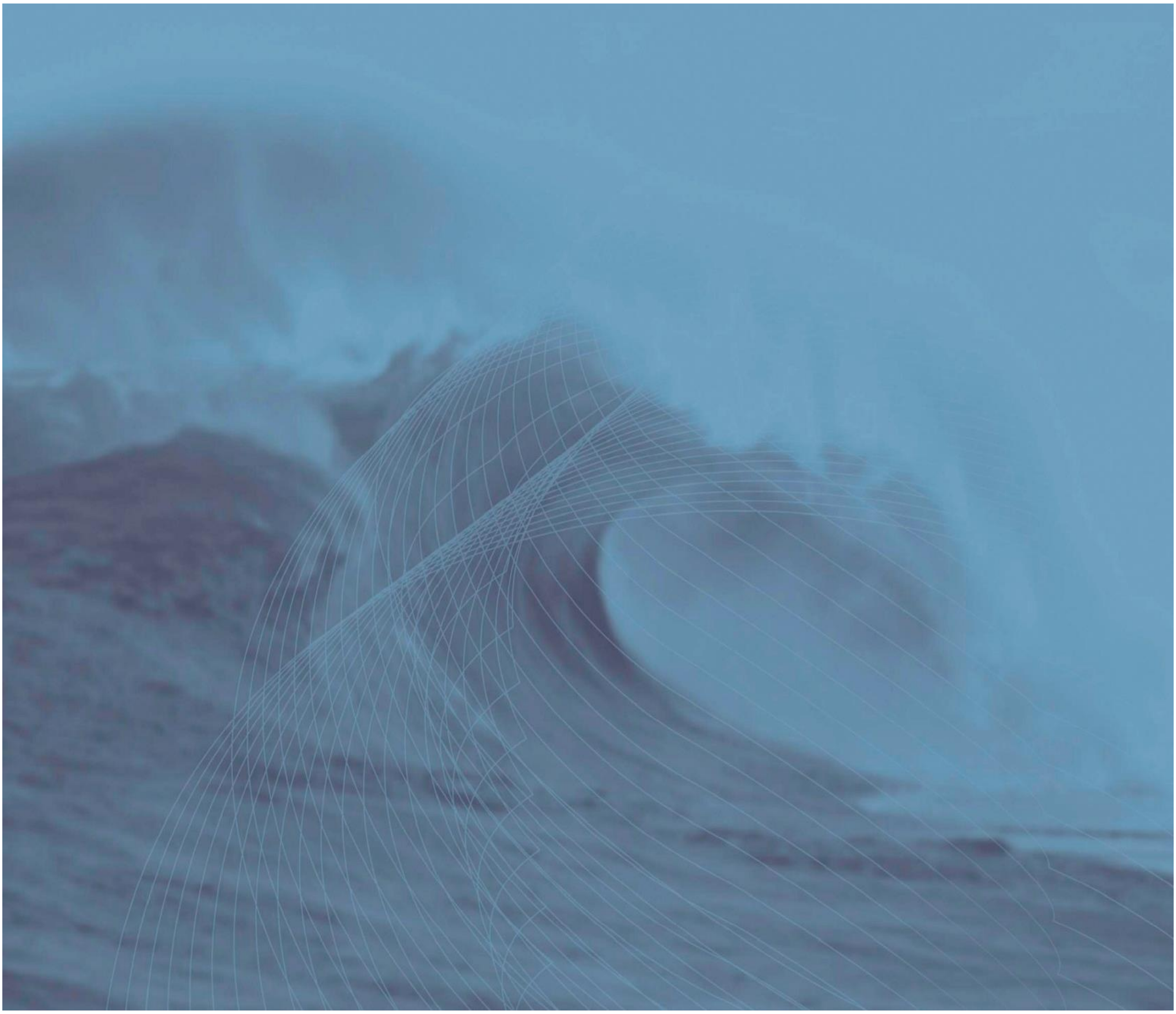
If developers take advantage of the resources and services available, they are encouraged to consider potential offsite environmental effects. Examples of the issues that should be considered include those listed in the table below, although the table should not be considered to be an exhaustive list as each location will have different sensitivities.

Offsite	Issues to be considered
Construction and fabrication	• Location of fabrication. • Noise and other pollution (eg dust, waste water, fuel, oils, etc) • Disturbance, displacement or damage to legally protected or sensitive habitats, species or landscapes – licenses may be required in advance
Standby, support, offsite maintenance and decommissioning requirements	• Areas/locations required e.g. offsite mooring, harbour/pier facilities (timing and duration requirements for these facilities). • Vessel requirements e.g. number, size (GRT, draft etc) duration, timing (i.e. months) etc. • Details of any onshore facilities required additional to those provided by EMEC e.g. lay down areas (devices and supplies), workshops, crane access, slipways, offices (including requirements at decommissioning). • Requirements in event of emergency including vessel requirements, mobilisation times etc. • Noise and other pollution (eg dust, waste water, fuel, oils, etc) • Disturbance, displacement or damage to legally protected or sensitive habitats, species or landscapes - licenses may be required in advance
Personnel requirements	• Numbers of people, time of visit, length of stay etc.
Tow to site	• Draft during tow, vessel requirements (number and size), speed during tow (knots/ms^{-1}), proposed route (description), manoeuvrability (e.g. length of tow etc). • Disturbance, displacement or damage to legally protected or sensitive species or habitats - licenses may be required in advance • Ballasting requirements
Temporary docking requirements	• Devices and associated vessels. • Areas/locations required e.g. offsite mooring, harbour/pier facilities (timing and duration requirements for these facilities). • Frequency of device off test berth including during maintenance and expected length of time at quayside. • Description of activities to take place at quayside. • Noise and other pollution (eg dust, waste water, fuel, oils, etc) • Disturbance, displacement or damage to legally protected or sensitive habitats, species or landscapes - licenses may be required in advance
Waste minimisation and disposal	• All efforts should be made to minimise waste. • Proposed waste disposal and oil/fuel spill procedures. • Arrangements for storing and handling non-hazardous and hazardous (special) wastes eg batteries, sludge, lighting units, paints, greases, oils, lubricants, solvents, coolants, sewage, domestic, scrap, packaging etc.

Appendix 2: Sample Commitments Table (Environmental Monitoring)

Issue	Commitment or action	Responsibility	Target completion date	Actual completion date	Notes
*EXAMPLE					
Planning & Construction	Antifouling to be applied to essential areas only and not over entire structure	Developer			
	All paints and coatings to conform to BSI ???	Developer			
	Lighting & marking of device to be agreed by consultation with NLB as part of consenting process.	Developer			
Installation	Local contractors will be used where practically and economically possible	Developer			
	Liaison with OIC Marine Services with regard to use of local harbour facilities.	Developer			
	Notice To Mariners will be issued as required and in accordance with EMEC Standard Operating Procedures.	Developer			
Device Operation	Emergency Response Procedure (ERP) to cover mooring line/device failure will be established in line with EMEC's ERP.	Developer			
	An Environmental Monitoring Plan approved by MS-LOT will be adhered to.	Developer			
	The noise signature of the device will be defined.	Developer			
Decommissioning	Decommissioning Programme to be submitted to EMEC and DECC.	Developer			

*****The details included in the table above are by way of example only and should not be considered as an exhaustive list. Any other issues/commitments which may be important from an environmental perspective should also be included.



FOR FURTHER DETAILS PLEASE CONTACT:

European Marine Energy Centre (EMEC) Ltd
Old Academy, Back Road, Stromness, Orkney, KW16 3AW
Tel: 01856 852060 fax: 01856 852068
email: info@emec.org.uk web: www.emec.org.uk

C.3. FabTest – Application request form

Falmouth Harbour Commissioners

FaB Test
Falmouth Bay Test Site
Marine Renewables Commissioning Site

Appendix 3 - APPLICATION FORM

COMPANY ....

ADDRESS ....

....

....

CONTACT ....

TEL ....

EMAIL ....

DEVICE NAME		
POSITION (WGS 84)	Lat.	Long.
DEPLOYMENT WINDOW	From:	To:

INFORMATION AND DOCUMENTATION CHECKLIST

This list forms the agenda for the FaBTest Regulatory Panel formal application meeting. Please confirm where in your documentation the information can be found.

	Information required	Document reference
1	**General project overview** To include device operating methodology, drawings, schematics etc. and map showing proposed device location and orientation within the site	
2	**Engineering Risk Assessment** Please complete the overview risk assessment sheet and attach relevant structural drawings of the device plus any other supporting evidence	
3	**Mooring design** Moorings design from the developer's in-house team or appointed contractor	
4	**Independent Mooring design validation** To be undertaken by suitably qualified individual or organisation	
5	**Project execution plan** To include an installation plan and method statement, decommissioning plan and emergency response plan, plus any other device specific documentation	
6	**Quality Health Safety and Environment Management Plan** To include operations and emergencies, seabed habitat risk assessment and a risk assessment of pollution to the marine environment from the test installation	
7	**Independent review of the QHSE plan** To be undertaken by a suitably qualified individual or organisation	
8	**Navigation risk assessment** Showing compliance with the Specifications for Navigational Safety, or notification and description of any requested deviation from these specifications	
9	**Other risk assessments** Risks to the general public emanating from unauthorised access to the moored device, plus other risk assessments specific to the device design, configuration and location	

I confirm that the information provided is correct to the best of my knowledge and belief.

SIGNATURE .... DATE ....

NAME ....

C.4. FabTest – Engineering Risk Assessment

Appendix 4 - Engineering Risk Assessment

Note: A drawing of the mooring system together with a parts list is to be submitted with this completed document (load ratings of components to be specified)

Leave margin clear

Q1	Has the behavior of the device and its finalised mooring system been modeled for the proposed FabTest deployment?		
Q2	What software was used for this model?		
Q3	Enter the coincident environmental conditions used in this model that correspond to peak mooring loads.		
	Hs		(m)
	Wave direction		bearing
	Wave type (regular, irregular, spectral)		
	Wind speed		(ms^{-1})
	Wind direction		bearing from
	Tidal current speed		(ms^{-1})
	Tidal current direction		bearing
	Mean sea level water depth		(m)
Q4	Enter values for the following:		
	Displacement of the floating device		(tonnes)
	Number of mooring limbs in system		
	Predicted peak single limb load (top end)		(kN)
Q5	What factor of safety (FOS) is applied to the mooring system design with respect to the peak limb loads identified in Q4?		
Q6	At what elevation angle (from the horizontal seabed) does the peak seabed end limb load act?		(°)
Q7	What length of chain (per limb) lies on the seabed when the floating device is becalmed and at low tide? If mooring limbs are of unequal lengths this must be specified on an accompanying drawing.		(m)
Q8	Are load cells to be fitted into the mooring system?		
	What is the load range maximum of the load cells?		
	What is the manufacturers declared load limit?		
	Is a back-up line provided to safeguard against failure?		
	Does the back-up line conform to the FOS given in Q5?		
Q9	Have the floating hull and its mooring attachment points been designed to accommodate the top end mooring load stated in Q4 with the FOS as stated in Q5?		

Comments

Margin for FabTest use

Q10 Define the splay of the mooring system in terms of the size of the seabed area occupied e.g. 200 m diameter ____ (m diameter)

Q11 What is the predicted excursion radius of the moored floating device (peak loadings coincident with LAT)? ____ (m)

Q12 Is the floating device positively stable when free floating in the upright condition (pitch and roll angles = 0°)? ____

Q13 At what angles does the free floating device become unstable?

Pitch		(°)
Roll		(°)

Q14 What are the predicted total vertical loads applied to the floating device by the mooring system during calm conditions?

LAT		(kN)
HAT		(kN)

Q15 What is the reserve buoyancy at calm sea HAT? ____ (m^3)

Q16 Describe the construction, material and protective coatings of the hull

Q17 Describe the galvanic corrosion protection measures intended for the hull and the mooring system.

Comments

Margin for FabTest use

C.5. FabTest – Operating Policy 2012

FHC - FaBTest Operating Policy FHC/FT/102

In line with the organisations Health, Safety and Environmental Policies, Falmouth Harbour Commissioners are committed to ensuring that all activities taking place within the FaBTest area do so in a safe manner with due regard to the affect they may have on the environment, other Harbour users and the wider stakeholders.

In discharging this commitment, FHC will ensure that any developer wishing to use the FaBTest site will be fully compliant with their responsibilities as defined by the Health and Safety at Work Act (1974), the Marine and Coastal Access Act 2009 and all other pertinent legislation or regulation.

This will be achieved through an independent review of a developer's project plan (with regard to health & safety) to be commissioned by the berthing applicant and presented to the FaBTest regulatory panel. The independent review will be performed by a suitably qualified and experienced contractor and will assess whether potential developers are fully aware of their responsibilities and have adequately planned to fulfil them. The regulatory panel will also apply the requirements of the FaBTest Device Specific Regulatory System as described in document FHC/FT/101.

Areas for consideration will include, but may not be limited to;

Safety of Navigation

The Falmouth Harbour Commissioners have a duty to ensure the Safety of Navigation for all Harbour Users.

A safety management system is in place as required by the Port Marine Safety Code which looks at the hazards involved with marine operations then establishes controls and procedures to mitigate the risks. Considerations include, but are not limited to;

- Close liaison with Trinity House according to accepted existing practice.
- The effect of deployed devices and associated operations on the safety of navigation.
- The interaction between operational, support and third party vessels.
- The safety of FHC, developer and contractor infrastructure.
- Emergency preparedness.

All vessels proposed for operations at FaBTest must comply with Harbour Regulations and Harbour Master's directions at all times.

Safety of people, assets and the environment during marine operations at FaBTest

To ensure that marine operations are undertaken in a safe manner, it is crucial that;

- Any equipment being deployed is designed and constructed to deal with the loads that will be experienced throughout the life of its deployment.
- The operations are planned by competent persons giving due consideration to the hazards which can occur.
- Vessels and plant used during any marine operations are fit for purpose and in a good condition.
- Operations are executed by trained and experienced personnel.
- All health and safety incidents including near misses are reported to FHC, thus allowing safe operating policy to evolve in an informed manner.

Any developer or contractor wishing to operate at the FaBTest site must ensure that they have planned their marine operations in line with recognised standards. Throughout the life of any deployment or project, the developer or contractor remains responsible for all Health, Safety, Quality and Design issues associated with their project.

To ensure that operations will not be detrimental to the overall safety of the FaBTest site, its infrastructure or other users, a robust auditing procedure is implemented. This is administered by the Regulatory Panel who will ensure that operations planned by device installers and/ or marine contractors are thoroughly vetted by competent personnel where necessary.

Detailed guidelines will be issued to developers to aid them with this process.

Managing interaction between users

In meeting the FHC and developers responsibilities with regard to the safety of the FaBTest site, due consideration must be given to the interaction between various site users. This can include up to three MEC developers at any time.

It is understood that the activities taking place may adversely affect the operations of other users. It is also understood that during periods of high activity, there could be significant numbers of personnel and plant operating at the site. It is therefore important that the activities are coordinated to prevent adverse interactions taking place.

For developers, and marine contractors connected therewith, this will form part of the considerations of the permitting process.

Permits to operate will only be issued once the FaBTest regulatory panel is assured that the operations will not adversely affect any other user of the site, infrastructure or port operations.

In the event that more than one permit has been issued, FHC will ensure that co-operation and communication is in place between the permit holders.

Emergency Preparedness

Operating at sea is an inherently hazardous activity and despite effective controls, we must be prepared in such a way as to minimise the effect of an emergency situation.

Procedures must be in place to deal with a range of emergency scenarios and these must take into account the Port of Falmouth's emergency plan. Lessons learnt from drills and reviews will be used to keep procedures up to date and relevant.

Specific procedures to deal with mooring failure or device excursion will be particularly important.

Insurance

The harbour authority will require all projects to be adequately insured. This will include third party liability insurance and adequate cover for remedial/removal works in the event of a mooring/device failure and/or financial failure of the organisation.

Device owners are required to remove any sunk or wrecked devices from the Site as soon as practicable after the sinking or wreck occurs. They are required to have insurance cover in place against these eventualities which complies with the following;

1. Cover in place to a minimum of £10,000,000.
2. The policy is to name Falmouth Harbour Commissioners as first party insured.
3. The name of the Insurance Company is submitted with the first application.
4. A copy of the policy is to be provided prior to issue of the permit.
5. A bank guarantee or bond is to be provided for any deductable stated in the policy.
6. Evidence is to be provided of payment of premium.
7. The owner warrants that the policy shall not be cancelled whilst the device is deployed. Falmouth Harbour Commissioners interest shall be noted on the policy.
8. The cancellation of the policy whilst the device is deployed shall cause the permit to be rescinded. The bond or bank guarantee shall also become immediately payable.

C.6. FORCE– Financial Highlights

APPENDIX A:

FINANCIAL HIGHLIGHTS

Funding by NRCan's Clean Energy Fund ($23 million) is approximately 10% of total FORCE project funding of $239.6 million.

In other words, FORCE's initial seed funding is expected to leverage nearly 10 times its investment. Please refer to tables below for further explanation.

FUNDING: Total Projected	
Government sources (approximately 15% of total funding)	
Province of Nova Scotia	$11,225,000
ACOA	$1,686,788
NRCan: Clean Energy Fund	$24,000,000
Total Government	**$36,207,924**
Private sources (approximately 85% of total funding)	
Berth holder contributions	$14,266,411
Encana Corporation	$3,000,000
TISEC development/deployment *(projected estimate)	$186,174,000
Total Private	**$203,440,441**
TOTAL	**$239,648,335**

PROJECT ELEMENTS: (To date)	
Design electrical systems/facilities and transmit electricity	$16,161,014
Submarine power cable design, fabrication, installation	$14,956,476
Operations	$4,262,444
Collect, analyze, environmental data,regulatory approvals	$2,468,896
Ongoing environmental monitoring	$2,170,705
Sensor platform design, build, deployment	$7,900,249
Research/data collection	$1,990,258
Visitors Centre	$1,570,181
Project Planning & Management	$1,994,112
TISEC estimated costs *(projected)	$186,174,000
TOTAL	**$239,648,335**

C.7. FORCE– Project health, safety and environmental expectations

Appendix 1: Advisory Committees – SEENEOH Test site

Members of the Steering Committee	
Caisse des Dépots	Public
Aquitaine Développement Innovation (Aquitaine Development & Innovation)	Private
Bordeaux Gironde Investissement (Bordeaux Gironde Investment Fund)	Private
Bordeaux Métropole (Bordeaux conurbation)	Public
Cérenis	Private
Comité départemental des pécheurs professionnels maritime (CDPMEM 33)	Private
Conseil Départemental de la Gironde	Public
Dalkia France (Groupe EDF)	Private
EDF Delegation Aquitaine	Private
Energie de la Lune	Private
ENEDIS	Private
Grand Port Maritime de Bordeaux (Bordeaux Great Maritime Port)	Public
GTM Sud-Ouest TP/GC (Groupe Vinci)	Private
Mixener	Private
Neotek	Private
Région Aquitaine - Limousin- Poitou Charentes (Aquitaine - Limousin- Poitou Charentes Region)	Public
SEENEOH SAS	Private
SEMI Route des Lasers	Private
EVIAA MArine	Private
Valorem	Private

Members of the Scientific Council
AADPPED 33
Agence de l'Eau Adour-Garonne
CDPMEM
CEREMA
Conseil Scientifique de l'Estuaire
DDTM
DREAL
Energie de la Lune
Grand Port Maritime de Bordeaux (Bordeaux Great Maritime Port)
IFREMER
IRSTEA
MIGADO
REGION AQUITAINE LIMOUSIN POITOU CHARENTES (AQUITAINE LIMOUSIN POITOU CHARENTES REGION)
SMEAG
SMIDDEST
Université de Bordeaux (University of Bordeaux)
AADPPED 33

C.8. Seeneoh – Advisory Committees

FORCE frequently engages contractors (referred to as the "Constructor"), and other supporting contractors and subcontractors, as part of its ongoing operations.

FORCE acknowledges that under the *Nova Scotia Occupational Health and Safety Act* (OHS Act), the Constructor has responsibility to take every precaution that is reasonable in the circumstances to ensure:

a) the health and safety of persons at or near a project;
b) that the activities of the employers and self-employed persons at the project are co-ordinated;
c) the full communication, between the employers and self-employed persons at the project, of all information necessary to the health and safety of persons at the project,
d) the facilitation of communication with any committee or representative required for the project pursuant to the OHS Act or the regulations;
e) that the measures and procedures prescribed under the OHS Act and the regulations are carried out on the project;
f) that every employee, self-employed person and employer performing work in respect of the project complies with the OHS Act and the regulations.

FORCE also has a responsibility to take every precaution that is reasonable in the circumstances to provide and maintain its premises:

a) in a manner that ensures the health and safety of persons at or near the workplace
b) in compliance with the Act and the regulations, and
c) to give to the employer at the workplace the information that is;

(i) known to the owner or that the owner could reasonably be expected to know, and

(ii) necessary to identify and eliminate or control hazards to the health or safety of persons at the workplace.

FORCE provides this document as over-arching guidance for the Constructor (and/or contractor) when the Constructor (and/or contractor) creates and implements the policies, procedures, or practices required to manage the work in a healthy, safe, and environmentally responsible manner.

This document is divided into two sections: HSE Administrative Considerations; and HSE Operational Considerations.

1.0 HSE Administrative Considerations

1.1 Policy

The Constructor shall have in place, or create for the project, suitable Health, Safety and Environmental policies to inform all parties of their responsibilities to comply with the Nova Scotia health, safety and environmental related statutes and regulations.

The Constructor policies, procedures and/or practices should clearly inform the supporting contractors and subcontractors of the Constructor's requirements to establish, implement, and maintain the work in a healthy, safe and environmentally-responsible manner.

1.2 Legislative / Regulatory Compliance

It is the FORCE expectation that the Constructor shall plan, coordinate, and execute the work to which it has been appointed in accordance and compliance with the relevant Health, Safety and Environmental Acts, Regulations, Standards, and Guidelines applicable to the work. FORCE may conduct an evaluation of the Constructor's adherence with the relevant Health, Safety and Environmental Acts, Regulations, Standards, and Guidelines applicable to the work, if it deems necessary.

1.3 Performance Measurement

It is the FORCE expectation that the Constructor should have in place adequate guidance in terms of establishing expected levels of performance, methods to inspect, audit or assess performance to Constructor requirements, and the tools to regularly measure and report to the Constructor the status of compliance with the expected levels of performance.

1.4 Training, Certification and Competence

It is the FORCE expectation that the Constructor shall ensure that the Constructor's personnel, and the personnel of the supporting contractors and subcontractor for which the Constructor is responsible, are appropriately trained and, where necessary certificated pursuant to the Nova Scotia *Technical Safety Act*, to undertake the work for which they have been hired.

Training and/or certification do not result in competence. In the Nova Scotia *Occupational Safety General Regulations*, 'competent person' means a person who is:

> (i) qualified because of that person's knowledge, training and experience to do the assigned work in a manner that will ensure the health and safety of every person in the workplace, and
>
> (ii) knowledgeable about the provisions of the OHS Act and regulations that apply to the assigned work, and about potential or actual danger to health or safety associated with the assigned work

The Constructor is to ensure that all personnel conducting the work, and in particular critical work which may result in injury to a person or damage to the environment, are properly certificated and deemed competent to conduct that work.

The training expectation includes an appropriate Workplace or Project Orientation (or Familiarization) program/session for all personnel prior conducting the work. FORCE may request proof of training.

1.5 Health, Safety and Environmental Communications

It is the FORCE expectation that the Constructor is to ensure, for the FORCE workplaces for which the Constructor is responsible, that an effective HSE communications process is established and maintained, such that important information regarding health, safety and environmental hazards and their work place controls flows among the Constructor, contractors, subcontractors, owner, and any other person who may be affected by the work. This communication process must flow both ways: to transmit and to receive important information.

The HSE communications expectation includes an appropriate Pre-Job Safety Meeting in which the Job Hazard Assessment (see Section 2.1, below) is discussed among the personnel conducting that task, and any other HSE issues that may arise during the meeting.

1.6 Workplace Health and Safety Representation

Where required by the OHS Act, or by an order or direction from a Labour Officer or an Environmental Officer, the Constructor will ensure that a Joint Occupational Health and Safety Committee or a Workplace Health and Safety Representative is elected or appointed in accordance with the applicable regulatory provision.

1.7 Handling of Incident / Accident Information

It is the FORCE expectation that the Constructor will ensure that an effective Incident/Accident investigation and management process is in place during the work, such that:

- all personnel are familiar with the Constructor's requirements for incident reporting (see Section 2.2, below)
- the Constructor reviews the incident information and takes appropriate action to remediate any injury or damage, and takes the appropriate steps to eliminate the reoccurrence of the incident / accident, or at least to mitigate the harm or damage from such an incident in the future

The Constructor will report all incidents and accidents to the FORCE designated representative as soon as practicable, including a summary of the actions taken to mitigate the harm and prevent reoccurrence of the event.

1.8 Work Refusal Process

In accordance with the requirements of the OHS Act, it is the FORCE expectation that the Constructor, and any supporting contractors or subcontractors for which it is responsible, have in place a documented process to receive and manage Work Refusals based upon health or safety grounds, and that this process is explained and is clearly understood by all personnel working on the project.

Further, it is the FORCE expectation that any case of a health or safety work refusal is reported to the FORCE designated representative as soon as practicable, prior to finalizing the situation.

2.0 HSE Operational Considerations

2.1 Job (or Task) Hazard Assessment

The Constructor shall conduct its work so as to be in compliance with the regulatory requirements for hazard identification, assessment, communication, and control system, as embodied within the OHS Act and pursuant regulations, that includes:

(i) evaluation of the workplace to identify potential hazards,

(ii) procedures and schedules for regular inspections (see Section 2.3, below),

(iii) procedures for ensuring the reporting of hazards and the accountability of persons responsible for the correction of hazards, and

(iv) identification of the circumstances where hazards must be reported by the employer to the committee or representative, if any, and the procedures for doing so

It is the FORCE expectation that the Constructor shall ensure that its personnel, and those of the supporting contractors and subcontractors for which it is responsible, conform to the requirements of the Constructor's Job (or Task) Hazard Assessment procedure or process, particularly in respect of conducting and communicating the results of Pre-Job or Pre-Task Hazard Assessments.

Constructor should ensure that where a Hazard Assessment has established and documented certain hazard controls for the performance of the work, that such controls are implemented. It is the FORCE expectation that workplace deviations from those controls will be documented for Constructor and FORCE post-project review.

2.2 Incident / Accident Reporting

It is the FORCE expectation that the Constructor will establish, implement and maintain an incident/accident notification, reporting, investigation, and management system that is regulatory-compliant and fit-for-purpose for the work the constructor is undertaking.

Personnel are to understand the definitions that the Constructor has established as an incident / accident, how and to whom to report the event, including the applicable regulatory authorities (OHS, WCB, Environment), and the Constructor's requirements for incident documentation.

2.3 Work Place Inspection

It is the FORCE expectation that the Constructor, and the supporting contractors and subcontractors for which it is responsible, establish, implement, and maintain a Work Place Inspection System pursuant to the regulatory requirements of the OHS Act that encompasses the facilities, equipment, and critical equipment maintenance associated with the work.

The Constructor Inspection System should include a process to establish and implement an inspection schedule, appropriate documentation to record the inspection findings, and a process to report the findings and to take action to correct identified deficiencies.

2.4 Safe Work Procedures and/or Practices

It is the FORCE expectation that the Constructor, and the supporting contractors and subcontractors for which it is responsible, establish, implement, and maintain applicable, appropriate, and adequate safe work procedures or practices for at least identified critical tasks, including any task where there exists a risk of a serious consequence in terms of health or safety of an individual, damage to the environment, or damage to critical equipment.

The safe work procedures or practices should be documented and made available to the work force to ensure continuity of information as they are used by different personnel, possibly in different situations.

2.5 Emergency Preparedness and Response

It is the FORCE expectation that the Constructor will establish, implement and maintain an effective plan for emergency preparedness, as well as appropriate and achievable actions to respond to a health, safety or environmental emergency. This should include the definition of, and pre-positioning of, appropriate spill clean-up materials at suitable locations.

The plan should be documented and all personnel made familiar with its contents, including reporting requirements, during the orientation or familiarization sessions (see Section 1.4, above).

2.6 Spill or Emission Reporting and Clean Up

It is the FORCE expectation that the Constructor will establish, implement, and maintain an effective plan for identifying and cleaning-up any spill in terrestrial or marine environments, or emission to the air, and to include the regulatory reporting of any event that exceeds legislated limits.

Further, it is the FORCE expectation that the Constructor take immediate and effective steps to stop the source of the spill or emission, isolate the spill where possible, clean up the spill and dispose of the clean-up materials and spills residuals in an environmentally-responsible and regulatory-compliant manner.

Any spill or emission and details regarding its clean-up and reporting to regulatory officials are to be reported to the FORCE designated representative as soon as practicable through the incident/accident reporting system (see Sections 1.7 and 2.2 above).

2.7 Work Place Rules

It is the FORCE expectation that the Constructor will establish for all personnel on the project, a set of appropriate and enforceable work place rules to identify and communicate Constructor requirements with respect to work place behaviours and the actions that may be taken should those work place rules be broken by any party.

Further, it is the FORCE expectation that the Constructor work place rules will prohibit the presence, consumption, offering to provide, or providing (whether as a gift, loan or sale) of alcohol and drugs. Drugs include illicit and legal substances other than emergency response medicines administered by a competent First Aider/ Medic in response to a medical emergency. Legal substances include prescriptions and over-the-counter patent medicines that can impair a person's ability to safely operate machinery/equipment, road vehicles or water craft.

2.8 Personal Protective Equipment

It is the FORCE expectation that the Constructor will establish the appropriate types of Personal Protective Equipment (PPE) to be used by personnel conducting tasks that require the wearing or use of PPE.

Further it is the FORCE expectation that the Constructor's HSE policies (see Section 1.1, above) and Safe Working Procedures or Practices (see Section 2.7, above) will establish that the proper wearing and use of PPE is mandatory for all personnel for those tasks where PPE has been established by the Constructor as being necessary.

All PPE authorized for use by the Constructor, for its personnel and for the personnel of the supporting contractors and subcontractors for which the Constructor is responsible, shall conform to the standards specified within the OHS Act, the Nova Scotia *Technical Safety Act* and the regulations pursuant to those two pieces of legislation.

2.9 Environmentally Sensitive Areas / Endangered Species

It is the FORCE expectation that at no time will the Constructor plan or conduct its work in a manner that will cause risk to an environmentally-sensitive area, or cause a risk to any endangered species. The Constructor shall conduct its work in adherence with FORCE's Environmental Management Plan (EMP), which is available upon request.