Offshore Supply Chain Requirements for Ocean Energy in Europe - Results from the ORECCA Project

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Abstract

This paper presents results of the ORECCA project [1]. Combining the data and projections from the infrastructure report with other available data, the current deployment and O&M status regarding ocean energy, the ocean energy (OE) installation schedule and impacts on requirements, OE port- and vessel specifications and classifications, conflicts, synergies and overlapping of offshore wind industry requirements with these of the ocean energy industry regarding shared use of port infrastructure and vessels and co-location of offshore renewable energies converters including area identification and resource quantification utilizing geographical information systems (GIS) are highlighted.

Keywords: Co-location, installation schedule, port requirements, vessel requirements.

1. Introduction: The ORECCA project

The ORECCA (Offshore Renewable Energy Conversion Platform Coordination Action) Project is an EU FP7 funded collaborative project in the offshore renewable energy sector covering offshore wind-, wave- and tidal current energy. The project's principal aim is to overcome the fragmentation of know how available in Europe and transfer it amongst research organizations, industry stakeholders and policy makers. The project's focus is pan European and pan technology, with a specific focus on the opportunities that exist across Europe when the three offshore renewable energy sectors within the project's scope are considered together.

The results in the form of reports delivered and data made available are structured around the following five key streams which are essential to the development of the offshore renewable energy sector:

- Resource,
- Finance,
- Technology,
- Infrastructure,
- Environment, Regulation & Legislation.

The results for the five key streams are published in ten topical reports available for download on the document section of the ORECCA website [1].

One main objective of ORECCA was to develop roadmap studies for the research-, deployment- and regulatory activities in this field. The roadmap aims at defining the strategic priorities, including socio-economic aspects, for the development of offshore renewable energy conversion platforms in the context of an integrated European maritime policy.

2. Ocean energy project pipeline

As part of the ORECCA report on offshore infrastructure [2] a project pipeline has been developed which shows the cumulated capacity of announced projects. It covers leasing rounds for OE farms and their specified timeframe and capacity as well as announced projects by OE converter manufacturers, utilities and other types of investors who have published plans to install and operate devices commercially. The outcome of this investigation is presented in form of the project pipeline in Fig. 1, showing the predicted cumulated capacity of installed OE converters, separated into technology groups in specific years.

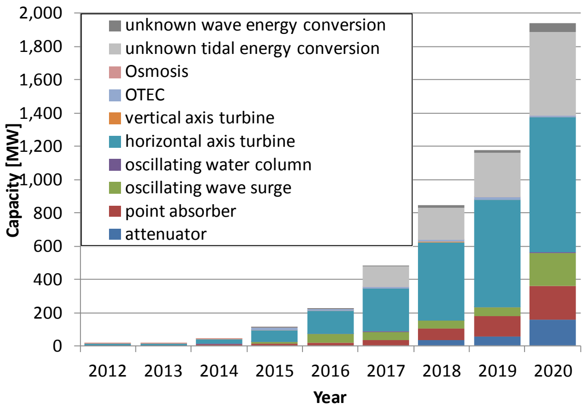

Figure 1: Installation schedule of different wave and tidal conversion technologies in Europe 2011 [2, updated]

In the context of the National Renewable Energy Action Plans (NREAP) UK, France, Portugal, Spain and Ireland have announced binding national targets of 1880 MW of OE capacity in total. During the investigation it became clear that despite these announcements the UK projects announced in the course of the first OE leasing round by the British Crown Estate alone account for 1,900 of the approx. 1,940 MW of OE scheduled to be installed until 2020 throughout Europe. The installation in and around the Pentland Firth in Scotland is scheduled from 2013 to 2020 and the second round in the Irish Sea near the coast of Northern Ireland (installation possibly from 2015 on). As shown in Fig. 1, a major share of technologies is for horizontal axis turbines, accounting for at least 800 MW alone; no technology has been chosen for the 200 MW Westray South development zone at the Pentland Firth and the 300 MW zones in the Irish Sea yet. Outside the UK waters only very few and relatively small projects have been announced and it remains to be seen how those countries with National targets in OE are going to meet those by 2020.

3. Offshore supply chain

In support of the installation and maintenance operations it has to be made sure that an appropriate supply chain is in place as soon as the commercial rollout of energy converters begins. The elements of the OE supply chain investigated in the course of the ORECCA project were the electrical infrastructure, ports and installation - as well as operation and maintenance (O&M) vessels.

Four life cycle phases of an offshore renewable energy farm can be identified, where physical presence of personnel and equipment at sea is required: Pre-Installation, Installation, Operation and Decommission (Table 1).

Phase	Pre-Installation	Installation		Operation	Decommission
Tasks	Geotechnical & environmental surveys	Foundations	Turbines	O&M visits	Turbines
		Grid	Substation		Substation
Utilised ports	Port A	Ports A, B&C		Port A	Ports A, B&C
Utilised vessels	Service vessels	Service and installation vessels		Service vessels	Service and installation vessels

Table 1: Life cycle phases of an offshore renewable energy farm

The different tasks to be carried out during these phases require ports with certain properties and facilities as well as the utilization of a variety of vessels with certain abilities and features (Table 1). E.g. port A is a small local port that is used by small service vessels to realize the service crew transfer to and from the farm. In contrast, ports B and C provide infrastructure for installation and assembly of foundations, energy conversion devices, substations etc. and might be much further away from the farm site.

3.1 Offshore energy farm installation strategies

Regarding the installation process of offshore energy farms two different approaches are currently of interest, each making use of different types and numbers of installation and transport vessels:

- Feeding (Fig. 2): Feeder vessels or barges with tugs transport components, foundations or complete devices from a port to the installation area (blue arrows) where the items are transferred to stationary installation vessels with the help of onboard cranes. Afterwards the feeder vessels return to the port to reload additional items while the installation vessels stay at sea to assemble and/or install the devices or foundations (green arrows). Transferring components offshore might require about 20 % more time [3] than loading items in an appropriate port. However, this installation strategy can be time saving as a constant flow of items to be installed can be maintained, resulting in a high degree of utilization of the installation vessels with typically significant daily operating rates. Of course a sufficient number of feeder vessels are required to achieve this, probably affecting the farm's installation costs at a significant level, dependent on the feeding distance to cover.

Figure 2: Feeding installation strategy [4]

- Transiting (Fig. 3): Components, foundations or fully assembled devices are loaded directly onto installation vessels in a port and are then transferred to the installation area (green arrows) where they are assembled and installed. Afterwards the installation vessels return to the port to reload additional items.

This strategy requires no other vessels than the installation vessels but can be time consuming, especially when the installation area is not near the port of call: Long transit routes lead to a lower degree of utilization of the installation vessels and may lead to an uneconomical installation process. To avoid this, the items to be installed can be transferred from the far port to a local mobilization port by transport vessels at reasonable costs. The installation vessels now load at the mobilization port and transit from there, benefiting from the shortened distance to the installation area. The same method could be applied to the feeding strategy if desired. Where floating OE devices are tugged to the site the installation procedure becomes a variation of the transiting strategy. It has to be stressed that due to low sailing speeds of typically few Knots only transition times of tugging teams can be substantially longer than transition times of loaded transport vessels but transport costs are still likely to be significantly lower. The requirements on weather windows are of course substantially different.

Figure 3: Transiting installation strategy [4]

3.2 Installation durations

Regarding OE farms there are currently not enough empiric data available to make general statements about concrete installation durations as the commercial roll-out of OE devices will not begin before the installation of the Pentland Firth projects from 2013 onwards. A study by Imperial College London [5] makes a forecast for installation and O&M vessels for tidal current converters under the following assumptions:

- Installation can only happen at slack tide,
- Day light slack tides occur each 24 h period,
- The distance from the installation port is 30 nautical miles (approx. 56 km),
- The speed of the installation vessel is 5 kn (approx. 9 km/h),
- The capacity of one tidal energy converter unit is 1 MW.

The result of these calculations is that one vessel is needed for one day to install 1 MW of tidal energy capacity. The Crown Estate estimates a duration of one to two days for installing a single OE converter of non specified capacity and type [6]. Drawing conclusions from the installation experience and statistics of the offshore wind energy sector it can be expected that installation durations per item are massively reduced with increasing numbers of items to be installed along typical learning curve as it was found during the ORECCA investigations (Fig. 4). The reasons behind this are the gathered experience of all personnel in the supply chain (especially vessel crews) on the one hand and the increasing adaption of technical equipment and supply chain facilities (specialized port infrastructure and modified or purpose built installation- and crew transport vessels) on the other hand.

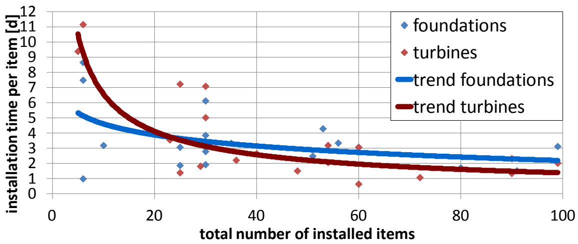

Figure 4: Mean installation time of offshore foundations and wind turbines over total number of installed items [2]

3.3 O&M operations regarding OE

The Crown Estate considers typical ocean energy devices to have a 25 year design life but points out that many contain wear-parts or consumables such as lubricants that need to be exchanged a number of times during the lifetime of the device. Typically a 5 year rolling program of planned maintenance is proposed for devices that are not accessible for in-situ maintenance. For devices where in-situ inspection is possible, intervals of six months are preferred for some systems. Beside of planned maintenance condition based and maintenance in cases of failures is considered: Depending on access to the device and the type of failure, these activities could entail anything from a short visit to returning the device to shore for a strip-down and rebuild of key components [6].

3.3 Vessel demand forecast

The resulting numbers of vessels required for different installation scenarios according to [5] without considering O&M requirements are shown in Table 2.

	2012-2015	2015-2020	2020-2025	2025-2030
Best case	4.3	8.1	8.7	21.1
Mid case	1.3	1.4	2.1	7.1
Worst case	0.4	0.6	1.1	1.3

Table 2: Tidal energy installation vessel demand forecast [5]

The installation schedule presented in Fig. 1 corresponds to the „Institution Medium Scenario“ in [5] and is therefore placed between the “Mid case” and “Best case” scenarios in Table 2. According to [5] the vessel demand forecast suggests that, unless the best case scenario occurs, there is unlikely to be a problem with the supply of installation vessels during the transition from pre-commercial to commercial scale roll-out between 2012 and 2020. In case the vessel type used for installation and O&M services is the same, an increased demand of installation respectively O&M vessels of up to 200 % between 2012 to 2015 and possibly up to 300 to 400 % between 2020 to 2025 is predicted, although the author of the study explicitly states that this figure has not been rigorously researched.

Dating back in 2009, reference [5] does not account for the discussed tidal projects in the Irish Sea announced in 2011 which are scheduled to be installed partially parallel to the Pentland Firth OE farms. Consequently the announced figures would have to be multiplied by about 1.2 to match the new situation. Furthermore the presented numbers consider vessels related to the installation of tidal energy converters only: From the shares of tidal and wave energy converters in the installation schedule in Fig. 1 it can be concluded that at least about 50 % vessels are required additionally for the installation of wave energy converters. In fact higher numbers are to be expected due to the fact that the rated output of wave energy converters is typically lower than that of tidal current devices and therefore higher numbers of wave energy devices are required for a farm with identical capacity.

3.4 OE utility vessel specifications

Regarding OE installation- and O&M vessels it has to be taken into account that the environmental conditions at the installation site are inevitably harsh, with strong water currents or high waves present. This complicates installation and maintenance and massively limits time windows for safe vessel operations. Therefore utilized vessels must be able to perform installations and maintenance quickly and be able to maneuver and keep station during times of high water current velocities and high significant wave heights. The Crown Estate states that the situation regarding the maintenance of OE converters like the Pelamis device by Pelamis Wave Power may be less serious, as these devices may be towed to an O&M port or shipyard for servicing without much time spent on site. That does however imply the disconnection of the mooring lines as well as the power cable for each maintenance procedure.

As OE devices come in a great variety of sizes, weights and shapes and the commercial roll-out of devices has not begun yet, common installation procedures and vessel specification standards have not been developed by now. Several device manufacturers have or are planning to modify standard vessels or develop designs of purpose built vessels; in this context The Crown Estate proposes the use of dynamic positioning (DP) systems. The use of jack-up vessels may be required for installation of some devices. The utilization of such vessels may become more economically viable in the near future as a considerable number of less capable jack-up barges and self-propelled jack-up vessels may not be required anymore for offshore wind installation services, but project developers and device manufacturers are seeking alternative methods - e.g. float-out-and-sink operations. Where piling is required, novel tooling may be used to enable drilling and installation in a single operation. In [5] a long hulled, semi-submersible catamaran is proposed as the best suitable vessel type for installing and also servicing tidal energy converter units. Taking advantage of the catamaran design’s good stability under rough weather conditions a converter device could be transported and assembled between the two hulls. Featuring even better behavior in heavy seas than catamarans, SWATH vessels can also be considered as possible installation vessels. In fact, tidal energy converter manufacturer OpenHydro Group first utilized a purpose built catamaran barge, the “OpenHydro Installer”, to transport, submerge and recover their turbine since 2008. As an alternative to this scheme the chartering of sheerleg barges together with appropriate support vessels is brought up, considering that these vessels will be rarely used by the O&G and offshore wind industry in the future and therefore their deployment will be most economical. There is however an evident financial risk that future increasing activities of the Oil and Gas industry in the North Sea as a result of increased world market prices and recent discoveries of further reserves might absorb a significant share of the general purpose vessels available on the market which would result in a significant increase of prices for such services.

3.5 Port specifications regarding OE

Regarding OE the schedule of the project pipeline suggests that there could be a significant step up from small scale installation (project phases with capacities of 10 MW order) in 2013 to 2015 to large scale installation (capacities over 100 MW) from 2016 onwards. Such a step would require suppliers to move from low volume to high volume techniques, requiring more storage and assembly space as well as more efficient installation methods. The Crown Estate expects that the assembly and commissioning of OE devices is carried out onshore. Key requirements for construction ports suitable for a range of devices include [6]:

- Heavy lift capacity of up to 1,000 t,
- Large lay-down and storage areas of several hectares to enable assembly of components and rapid deployment of devices for larger scale developments,
- Suitable space for final assembly adjacent to the quayside,
- Dry and potentially wet commissioning of electrical parts with the need for a sufficient quay length for in-water activities that could exceed 200 m,
- Supply of support vessels and personnel. During installation of an individual project phase up to

six vessels and several person years of support are required on site,

- Sufficient draft and beam to facilitate movement of vessels and devices at a range of tides.

O&M ports should have the following properties:

- A quayside lifting capability to lift the device to shore,
- Local workshop facilities to allow strip down, refurbishment, re-assembly and testing of devices,
- A local skills base with mechanical and electrical technicians and familiarity with devices and necessary maintenance requirements.

3.5 OE utilization zones and ports in GIS

ORECCA provides several databases online including a web based GIS application, covering resource information across Europe including information such as national Exclusive Economic Zones, bathymetry, wind speed, wave power, tidal stream sites, exclusion zones, distance to shore, ports, installed RE projects and project pipelines [1]. Fig. 5 to 7 show the major part of commercial OE power plants or farms in Europe, either operational or in the planning phase. Not portrayed on the presented maps are the operational PICO oscillating water column plant located at the Azores under Portuguese jurisdiction and the also operational Kobold I tidal current power plant located in the Strait of Messina under Italian jurisdiction.

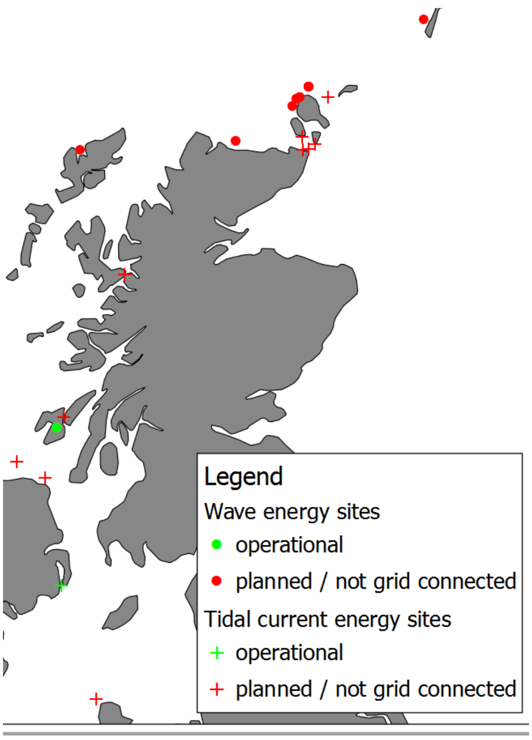

Figure 5: Operational and planned wave- and tidal current energy converters around the British islands 2011

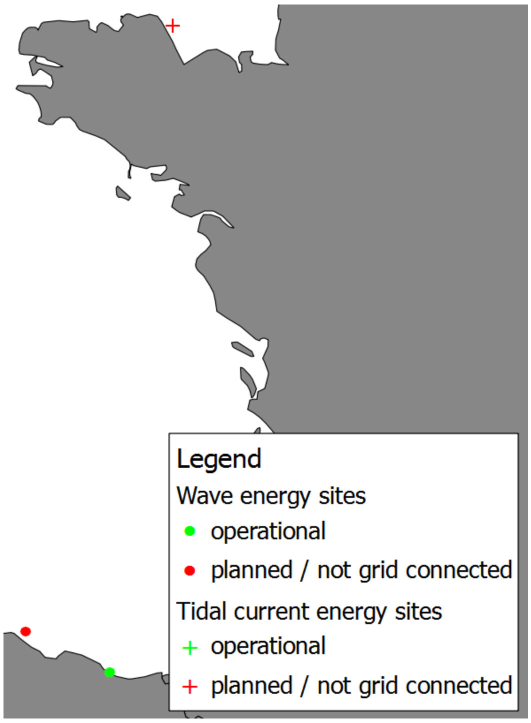

Figure 6: Operational and planned wave- and tidal current energy converters at the French and Spanish coasts 2011

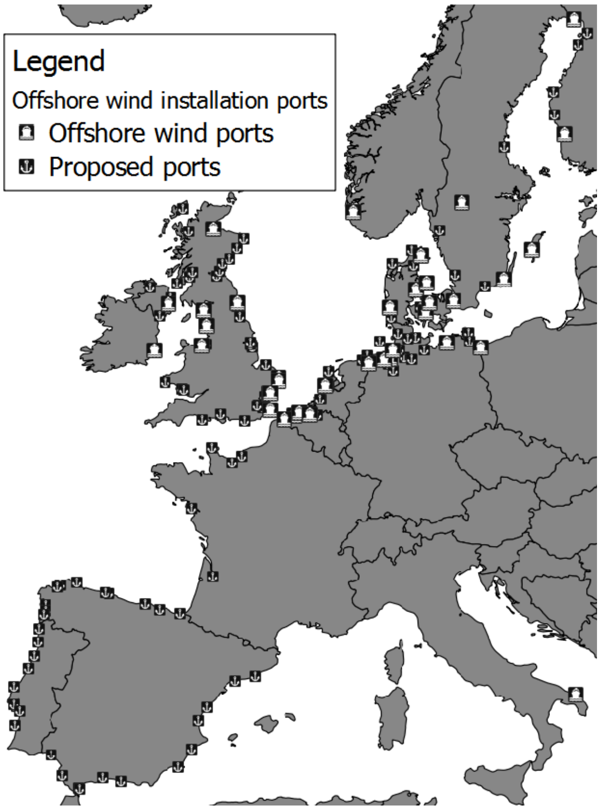

Figure 7: Ports utilized for offshore wind installation operations in Europe [2]

3.6 Synergies of OE- and offshore wind utilization

In comparison to the offshore wind industry, OE operations have much lower port requirements (see [2] for details) due to the significant smaller size and weight of the utilized OE devices compared to state of the art offshore wind turbines that have to be handled. In fact, ORECCA investigations showed that except for the potential need for dry dock capacities all OE requirements towards construction- and O&M ports are more than fulfilled if a port meets the specific requirements for offshore wind operations, may it be storage areas, clearances, quay lengths and -maximum loads or lifting capacities.

Regarding the utilization of installation- and O&M vessels in the OE sector the shifting in the offshore wind sector from utilizing multi-purpose vessels to utilizing highly specialized purpose-built wind farm installation vessels offers the opportunity to utilise general purpose vessels from that sector at a highly economical level.

Probably the most obvious synergy of OE and offshore wind utilization is the use of a common electrical infrastructure, such as specific converter stations, export cables and grid landing point facilities. If a co-location of OE- and wind energy devices is considered, also many tasks from the pre-installation- and survey phase of the co-located project are not necessarily performed a second time, which saves time and costs. While ORECCA investigations found the possibility of co-location of devices an excellent possibility to save resources, the utilization of hybrid devices, combining e.g. one or more wave- and wind energy converters, was considered to be technically immature and unfeasible at this time requiring further engineering work and research.

The approach and results of ORECCA are complemented by the MARINA Platform research project. Whereas ORECCA looks into a technology and market perspective based on the resources, MARINA Platform goes further into the technology development, methodology assessment and guidelines, looking towards possible combined solutions [7].

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