WP2- Deliverable 2.6

Annual study of EU-OE sector development and opportunities – Updated report: 2017

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1. Introduction

The OCEANERA-NET project has been funded for a duration of 4 years starting in December of 2013. In this, the fourth year of the OCEANERA-NET project, work is continuing among the consortium members to build on the efforts of the first three years, including the successful launching of two joint calls for RTDI projects in Marine Renewable Energies (MRE). In addition, several initiatives stemming from the definition of new Joint Activities (WP 3.3) among participating project partners are being carried out and have necessitated the prolongation of the original project duration by three months (the new project closing date is February 20th, 2018).

To summarize the ongoing OCEANERA-NET work, the following list includes project priorities currently under consideration:

- Execution of the project action plan in order to deploy joint activities supporting the development of the MRE sector,
- Laying the framework for continued cooperative action between OCEANERA-NET consortium members and other European stakeholders to continue work beyond the lifespan of the current project.

In this context of continued efforts and in following the initial description of work, Work Package 2 of the project has moved beyond initial data collection/analysis, and the building of a consortium common language, to continue the updating of work completed during the first phases of the project. WP 2 also continues work in support of:

- Joint activities deployment and dissemination of results (WP 3),
- Development of activities surrounding consortium joint calls for proposals (WP 4),
- Implementation of the plan for communication (WP 5).

Initial data collection and analysis taking place in 2014/2015 was updated with additional data collection from late 2015 (cf. D2_6_Annual_Study_Updated_2016). The updates from late 2015 concern the solicitation of continued participation in Programme Management and Science & Technology Mapping surveys. A specific questionnaire was also designed to help support directly the OCEANERA-NET joint call for proposals decision making process by requesting information from MRE stakeholders on RTDI priorities for the near future and preferred Technology Readiness Levels of research. Results of these data collection efforts and subsequent analysis were described in the previous update of this report. The collected data allowed the updating of programme financing information available on the European Research Knowledge Centre on-line database and the science and technology information available on the OCEANERA-NET project web site.

Updates to this report are based on information gathered from continued Joint Activities of the OCEANERA-NET project, reference to current documents and reports treating marine renewable energy topics and additional information from OCEANERA-NET project participants.

2. The Ocean energy sector

Recent key developments of the ocean energy sector

From the year 2014, the ocean energy has been the subject of different initiatives at European level. In 2014 it was launched the Communication *Blue Energy Action needed to deliver on the potential of ocean energy in European seas and oceans by 2020 and beyond (COM(2014)8)*.

In the same year was created the Ocean Energy Forum which helped to put the industry at the task of identifying the common actions needed to bring the technology to the market.

In 2015, ocean energies were included into the Strategic Energy Technology Plan (SET-PLAN). *The Declaration of Intent on Strategic Targets in the context of an Initiative for Global Leadership in Ocean Energy* [1]set for the targets to these technologies to make a significant contribution to the future European energy system. To get this participation in the European energy mix, the Levelised Costs of Energy (LCoE) targets for wave and tidal technology have to evolve as is presented in the following table:

TECHNOLOGY	YEAR	TARGET
TIDAL	2025	15 cEUR/kWh
TIDAL	2030	10 cEUR/kWh
WAVE	2025	20 cEUR/kWh
WAVE	2030	15 cEUR/kWh
WAVE	2035	10 cEUR/kWh

Table 1: LCoE targets. *Declaration of intent on strategic targets*

The European ocean energy sector is a world leader in technology development and several experiences in the deployment of technologies for ocean energy exploitation have been tested in European waters. Nevertheless, there is needed to improve the performance of ocean energy technologies throughout the innovation, supply and value chain. Maintaining this leadership position will allow the European countries to export technology and high added value products to the rest of the world.

To reach the targets appointed in the SET-PLAN, it is expected the improvement in the reliability and survivability of the ocean energy converters. The device availability and capacity factor should be increased as much as possible. For the availability at least 80% in 2025, 90% in 2030 and 95% in 2040 should be targeted.

As can be seen in the following graph, the costs of developing an ocean energy technology project evolve as the sector moves further towards industrialisation.

[1] SET-PLAN

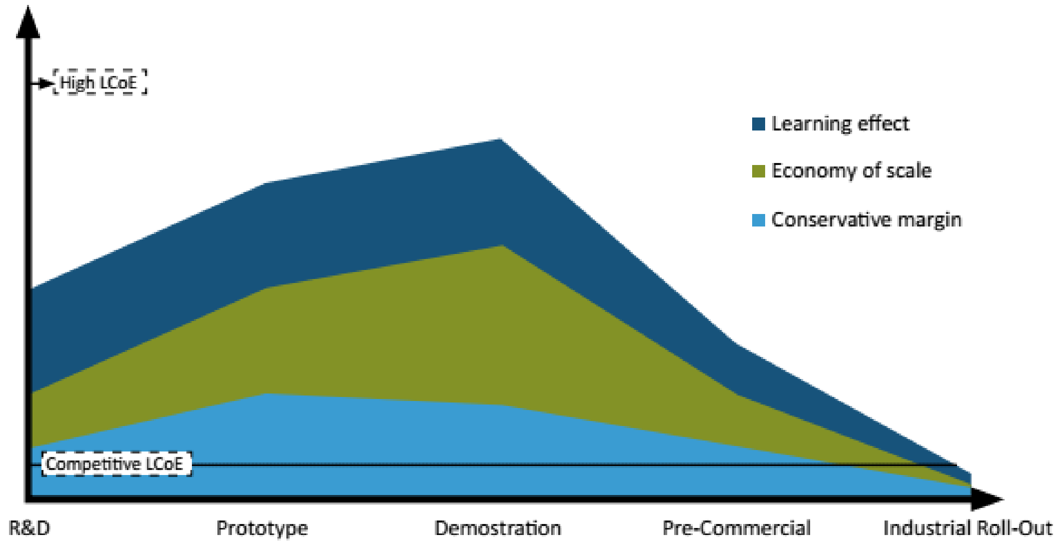


Figure 1: Strategic Research Agenda for Ocean Energy European Technology and Innovation Platform for Ocean Energy

Early R&D stage is less capital intensive than the first demonstration arrays. After the first demonstration arrays go into the water the economies of scale and learnings will allow the sector to engage in a steep cost reduction path, bringing down the Levelised Cost of Energy.

Significant technology cost reductions are required to meet the targets of the SET-Plan and the policy framework at European level must provide the stability and commitment to bring ocean energy technology to the market.

2016 has been an important year for the ocean energy sector given the significant developments have taken place and the reinforcement of the European institutions in the commitment to the development of ocean energy technology. The SET-Plan Declaration of Intent has set out ambitious targets for the ocean energy industry and ensures the support of the EU through research, demonstration and innovation actions.

The roadmaps developed by the Ocean Energy Forum and by the European Technology and Innovation Platform for ocean energy have identified key actions for making ocean energy a commercial reality in the EU and on a global stage.

The development of the ocean energy market implies the creation of a new industrial sector with important impact on the regional economies. The value chain associated to ocean energies is very broad and involves different levels of activity, from the R+D+I system, to the level of providers of every element and component and the providers of services for operation and maintenance. All of this, associated with the creation of high-skilled jobs and the maintenance of the existing employment rates all along the value chain.

A favourable support over the coming decade is needed to allow the transition from the R&D stage to a pre-commercial stage. This implies the access to finance, both public and private and the reduction of costs and risks to make the ocean energy sector more attractive to investors.

Technology status and development

In order of decreasing technological maturity and commercial development ocean energy sectors can be ordered as follows (Indicta & France Energies Marines, 2014):

1. Tidal energy
2. OTEC
3. Wave energy
4. Osmotic energy

The OCEANERA-NET programme is considering tidal energy (tidal range and tidal current,) OTEC, wave and salinity gradient technologies in its funding efforts and this report will reflect this fact by only addressing these technologies.

Europe's technological leadership in the sector has been strengthened. Europe accounts for 52 % of tidal stream and 60 % of wave energy developers.

Tidal energy

In the period 2014-2016 the development of tidal energy converters has suffered an important progress towards commercialisation. A number of pre-commercial deployments have taken place in different countries and currently, the tidal sector has reached a critical phase of development, where demonstration farms are needed, with a clear focus on prioritising deployment and identifying systems for the optimisation of farms.

The increasing number of deployment projects signals that tidal energy has reached a high level of technological maturity. The following figure shows the Technology Readiness Level reached by each tidal technology[1]:

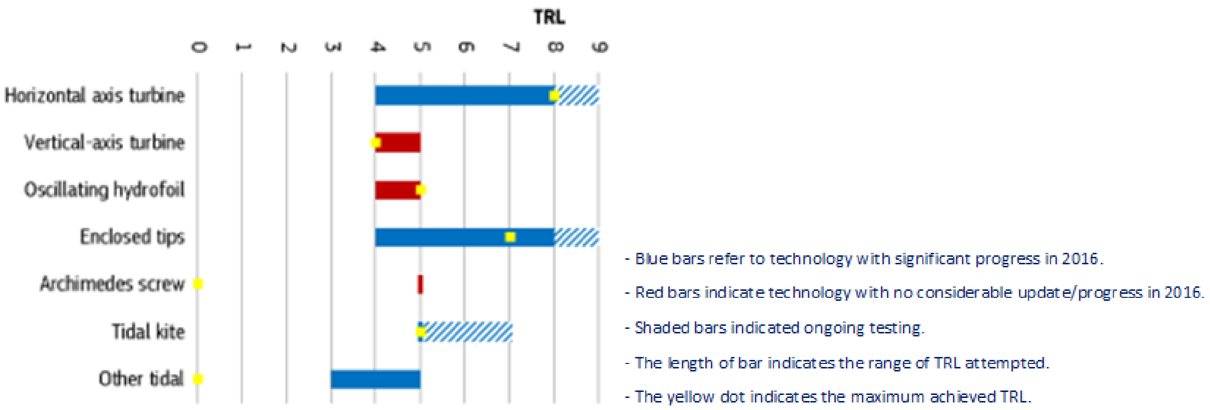


Figure 2: Ocean Energy Strategic Roadmap. Building Ocean Energy for Europe. Ocean Energy Forum

The forecasts indicates the progress towards commercialisation will be small-size turbines and MW-rated devices. The development of small-size turbines were identified as one of the key transition of the tidal energy market together with floating systems. The increase in the number of deployments of small-size turbines (bottom-fixed and on floating structures) appears to indicate that this type of installations are viable and cost-effective. The ongoing developments are encouraging sings for a technology that can be expected to grow considerably in the coming years and play a central role in European energy system.

The following table shows the major tidal current pre-commercial demonstration projects and its status:

[1] JRC Ocean Energy Status Report 2016 Edition

Project	Country	Location	Capacity	Class	Turbines	Status
Paimpol-Bréhat	France	Paimpol-Bréhat	1 MW	ET	2 x 0.5 MW OpenHydro 16 m	Devices deployed
Passage du Fromveur	France	Ouessant	1 MW	HAT	1 x 1 MW Sabella D10	Retrieved July 2016,. Reinstalled Nov 2016
Ramsey Sound	UK	Ramsey Sound	0.4 MW	HAT	1 x 0.4 MW Daffodil – Tidal Energy Limited	Decommissioned in March 2016.
Oosterschelde	Nether-lands	Oosterschelde	1.2 MW	HAT	5 x 0.24 MW Tocardo T2	Operational since 2016
Afsluitdijk	Nether-lands	Den Oever	0.3 MW	HAT	3 x 0.1 MW Tocardo T1	Operational
BlueTEC	Nether-lands	Texel	0.24 MW	HAT	1 x 0.24 MW Tocardo T2	Floating structure.
DeepGreen 1/10	UK	Stangford Loch	0.012 MW	Tidal Kite	1 x 0.0120 MW DG8 (Tenth scale prototype)	Test in preparation for the 1.5 MW de-ployment in Wales
Plat-O	UK	Yarmouth	0.1 MW	HAT	2 x 50 kW Schottel SG50 mounted	Operational since 2015
Yell	UK	Yell	0.03 MW	HAT	1 x 30 kW Nova Innovation Turbine	Operational since 2014
Shetland	UK	Shetland	0.2 MW	HAT	2x 100 kW Nova Innova-tion Turbine	Two of three tur-bines installed and generating. Opera-tional since 2015
MeyGen Phase 1A	UK	Pentland Firth	6 MW	HAT	4 x 1.5 MW (3 Andritz HS1000, 1x Atlantis)	Operational since November 2016
SR2000 @EMEC	UK	Orkney	2 MW	HAT	1 x 2 MW SR2000 from Scotsrenewables	Installed in October 2016
Cape Sharp	Canada	Bay of Fundy	4 MW	Enclosed tips	2 x OpenHydro (2 MW)	Installed in Novem-ber/December 2016
Xiushan Island	China	Zhoushan, Zhejiang	3.4 MW	N/A	First component of 1 MW	Modular device to be expanded to 3.4 MW
Tocardo - EMEC	UK	Orkney	2 MW	HAT	5 arrays of 2x T2 turbines rated (200 kW)	Expected 2017
Plato - EMEC	UK	Orkney	1 MW	HAT	16 Schottel Instream tur-bine (62 kW each)	Expected 2017
Nephtyd	France	Raz Blanchard	5.6 MW	HAT	4 x Alstom Oceade 18 (1.4 MW)	On hold
Normandie Hydro	France	Raz Blanchard	14 MW	Enclosed tips	7 x OpenHydro (2 MW)	Planning, grid con-nection in 2018
Sound of Islay	UK	Islay	10 MW	HAT	4 X: Andritz HS1000 & Alstom	Consented, installa-tion in 2016
Stroma Tidal (Meygen 1B)	UK	Pentland Firth	8 MW	HAT	To be announced	Meygen acquired the Kyle Rhea NER300 project from Marine Current Turbines
Holyhead Deep	UK	Anglesey	10 MW	Tidal kite	Minesto deep green kites	Initial phase ex-pected to reach 0.5 MW

Table 2: Ocean Energy Strategic Roadmap. Building Ocean Energy for Europe. Ocean Energy Forum

Worldwide, many companies are currently developing tidal energy devices with most of them (about 52 %) being based in the EU.

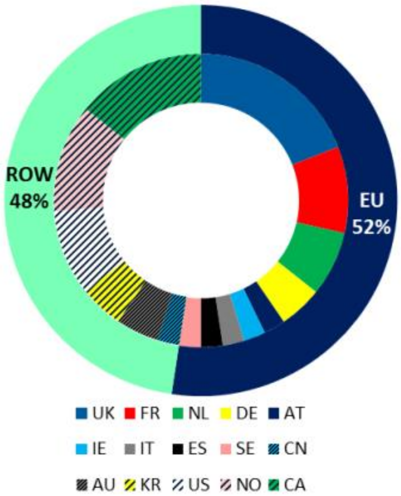


Figure 3: Ocean Energy Strategic Roadmap. Building Ocean Energy for Europe. Ocean Energy Forum

In Europe, the country with the highest number of developers is the United Kingdom, followed by the Netherlands, and France.

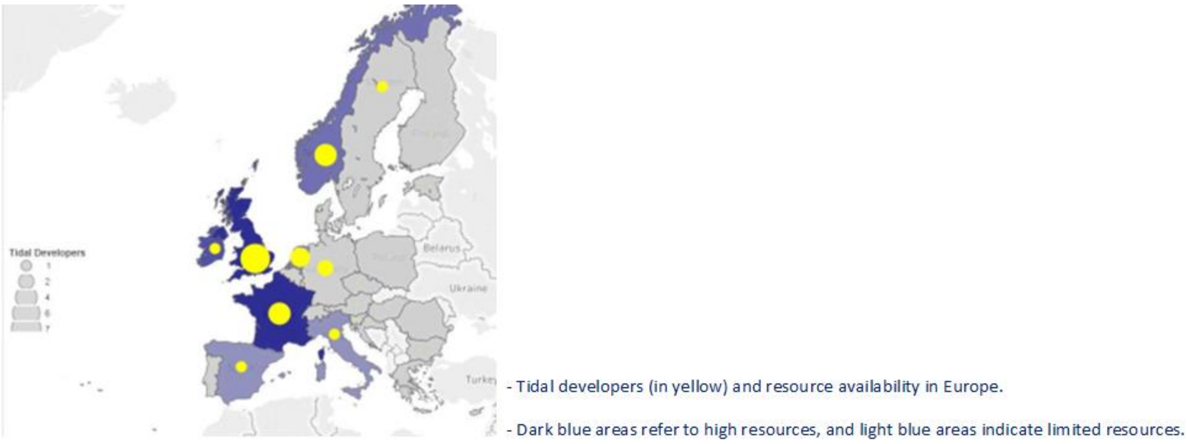


Figure 4: Ocean Energy Strategic Roadmap. Building Ocean Energy for Europe. Ocean Energy Forum

Major non-EU players are the United States and Canada.

Wave energy

While the tidal energy sector has experienced an important development since 2014, the wave energy sector has slowed down. Technical problems of some of the most promising devices have contributed to the lost of confidence of the investors and the current status is similar to the one in 2014.

The main focus for the wave energy industry is to work on the demonstration of existing prototypes, and to improve the performance of key subsystems and components to increase the overall device reliability and survivability.

Despite the high TRL reached by some devices, their commercial readiness is still to be proven. Most of devices tested are still to be considered advance prototypes having demonstrated survivability to ocean conditions, but with limited electricity generation.

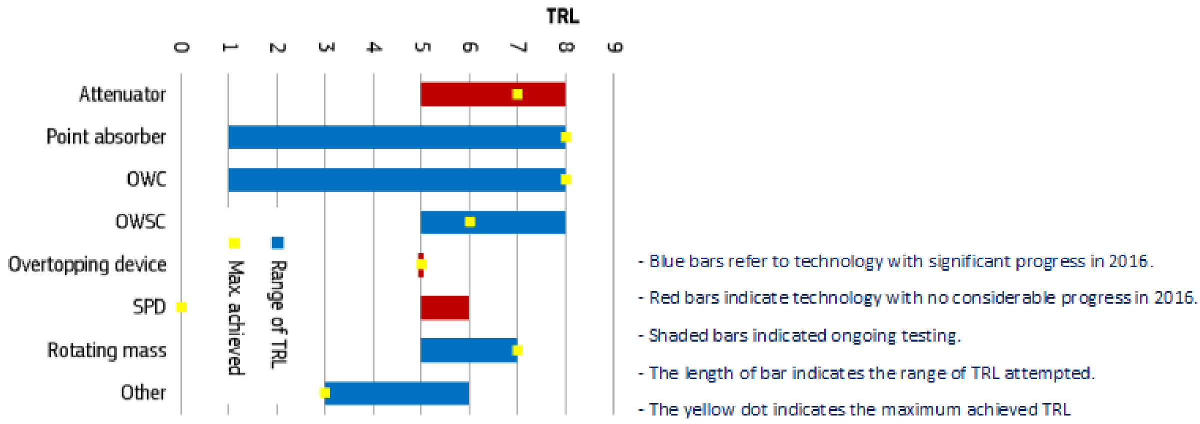


Figure 5: Ocean Energy Strategic Roadmap. Building Ocean Energy for Europe. Ocean Energy Forum

A limited number of projects have been installed in the period between 2014 and 2016.

In total 21 projects are currently in the water or expected to become operational in the near future. Fifteen projects are located within the EU. Whilst many projects are modular and expected to reach in the long-term a capacity of 10 MW; current installations have a power rating of less than 1 MW.

The next table shows the wave energy pre-commercial demonstration projects and its status:

Project	Country	Location	Max Capacity	Class	Devices	Status
Pico	PT	Azores	400 kW	OWC	OWC	In Operation. To be decommissioned
Limpet	UK	Islay	500 kW	OWC	Voith Hydro Wagen	Operations suspended
WaveHub	UK	Cornwall	10 MW	Point absorber	Seatricity Oceanus 2	Currently two devices installed. No grid connection
Sotenäs	SE	Västra Götaland	10 MW (modular)	Point absorber	Seabased	First devices deployed (1 MW)
Perth project	AUS	Perth	0.72 MW (modular)	Point absorber	Carnegie CETO5	Three CETO5 units were deployed in an small array
Ghana	GH	Ada	14 MW (modular)	Point absorber	Seabased	First 6 converters assembled and grid connection installed
WaveStar	DK	Hanstholm	0.6 MW	Point absorber	WaveStar	Grid connected since 2010, 1:2 scale. Project no longer operational
Mutriku	ES	Mutriku	0.3 MW (modular)	OWC	16 OWC chambers rated 18.5 KW	Operational since 2011. One of the chamber is used for R&D testing of new type of turbines.
Isle of Muck	UK	Isle of Muck	22 kW (modular)	Attenuator	Albatern	3 WaveNET unit installed
Westwave	IE	Killard, Ireland	5 MW (modular)	t.b.d.	5 suppliers shortlisted, will be chosen mid 2016	Project funder under NER 300 (34 mio. EUR), planned for 2018
Fred Olsen	US	Navy Test Centre, Hawaii	23 kW	Point absorber	Fred Olsen Life Saver	Device grid connected, operating at 30% (6.7 kW)
Azura Wave	US	Navy Test Centre, Hawaii	20 kW	Point absorber	Northwest Energy Innovations	Half scale prototype. Generating electricity since 2015
Oceantec	ES	Bimep	30 kW	OWC	Oceantec Marmok-A5	Installed in October 2016
40SouthEnergy	IT	Marina di Pisa	100 kW	OWSC	H24 from 40Southenergy	Device installed at the end of 2015.
PB3	US	New Jersey	3 kW	Point absorber	PB3	Device installed in July 2016
Wave4Power	NO	Runde	N/A	Point Absorber	WavEel	Device installed in February 2016. Company does not provide information on rated power
Eco Wave Power	GI	Gibraltar	100 kW (modular)	Point absorber	Wave clapper	Device installed and operative since June 2016
Seapower	IE	Galway Bay	N/A	Attenuator	Seapower Platform	1:4 scale model to be tested in 2016 in Galway Bay
CEFOW	UK	EMEC	3 MW	Roating Mass	3 X Wello Penguins 1 MW	Installation expected in 2017, 2019 and 2019. A device each year within H2020 project
Corpower	UK	EMEC	25 kW	Point Absober	1 x 25 KW Corpower	Device built in Portugal. Yo be tested in dry rig in Sweden before deployment at EMEC
Swell	PT	Peniche	5.6 MW (modular)	OWSC	WaveRoller	Funded by NER 300 (9.1 mEUR), planned for 2018, 16 devices
CETO6	AUS	Garden Island	4 MW (modular)	Point absorber	Carnegie CETO6	1 MW device, 3 MW demo array planned
CETO6 Wave Hub	UK	Cornwall	15 MW (modular)	Point absorber	Carnegie CETO6	1 MW device in 2017, to be expanded to 15 MW by 2021
Camp Rilea	US	Oregon	40 kW	OWSC	Resolute Marine Energy	Small project with 2 devices (2017). Water will also be used onshore for desalination
Baby Penguin	ES	Canary Island	N/A	Rotating mass	Wello Penguin	Reliability for new 'mild-climate' device
Wedge Global	ES	Canary Island	N/A	Point ab-	Wedge Global	Reliability testing new PA

Table 3: Ocean Energy Strategic Roadmap. Building Ocean Energy for Europe. Ocean Energy Forum

The majority of companies developing wave energy devices are based in the EU. The United Kingdom has the highest numbers of developers, followed by Denmark. Outside the EU, countries with a larger number of wave energy developers are USA, Australia, and Norway.

Wave energy developers are spread throughout Europe, even in countries with limited resources or no access to the sea.

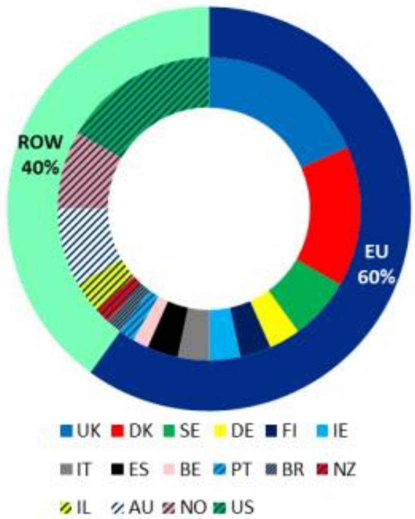


Figure 6: Ocean Energy Strategic Roadmap. Building Ocean Energy for Europe. Ocean Energy Forum

Globally, about 57 wave energy developers have tested their devices in open waters or will do so in the near future.

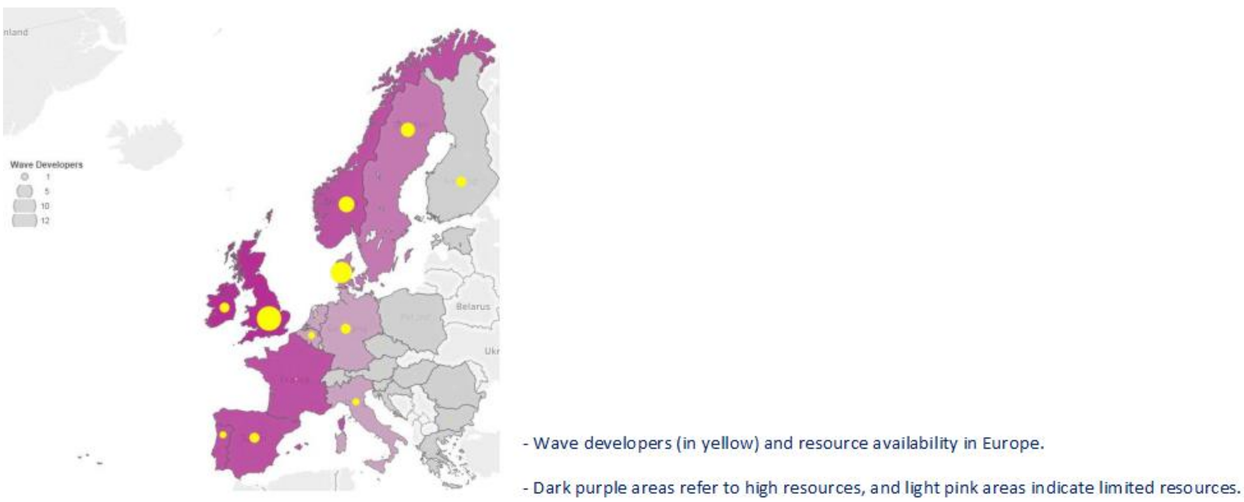


Figure 7: Ocean Energy Strategic Roadmap. Building Ocean Energy for Europe. Ocean Energy Forum

The number of companies slightly decreased compared to 2014. As in the case of tidal energy, for some wave energy developers, it is not clear if they still pursue their activities.

Ocean Thermal Energy Conversion (OTEC)

The development of OTEC has made significant advances. A number of projects are moving forward, including 100 kW Okinawa Plant in Japan, the 1 MW Kriso plant under development in Korea, a 500 KW OTEC Pilot in Curacao developed by Bluerise and the commercial OTEC project expected to be installed in the Maldives developed by Bardot Ocean[1].

The 10 MW Nemo is expected to be become operational by 2019 in Martinique. The project is funded through NER300 for a total of 72 EUR million, and validation works are currently taking place.

Salinity gradient

Salinity gradient technology is still at R&D phase. A 50 kW demo plant is currently operational in the Netherlands, developed by REDStack. R&D activities are taking place both in the Netherlands and in Korea in order to improve the performance of membranes and reduced the associated cost. The Ocean Energy Forum roadmap predicts that demonstration plants for up to 50 MW could be installed after 2020.

Ocean energy challenges

There are several types of challenges that must be overcome, both technological and non-technological[2] to reach the industrialization phase of ocean energy technologies. The non-technological challenges can be mentioned as:

- High capital expenditure

The nature of the structure of the capital costs in marine renewable energy projects implies that developers need large amounts of capital at the beginning of projects, when the generation of energy seems to be very far.

- High risks associated to the ocean energy projects

The cost of finance ocean energy projects is very high in a way, due to the high risks associated to the deployment of devices in a harsh environment as the sea. Risks are higher in the early stages of the technologies. To learn about the risks, it is needed to install technologies for assessing the risks trying to make them measurable and predictable. Doing that, the costs of capital and insurance could decrease.

- Lack of investors

The international context of economic crisis, the limited visibility of market for ocean energies and low prices of energy have contributed to the lack of investors and new financing models are required. For these reasons, public support for new technologies and first farms can pave the way to other kind of inversions.

- Planning and licensing frameworks

The planning, consenting and licensing processes must be enhanced to try to attract interest and to give confidence to the promoters. In this sense, the implementation of the Maritime Spatial Planning (MSP) Directive across the EU presents an opportunity for improving planning and consenting processes for ocean energy.

[1] OES 2016

[2] OCEAN ENERGY STRATEGIC ROADMAP

- Grid connection

In the most of cases, the cost of connecting an ocean energy farm to the grid, which can reach a 40% of the total project cost, is left to the project developer. In economic terms, this makes project development very difficult so there is some experiences in mutualise this costs among the electricity operators and end users of the grid.

Relating to the main technological aspects, it is crucial to accelerate the works on the following aspects:

- Testing and modelling

Demonstration and modelling on sub-systems, components and the complete device in controlled and in real conditions are needed at the different stages of the technology's development.

- Reliability and survivability

To increase the reliability and survivability of devices is a priority to protect investment and to guarantee the long-term availability of power production and income.

- Installation and logistics

It is needed to develop a new generation of ad-hoc solutions to match the specificities of ocean energy devices and reach the targeted costs per kWh.

- Power generation and grid

It is needed to develop the system to collect and transmit compliant energy from multiple devices to the grid.

- Standardisation of the industry leading to certification.

The development of all the standards and guidelines will contribute to decrease the risk perception which will favour the industrial roll-out and the access to finance.

European Strategic Roadmap for Ocean Energies

In order to overcome the barriers and make progress from the R&D phases to the industrial stage, the European Commission has published *the Strategic Roadmap for Ocean Energies* which sets up four Action Plans aimed at scaling up this new industry:

- ☐ Action Plan 1 – R&D and Prototype: A European phase-gate technology development process for sub-systems and devices

To reduce the perception of risks among the potential investors is critical. This action plan is directed to reduce the perception of risk by following a phase-gate process through a sequential process of testing and development of subsystems and prototypes. This will allow to obtain the performance indicators that must be faced to move from one phase to the next one.

Within the phase-gate process the indicators developed will encompass the full range of technical criteria to be met to deliver valid technology such as performance in power generation, availability, survivability, affordability, installability, etc.

The indicators will be built upon existing industry standards and will be stablished by an expert committee which will take into account all the relevant phases for each sub-system and device. Once these performance indicators for each phase are achieved, it will be possible to full-scale prototyping with reliability.

This proccess will be successful if research centres, technology developers and the whole supply chain cooperate and it is needed to meet the requirements of future investors. It is proposed the creation of two different committees which must work together, an Investor Committee and an Industry Expert Committee.

It is proposed the creation of a fund by the European Commission with contributions from Member States. This should cover a significant share of eligible project costs, but would require participating companies to commit the rest.

The Fund could be set up during 2017 and be operational from 2018.

- ☐ Action Plan 2 - Demonstration & Pre-Commercial: An Investment Support Fund for ocean energy farms

The technical risk associated to the installation timing, maintenance arrays and electricity production imply significant levels of financial risk. The public support can help the operators to take on some of those risks and stimulate the participation of private financiers.

It is proposed the creation of a fund for financing demonstration and pre-commercial projects, able to provide different types of finance and able to help developers access other financing sources, whether public or private. This fund will make funds available to projects after thorough due diligence, counting with a recognised body to help leverage additional private capital and reduce the finance costs.

Estimated budget is €200m-€300m over a 5-10 year period.

- ☐ Action Plan 3 - Demonstration & Pre-Commercial: An EU Insurance and Guarantee Fund to underwrite project risks

At current stages of deployment, data about the electricity production and delivery and data about the costs of operation of the farms are not available. The only way to obtain these data is by the installation of ocean energy farms, which, as seen before, implies important degree of uncertainty.

To solve this situation, it is proposed the creation of an Insurance and Guarantee Fund to support deployment of the first demonstration and pre-commercial farms with the aim of generating enough knowledge and commercial coverage of risks.

It is expected that the creation of the Insurance and Guarantee Fund help to attract additional private finance, increase the understanding of risks and insurance offers.

It would make projects more investable, as insuring technological/operational risks will reduce financial risks, increasing the private finance, lower the cost of capital and ease access to finance at minimum cost.

- Action Plan 4- De-risking environmental consenting through an integrated programme of measures

There are a number of development challenges relating to Environment and Consenting process which are long known in the ocean energy sector. To address these constraints, they have been designed a set of environment and consenting projects aimed at facilitating sustainable developments.

Project 1: Planning

Expected outcome: Guidance and recommendations on how to apply spatial planning and assessment to aid the ocean energy sector in selecting sites and ensuring compliance with Directives/Regulations in a proactive manner.

Project 2: Consenting

Expected outcome: Guidance on promoting best practice techniques based on review of consenting and licensing processes.

Project 3: Research

Expected outcome: Guidance on describing the approaches to secure delivery of site specific planning and monitoring, research and assessment.

Project 4: Socio-economics

Expected outcome: An advice note that will provide data on potential socio-economic benefits and impacts as well as recommendations on the most effective techniques to assess and report upon cost reduction and maximising social and economic benefit.

Project 5: Demonstration Strategy

Expected outcome: An Environmental Demonstration Strategy which will take advantage of first arrays. The Strategy must consider different technologies and geographic considerations.

The proposal indicative budgets are €200k to €250k each for Projects 1 to 4, and €600 to €750k for Project 5. The projects should commence in early 2017 for delivery from late 2017 to end of 2018.

The next chart has been extracted from the *Ocean Energy Strategic Rod Map* and shows a summary of the above mentioned Action Plans:

SECTION		ACTION BY			BENEFITS
Phase of Development	**Actions**	**European Commission**	**Member States / EU Regions**	**Industrial Players**	
ACTION PLAN 1 SECTION 4.1	**TIMELINE: 2018-2025**				
R&D Prototype	A European phase-gate technology development process for systems and devices	Establish the Fund for the process from existing allocations – e.g. EU Horizon 2020, EU Research and Innovation funds, ERA-NET (co) funds	Identify and promote funding sources that can contribute to the Fund	Design criteria and performance indicators. Promote findings and learnings. Participating companies to contribute to the Fund	Enables countries with different ocean resources to have comparable measures and performance indicators that will allow learnings and results to be shared at a European level, ensuring better value for public funding and acceleration of technology development.
ACTION PLAN 2 SECTION 4.2	**TIMELINE: 2018-2025**				
Demonstration Pre-Commercial	Create an Investment Support Fund for ocean energy farms, financing single demonstration/ pre-commercial projects, providing different types of finance and access to finance to developers	Promote the establishment of, and contribute to a public-private partnership (PPP) through best use of existing sources of funding	Contribute to a PPP	Further discussion by key industry stakeholders and financial institutions on design options and development of the finance model. Actively participate in PPP.	Enables several demonstration/pre-commercial farms beyond the MeyGen and Raz Blanchard projects to be built and ensures that learnings and results shared at a European level.
ACTION PLAN 3 SECTION 4.3	**TIMELINE 2016-2018 PREPARATION & DESIGN; 2018 - LAUNCH**				
Demonstration Pre-Commercial	Create an EU Insurance and Guarantee Fund to underwrite project risks, focusing on the gaps in existing guarantee/ insurance cover	Create Fund and contribute through best use of existing sources of funding	Contribution to Fund; defining scope of cover to be provided, underwriting, risk-sharing and acceptance criteria	Further discussion by key industry stakeholders and financial institutions on design options and development of the finance model. Contribution through insurance premiums.	Insuring technological/ operational risks will reduce financial risks which increases the ability to leverage additional private finance. Allows development of suitable commercial insurance products and the use of data and knowledge from first projects to inform future projects.
ACTION PLAN 4 SECTION 4.4	**TIMELINE: 2017-2018**				
R&D Prototype Demonstration Pre-Commercial Industrial Roll-out	De-risking environmental consenting through an integrated programme of measures (five projects) to overcome development challenges: Planning, consenting, research, socio-economics and demonstration strategy	Commission Directorate Generals to fund the projects	Input to development of tender specifications to ensure best project outputs		Facilitates sustainable developments, addressing key consenting issues, both currently and in the future as the industry develops and the first arrays are built out.

Table 4: Ocean Energy Strategic Roadmap. Building Ocean Energy for Europe. Ocean Energy Forum

Ocean energy industrialization considerations in Europe

The ocean energy supply chain is spread across European countries given the fact that there are leading companies and SMEs belonging to the supply chain in many European countries. To consolidate the supply chain it is necessary the success of technology developers in delivering viable ocean energy converters and on the reliability of the technology and its progress to higher TRL.

In Europe the ocean energy industry plans to deploy 100GW of production capacity by 2050, meeting 10% of electricity demand which is the daily electricity needs of 76 million households. Deploying 100GW of ocean energy will also mean creating a new industrial sector based in Europe, and 400,000 skilled jobs all along the supply chain.

In terms of market creation, the aim of the sector is to reach 100 MW of installed tidal energy capacity and 10 MW of wave energy capacity by 2020. Currently over 600 MW of tidal energy projects have been announced in the European Union with expected operation to start by 2020 and the wave energy pipeline accounts for 65 MW.

The current conditions of the energy market at global level and the state of art regards ocean technologies hinders the consolidation of the supply and value chain of the sector and it will be needed the contribution of public funds to step forward in the industrial deployment.

As said before, it is crucial the reduction of the cost of ocean energy technology, also through economy of scales. There are still technical, financial and environmental barriers, preventing large-scale ocean energy uptake in the EU.

The cost of tidal and wave energy technology has to be reduced by 75 % and 85 % and financial instruments are needed to help to reduce the risk associated with demonstration farms. Also, R&D mechanisms are needed to support the technological development of ocean energy technology.

As commented in this section, in 2016 the ocean energy sector gave important steps to reach the higher TRL levels. Taking into account the projects that have been installed en European waters, this progression towards commercialisation is expected to maintain a steady rhythm and, in this way, it can be possible that the industrial sector is consolidated in the European countries.

3. Update of funding Programs for R+D+I aimed at marine renewable energies.

Programme Management Survey

In order to help define the OCEANERA-NET action plan and to efficiently integrate consortium joint activities and funding programmes into the ocean energy RTDI landscape, information pertaining to regional and national ocean energy funding programmes was collected. This information will be used to identify possible barriers to cooperation as well as opportunities for mutualisation and cooperation among OCEANERA-NET funding partners.

Questions were therefore formulated to collect information pertinent to both the requirements of the OCEANERA-NET joint calls (the first joint call was launched in October, 2014 and a second is planned for February, 2016) and those of relevant European RTDI database initiatives.

Accordingly, the Programme Management information gathering questions were organised into six separate category headings:

Section 1 - General information: Programme name, acronym, duration and structural hierarchy.

Section 2 - Lead management institution: Details concerning the programme principal manager.

Section 3 - Programme details: Details of the programme scope, context, priorities and budget.

Section 4 - Expected benefits: self-explanatory.

Section 5 - Project information: Details of projects covered by the programme.

Section 6 - Call administration and process: Funding mechanics, including selection and evaluation procedures.

Programme Management survey results

In 2015 an online survey was made available to stakeholders by the OCEANERA-NET consortium partners to update the data regarding ocean energy RTDI funding programmes. In this attempt nine responses were received while in 2014, four were submitted. As concluded in the previous version, the number of answers reflect that still only a limited number of ocean energy dedicated RTDI funding programmes are available to developers.

Number of completed questionnaires: 9 Main

conclusions:

- Nearly every programme (all except one) is organised on a national level (i.e. not on a regional level);
- Public organisations are mainly the managers of the programmes;

- Half of the programmes are dedicated to Marine Renewable Energies and the others cover a wide range of topics.
- Funding is available widely for large companies, SMEs, universities, research institutes, and in a minor way for public entities such as cities and municipalities;
- All TRL levels are covered, but with an emphasis on the higher ones;
- It is possible to submit proposals on all techniques / technologies mentioned;
- In general, programmes last 1 – 3 years with a minority lasting over 3 years;
- Budgets generally are high (over 10 M€) but there are some non-dedicated programmes to Marine Renewable Energies;
- Funding models generally take the form of a national subsidy. The next most common model is a mix of loan and subsidy;
- The scope of programmes is national and/ or transnational;
- Cooperation is allowed and in half of the programmes, required.

In analysing the questionnaire responses, one of the main conclusions is that the existence of funding programmes for marine energies is increasing. But this topic is included in larger R&D programmes, thus competing with other technologies.

The type of projects covered by funding programmes is also broad. Wave and tidal stand out above OTEC and salinity gradient and for those technologies, demonstration of technology and industrial research are more common than feasibility studies.

On the subject of ocean energy related project priorities, programmes comprise almost all topics. Those related to technology itself (design, manufacturing, testing & validating, installing a operations and maintenance) are more common than those addressed to social acceptance, standard and protocols, impact analysis or policy.

Funding context reveals among others that more than 88% of the institutions responding are public organizations. Regarding the geographical areas of research, representatives of 5 countries participated in the in the questionnaire (Spain, France, UK, Sweden, Portugal)

Concerning the estimated number of applicants for funding, those broader programmes in terms of TRL level or concentrating in lower TRLs, expect higher number of proposals.

Following is a summary of the main characteristics of Ocean Energy RTDI Funding programmes from within the participating countries/regions:

Country/Region	Year	Programme topic / Name of Programme	Programme budget (M€)	Nº of applicants	Appro. projects Number	Complt. Project Number
Basque Country	2014	Applied research by promoting projects involving RDI activitiesfor developing and demonstrating new products				
	2015	Programa de Ayudas a Inversiones para la Demostración y Validación de Tecnologías Energéticas Renovables Emergentes / Garapen bidean dauden itsasoko energia teknologia berriztagarriak erakusteko eta balioztatzeko inbertsioen aldeko laguntzen programa 2015	2.5	5	3	Ongoing
France	2012	Défi Energie propre, sure et efficace	25	1-5		
	2013	Programme des Investissements d'Avenir : Energies marines : démonstrateurs et briques technologiques	34			
	2015	Appel à projets EMR ITE 2015	10M€			
Netherlands	2014	Demostratie Energie Innovative	20	10-100		
Portugal	2014	Concurso para projetos de investigação científica e desenvolvimento tecnológico em todos os domínios científicos	70			
Spain	2006	Proyectos de Investigación y Desarrollo	>1.000			
	2015	Programa Estatal de I+D+i Orientada a los Retos de la Sociedad	550	10-100		
Sweden	2015	Marin Energiomvandling	approx 6	10-100		
United Kingdom	2012	Marine Renewable Commercialisation Fund	22.5	5-10		
	2015	ETI Marine Energy Programme	10			

Table 1: Ocean Energy RTDI funding programmes

4. Update of Science and Technology mapping of marine renewable energy.

The purpose of the Science and Technology Mapping is to compile and analyse pertinent information on the development progress and maturity of different technologies and infrastructures, the nature of stakeholders and their work along the ocean energy value chain, and key research priorities within the field of ocean energy.

As this mapping exercise is considered a key element of the OCEANERA-NET project strategy, the survey designed and launched in 2014 was made available for stakeholders for updating again in 2015 in order to support the definition of the second call for proposals. This update eased the identification of the evolution of the sector through the analysis of the responses to the survey on the part of the main actors of the sector.

Given that the present report is an update of the replies obtained in 2014 and 2015, and in the absence of planning for a new call for proposals following the first two successful rounds, the surveys were not directly renewed in 2017.

The first two successful OCEANEAR-NET calls for proposals were deemed sufficient by the project partners given the current funding environment and future efforts toward funding European level cooperative R&D projects for MRE subjects were left for the already established follow-up project, OCEANERA-NET CoFund.

Nonetheless, the OCEANERA-NET partners have continued with their robust Joint Activity planning and execution, including an international conference in July of 2017, called “Turning Lessons into Constructive Actions”. This conference included presentations and discussions involving the funded OCEANERA-NET project partners as well as facilitated interactions with conference participants on R&D gap analyses and the prioritization of action plans aimed at progressing the MRE sector in terms of R&D.

Results of these discussions are presented hereafter.

Capabilities

This session looked at developer capabilities and tried to identify common strengths versus those areas where capability gaps exist or where the developer (usually an SME) would like to externalize portions of the work due to gaps in experience or expertise.

The results clearly point to internal technical expertise, and thereby confidence, while also highlighting gaps in skills concerning issues dealing with financial issues and valorization of results. The results of this session point to areas where external help in the form of financing or consulting could help a developer move beyond the "good idea" phase of project development.

The following graphics show discussion guidelines in bold with a summary of break-out session results in the text following the guidelines.

CAPABILITY (Internal)	What you do now, but could become external – or you would like to do (both external gaps and internal aspirations)	CAPABILITY (External)
Non-technical (where the main gaps are?) • Management strength – integration and business case • Cross sector knowledge • Technology transfer • Business strategy • Corporate memory • Succession planning • Stakeholder management and collaboration **Technical (well-covered?)** • R&D process / capability • Conversion technology • Technical – modelling and engineering • Final assembly integration • LCOE Modelling	• **IP management** • **Lobbying** • **Accounting and finance** • **Developing projects** • **Sales and marketing** • **Developing non-core technology (case by case)** • O&M provision • Component systems	**Non-technical (gaps?)** • **Market analysis and research** • **Support with funding proposals** **Technical** • Test facilities • Specific technical capabilities; e.g. CFD • Temporary expertise during growth • 3rd party verification and certification • Marine operators • Permits and licensing • Electrical systems and engineering • (Costly) funding opportunities are challenging with widespread reliance on subcontractors • **Sub-contracting – Inc. fabrications, manufacturing etc (difficult to source – inc local challenges)**

Value Proposition

The Value Proposition session focused on clarifying the messages to be best used when trying to promote a new technology. These messages can be used in a number of circumstances, including convincing investors during financial negotiations, promoting a technology to public actors in an effort to positively impact socio-economic perceptions and in discussions with energy providers looking for technologies ready for large-scale deployments.

- **Money making**. - it will make you money as an investor or as a final consumer
- **Sustainable solution** - and affordable
- **Helps Society** - job creation, sustainability
- **Predictable solution** (Tidal) – it is always there.
- **Supports public policy** – e.g. keeping the lights on - provides a balanced energy mix and reduces reliance on other forms (e.g. fossil fuel, nuclear).
- **Accepted solution** - high level of acceptance of offshore energy.
- **Visual appeal** - you can't see it – so better visual appeal / amenity than other renewables, linked to consumer distrust of wind

To help with value proposition and to dispel image issues, ETIP working on societal values;

Breakthrough Energy Coalition could help re investor promotion / investment.

Stress the potential of the sector as the main message to raise its profile

Should ocean energy as contributing to a global Grand Challenge

Issues / Gaps?

- Can't quantify the value for private investment
- Climate change, more extreme weather is a threat to technology
- **Some investor suspicion re: sector failure, stemming from raised expectations of payback period.**
- Consumer doesn't care where their electricity comes from. How much more will they pay more for green energy - Quoted 3% of people would go for a green premium.

Customer Needs

In this discussion between decision makers, project funders and technology developers, answers were sought to questions of the true understanding of MRE technology customer needs. Indeed, the conversation included the basic question of who exactly is the customer?

What are we providing to our customers - need to provide info on design, cost, performance for client decision

Energy utility companies - primary client

Funder as the client - Stages of funding can be considered as intermediate clients

- Funding needs: stimulate innovation; healthy businesses; local development; build industry.
- Needs jobs creation / conversion.
- Needs Green Energy
- Niche opportunities in marginal markets – e.g low energy needs: sensors for monitoring etc. Local communities looking for independence from fossil fuels
- Adapt to new market opportunities
- Other consumers - i.e. additional by-product (H20; H; food; aquaculture)
- Addition – cisyomer is the eprosn who gives you the money; e.g niche marekt example (fish farm); or a project developer.

GAP? Are we comfortable that we know what our 'customers' need?

Market Context

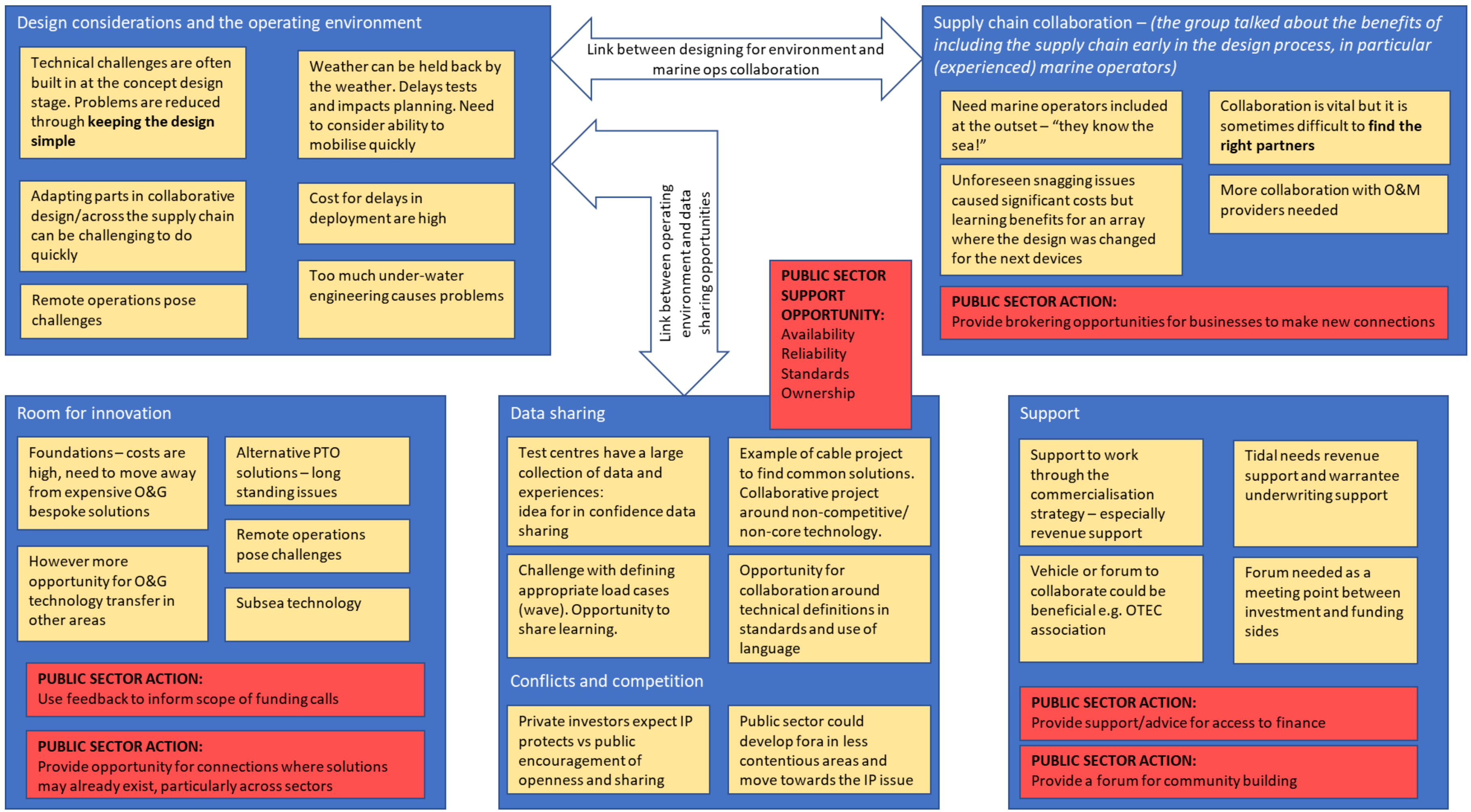
Market context, drivers and definitions were debated during the Market Context discussion session. Within this discussion an underlying idea of data sharing within markets was evoked as this significant cost expenditure can represent a barrier for smaller developers trying to penetrate new markets where basic data needs may already have been met, but are not available to new comers.

• Markets are dependent / linked to geography and policy. • Market studies exist bit not at granular level – or are too expensive to access. • Example of need for granularity of data - site characterisation / resource mapping could benefit developers and investors, this is costly so who should carry the cost. Potential for duplication (e.g. 3 payments for same study) – **can be a more centralised service**? • Competitors inc other renewables; non-renewables; biomass; energy storage solutions. Competition is both inside the OE sectors and outside. • Niche markets • Hybrids as an option?	**Market Drivers** • Government targets for green energy and emissions reductions • Cost of energy • Policies • Infrastructure / supply chain • Social and environmental acceptance

The conference workshop on Lessons Learned helped to identify priority topics for public sector support (financing). These priority topics are listed as follows:

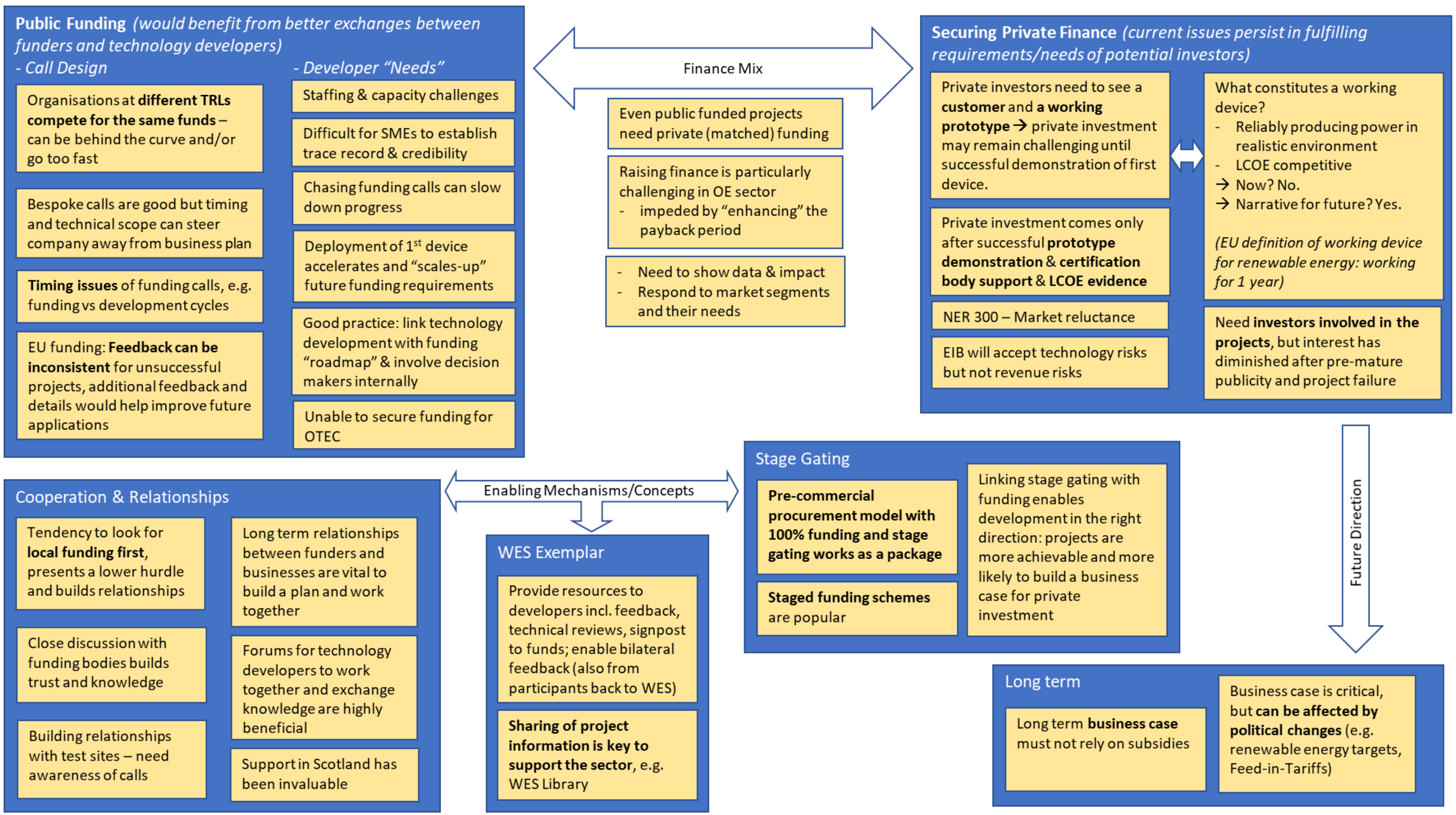
- Data Sharing:
  - Availability,
  - Reliability,
  - Standards,
  - Ownership,
- Supply Chain Collaboration:
  - Brokering opportunities for businesses to make new links,
- Room for Innovation:
  - Improvement of funding calls by incorporating sector feedback,
  - Facilitate cross-sector solution connections,
- Support:
  - Support and advice for access to financing,
  - Community building forum.

The following slide reports the related break-out session discussion topics as well as priority actions needed to address some of the identified bottlenecks.

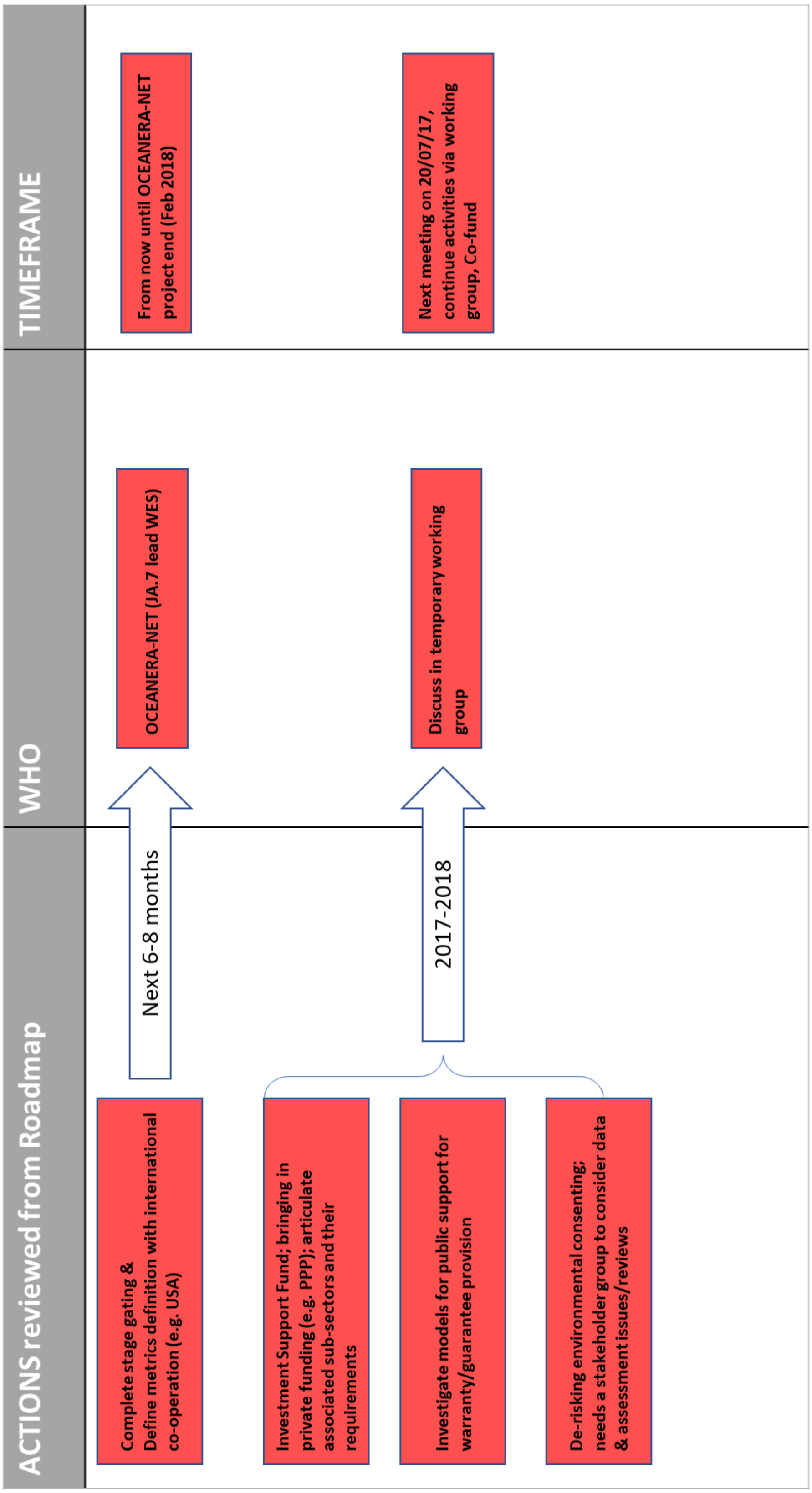

Design considerations and the operating environment
Technical challenges are often built in at the concept design stage. Problems are reduced through keeping the design simple
Weather can be held back by the weather. Delays tests and impacts planning. Need to consider ability to mobilise quickly
Adapting parts in collaborative design/across the supply chain can be challenging to do quickly
Cost for delays in deployment are high
Remote operations pose challenges
Too much under-water engineering causes problems
Link between designing for environment and marine ops collaboration
Link between operating environment and data sharing opportunities
Supply chain collaboration – (the group talked about the benefits of including the supply chain early in the design process, in particular (experienced) marine operators)
Need marine operators included at the outset – "they know the sea!"
Collaboration is vital but it is sometimes difficult to find the right partners
Unforeseen snagging issues caused significant costs but learning benefits for an array where the design was changed for the next devices
More collaboration with O&M providers needed
PUBLIC SECTOR ACTION:
Provide brokering opportunities for businesses to make new connections
PUBLIC SECTOR SUPPORT OPPORTUNITY:
Availability
Reliability
Standards
Ownership
Room for innovation
Foundations – costs are high, need to move away from expensive O&G bespoke solutions
Alternative PTO solutions – long standing issues
Remote operations pose challenges
However more opportunity for O&G technology transfer in other areas
Subsea technology
PUBLIC SECTOR ACTION:
Use feedback to inform scope of funding calls
PUBLIC SECTOR ACTION:
Provide opportunity for connections where solutions may already exist, particularly across sectors
Data sharing
Test centres have a large collection of data and experiences:
idea for in confidence data sharing
Example of cable project to find common solutions. Collaborative project around non-competitive/ non-core technology.
Challenge with defining appropriate load cases (wave). Opportunity to share learning.
Opportunity for collaboration around technical definitions in standards and use of language
Conflicts and competition
Private investors expect IP protects vs public encouragement of openness and sharing
Public sector could develop fora in less contentious areas and move towards the IP issue
Support
Support to work through the commercialisation strategy – especially revenue support
Tidal needs revenue support and warrantee underwriting support
Vehicle or forum to collaborate could be beneficial e.g. OTEC association
Forum needed as a meeting point between investment and funding sides
PUBLIC SECTOR ACTION:
Provide support/advice for access to finance
PUBLIC SECTOR ACTION:
Provide a forum for community building

The following slide presents the results of a debate on constructive means for moving forward in the MRE sector. Ideas are organized around the following discussion headings:

- Finance Mix:
    - Public funding,
    - Securing private financing,
- Enabling Mechanisms / Concepts:
    - Cooperation & relationships,
    - Wave Energy Scotland exemplar,
    - Stage gating,
- Future Directions:
    - Long term.


Public Funding (would benefit from better exchanges between funders and technology developers)
- Call Design
Organisations at different TRLs compete for the same funds – can be behind the curve and/or go too fast
Bespoke calls are good but timing and technical scope can steer company away from business plan
Timing issues of funding calls, e.g. funding vs development cycles
EU funding: Feedback can be inconsistent for unsuccessful projects, additional feedback and details would help improve future applications
- Developer "Needs"
Staffing & capacity challenges
Difficult for SMEs to establish trace record & credibility
Chasing funding calls can slow down progress
Deployment of 1st device accelerates and "scales-up" future funding requirements
Good practice: link technology development with funding "roadmap" & involve decision makers internally
Unable to secure funding for OTEC
Finance Mix
Even public funded projects need private (matched) funding
Raising finance is particularly challenging in OE sector
- impeded by "enhancing" the payback period
- Need to show data & impact
- Respond to market segments and their needs
Securing Private Finance (current issues persist in fulfilling requirements/needs of potential investors)
Private investors need to see a customer and a working prototype → private investment may remain challenging until successful demonstration of first device.
Private investment comes only after successful prototype demonstration & certification body support & LCOE evidence
NER 300 – Market reluctance
EIB will accept technology risks but not revenue risks
What constitutes a working device?
- Reliably producing power in realistic environment
- LCOE competitive
→ Now? No.
→ Narrative for future? Yes.
(EU definition of working device for renewable energy: working for 1 year)
Need investors involved in the projects, but interest has diminished after pre-mature publicity and project failure
Future Direction
Enabling Mechanisms/Concepts
Cooperation & Relationships
Tendency to look for local funding first, presents a lower hurdle and builds relationships
Close discussion with funding bodies builds trust and knowledge
Building relationships with test sites – need awareness of calls
Long term relationships between funders and businesses are vital to build a plan and work together
Forums for technology developers to work together and exchange knowledge are highly beneficial
Support in Scotland has been invaluable
WES Exemplar
Provide resources to developers incl. feedback, technical reviews, signpost to funds; enable bilateral feedback (also from participants back to WES)
Sharing of project information is key to support the sector, e.g. WES Library
Stage Gating
Pre-commercial procurement model with 100% funding and stage gating works as a package
Staged funding schemes are popular
Linking stage gating with funding enables development in the right direction: projects are more achievable and more likely to build a business case for private investment
Long term
Long term business case must not rely on subsidies
Business case is critical, but can be affected by political changes (e.g. renewable energy targets, Feed-in-Tariffs)

The following slide presents actions selected from the Ocean Energy Forum Strategic Roadmap and identifies specific actions to follow, an estimated timeframe and who should be responsible for the particular action:



In this final slide from the OCEANERA-NET workshop in July of 2017, specific actions have been identified that could help move forward the sector from the viewpoint of developers and project funders. Associated with each action point is a possible area of intervention where the public sector (regional, national, European…) could help to encourage progress in a particular domain. It should be noted that many of the public sector activities that have been identified by the workshop participants have been partially addressed by the OCEANERA-NET Joint Activity program. This could be interpreted as an industry sector desire to see these types of additional activities carry on within more traditional funding programs.

Actions identified from Workshop		WHAT CAN PUBLIC SECTOR DO
Build momentum & engagement to bring in private investors, e.g. via establishment of forum/network - To build credibility of OE sector - To increase investor confidence - To reduce risk premium	Private Finance	• Gauge Investor Interest • Support access to investors
National agencies – closer work with micro-enterprises and understanding of their needs (e.g. pre-finance models)	Public Funding	• Review funding schemes and pre-commercial support models
Develop & improve image of OE sector, e.g. through effective communication (e.g. success stories, realistic status and outlook of development) to build/increase trust in sector	Sector Perception	• Communication & dissemination activities, including public outreach (e.g. via ETIP)
Establish platform that maps actors & funding in OE will help - avoid duplication of effort through greater awareness - Identification of connecting bodies (e.g. test sites for supply chains)	Connectivity & Information	• Signpost to support services, e.g. EEN • Joint actions to aid navigating/reducing the complexity of the funding landscape (both national/regional and international/EU) • Improve of WEB GIS SIOCEAN (via OES)
Consider best practice examples (e.g. Brittany have developed a regional skills platform owned by the region which could be developed further) and regional relays for SMEs to Europe.	Best practice	• Greater knowledge exchange between funding organisations

The updated survey results from the OCEANERA-NET Science and Technology 2015 effort are included here as the results are deemed still relevant and worthy of review.

- FORM A Ocean Energy RTDI Thematic Priorities

The Form A is aimed at gathering information regarding priority research thematic lines within ocean energy, as well as indications of relevancy and competency within each indicated domain. Form A was addressed to a wide variety of ocean energy stakeholders and organisations.

- FORM B1 Ocean Energy Infrastructure

The Form B1 was addressed to those organisations playing a relevant role in the development, operation or management of research infrastructures dedicated to the testing and demonstration of ocean energy technologies.

- FORM B2 Infrastructure: Operational farms / Plant deployments

The Form B2 compiles information on infrastructure for ocean power generation. It is addressed to organisations playing a role in the deployment, operation and/ or management of operational farms or plants dedicated to ocean energy conversion.

- FORM C National / Regional stakeholders in Technology Advancement

The Form C1 is addressed to research and science organizations (research centres, research councils, universities and the equivalent) that play a role in the technology advancement of ocean energy technologies. It compiles information such as RTDI capacities, technologies and projects, facilitation and collaboration agreements.

- Quick Survey

This Survey is addressed to all actors of the marine renewable energy sector and complies information about the main topics of interest and priorities to which the OCEANERA-NET Calls must be oriented as well as the Technology Readiness Level (TRL) of interest to participate as applicants to an OCEANERA-NET Call.

2015 Survey campaign

From October until the end of November 2015, the online survey for collecting national and regional information on ocean energy science and technology capacities was made accessible to relevant stakeholders by the OCEANERA-NET partners.

<u>Form A Ocean Energy RTDI Thematic Priorities</u>

The number of new replies gathered in 2015 was 20, representing an increase of 25% related to the number obtained in 2014. The results provided below are an analysis of the accumulated replies for the years 2014 and 2015.

The information of the Form A was divided into 14 main thematic areas and subareas as shown in the Table 1.
For each subarea, the respondents were asked to indicate:

- The levels of relevance - in terms of need **- The level of priority** - in terms of urgency
- The self-evaluation of **the organization's expertise/capacity** within each particular area. The following table illustrates the Thematic Areas of Form A:

Thematic Area	
Resource Evaluation and Environmental Understanding	
	Modelling Tools
Device and Subsystems, Design and Industrialization	
	Components, Prototypes and others
	Design Tools
	Testing & Validation
Array Design & Integration and Plant Balance	
Reliability & Survivability of Materials and Structures	
Manufacturing & Supply chain	
Deployment - Infrastructures	
	Grid Connection and Power Systems
	Subsea issues, Foundations, Moorings
	Ports & Harbours
	Testing Facilities
Installation, O&M, Retrieval (Life Cycle)	
	Installation, Marine Operations
	Marine Vessels
	Monitoring Systems
Economic Issues and Feasibility	
	LLOE Optimisation, CAPEX&OPEX reduction
Environmental and social impacts, Regulatory framework	
	Impact on marine environment + wildlife
	Cumulative impacts (incl. Climate Change)
	Conflicts of Use and Marine Spatial Planning (MSP)

	Social Acceptance
Risk Reduction (Technical, Economical, etc...)	
Standards & Protocols	
Government Issues; Policy and Support	
Knowledge / Technology Transfer (particularly IPR)	
Enabling Technologies & Cross-Sector Opportunities	

Table 2: Thematic Areas

The number of completed Form A questionnaires is 81 (total answers collected in 2014 and 2015). Topics are well covered. All topics are relevant.

☐ The 10 topics selected as the most relevant for respondents are:

- Components + Prototypes
- Testing & Validation
- Subsea issues, Foundations, Moorings
- Reliability & Survivability of Materials and Structures
- Grid Connection and Power Systems
- Resource Evaluation and Environmental Understanding: Modelling Tools
- Risk Reduction (Technical, Economical, etc...)
- Installation, Marine Operations
- Government Issues; Policy and Support
- Economic Issues and Feasibility; LCOE Optimization, CAPEX&OPEX reduction

☐ The 10 topics selected as high priority are:

- Components + Prototypes
- Testing & Validation
- Government Issues; Policy and Support
- Reliability & Survivability of Materials and Structures
- Subsea issues, Foundations, Moorings
- Risk Reduction (Technical, Economical, etc...)
- Resource Evaluation and Environmental Understanding: Modelling Tools
- Grid Connection and Power Systems
- Testing Facilities
- Economic Issues and Feasibility; LCOE Optimization, CAPEX&OPEX reduction

☐ The 10 topics in which the respondents have most expertise are:

- Reliability & Survivability of Materials and Structures
- Components + Prototypes
- Testing & Validation

- Conflicts of Use and Marine Spatial Planning (MSP)
- Social Acceptance
- Manufacturing & Supply chain
- Government Issues; Policy and Support
- Impact on marine environment + wildlife
- Risk Reduction (Technical, Economical, etc...)
- Resource Evaluation and Environmental Understanding: Modelling Tools

The Figure 8 shows the results of the Form A as aggregated data in % of answers by each sub area and criteria.

Additionally, two columns are calculated for each criterion representing first, the sum of answers corresponding to not significant (0) and low (1), and second, the sum of answers corresponding to medium (2) and high (3).

Those subareas highlighted in dark green correspond to answers of “high” (3) for a given criteria in at least 50% of the cases, and in orange for those with a “high” response in less than 35% of the total results.

			Relevance						Priority						Expertise					
			Relevance 0	Relevance 1	Relevance 2	Relevance 3	Relevance 0 and 1	Relevance 2 and 3	Priority 0	Priority 1	Priority 2	Priority 3	Priority 0 and 1	Priority 2 and 3	Expertise 0	Expertise 1	Expertise 2	Expertise 3	Expertise 0 and 1	Expertise 2 and 3
1		Resource Evaluation and Environmental Understanding: Modelling Tools	4%	8%	34%	55%	11%	89%	3%	16%	38%	43%	19%	81%	9%	6%	42%	42%	15%	85%
2.1	Device and Subsystems Design/Industry	Components+Prototypes	3%	4%	16%	78%	6%	94%	1%	8%	28%	63%	9%	91%	5%	10%	42%	42%	15%	85%
2.2		Design Tools	4%	14%	40%	43%	18%	83%	1%	23%	41%	35%	24%	76%	6%	17%	42%	35%	23%	77%
2.3		Testing & Validation	1%	8%	15%	76%	9%	91%	1%	10%	31%	58%	11%	89%	5%	17%	32%	46%	22%	78%
3		Array Design & Integration and Plant Balance	6%	13%	41%	40%	19%	81%	5%	23%	53%	19%	28%	72%	8%	31%	44%	18%	38%	62%
4		Relaibility & Survivability of Materials and Structures	2%	7%	31%	59%	10%	90%	1%	11%	36%	51%	13%	88%	5%	21%	44%	30%	26%	74%
5		Manufacturing & Supply chain	1%	25%	44%	30%	26%	74%	3%	30%	53%	14%	33%	67%	8%	33%	32%	27%	41%	59%
6.1	Deployment - Infrastructures	Grid Connection and Power Systems	1%	10%	30%	59%	11%	89%	3%	15%	40%	43%	18%	83%	10%	23%	44%	23%	33%	67%
6.2		Subsea issues, Foundations, Moorings	8%	6%	20%	66%	14%	86%	6%	11%	37%	46%	18%	82%	10%	17%	46%	27%	27%	73%
6.3		Ports & Harbours	4%	32%	38%	27%	35%	65%	8%	43%	39%	10%	51%	49%	12%	32%	35%	22%	44%	56%
6.4		Testing Facilities	4%	14%	38%	44%	17%	83%	3%	19%	38%	40%	22%	78%	4%	28%	29%	38%	32%	68%
7.1	installation, O&M, Retrieval (Life Cycle)	Installation, Marine Operations	3%	9%	38%	51%	11%	89%	1%	17%	45%	36%	18%	82%	8%	27%	44%	22%	35%	65%
7.2		Marine Vessels	3%	15%	49%	34%	18%	83%	5%	27%	44%	24%	32%	68%	13%	33%	40%	14%	46%	54%
7.3		Monitoring Systems	5%	11%	43%	41%	16%	84%	4%	19%	44%	33%	23%	77%	9%	24%	44%	23%	33%	67%
8		Economic Issues and Feasibility; LCOE Optimisation, CAPEX&OPEX reduction	3%	18%	33%	47%	20%	80%	4%	17%	40%	40%	21%	79%	6%	32%	31%	31%	38%	62%
9.1	Environmental an social impacts, Regulatory framework	Impact on marine environment + wildlife	4%	18%	40%	39%	21%	79%	8%	24%	37%	32%	32%	68%	17%	27%	31%	25%	44%	56%
9.2		Cumulative impacts (incl. Climate Change)	5%	28%	46%	21%	33%	68%	8%	35%	30%	27%	43%	57%	14%	38%	27%	21%	53%	47%
9.3		Conflicts of Use and Marine Spatial Planning (MSP)	5%	20%	34%	41%	25%	75%	8%	25%	30%	37%	33%	67%	14%	32%	33%	21%	46%	54%
9.4		Social Acceptance	6%	20%	49%	25%	26%	74%	6%	30%	39%	24%	37%	63%	13%	30%	36%	21%	43%	57%
10		Risk Reduction (Technical, Economical, etc..)	3%	9%	35%	54%	11%	89%	1%	22%	33%	44%	23%	77%	4%	17%	42%	37%	21%	79%
11		Standards & Protocols	3%	25%	41%	31%	28%	73%	3%	30%	38%	29%	33%	67%	5%	31%	38%	26%	36%	64%
12		Government Issues; Policy and Support	3%	19%	28%	51%	21%	79%	5%	19%	20%	56%	24%	76%	12%	32%	37%	19%	44%	56%
13		Knowledge / Technology Transfer (particularly IPR)	4%	25%	44%	27%	29%	71%	6%	29%	42%	22%	36%	64%	4%	18%	43%	35%	22%	78%
14		Enabling Technologies & Cross-Sector Opportunities	1%	19%	44%	35%	20%	80%	3%	32%	40%	26%	35%	65%	3%	16%	62%	19%	18%	82%

Figure8: Summary of results

The thematic areas having high relevance and high priority (above 50% of the responses) according to the survey are:

- Device & Subsystems Design/Industry; Components & Prototypes (2.1)
- Device & Subsystems Design/Industry; Testing & Validation (2.3)
- Reliability & Survivability of Materials and Structures (4)
- Government Issues; Policy and Support (12)

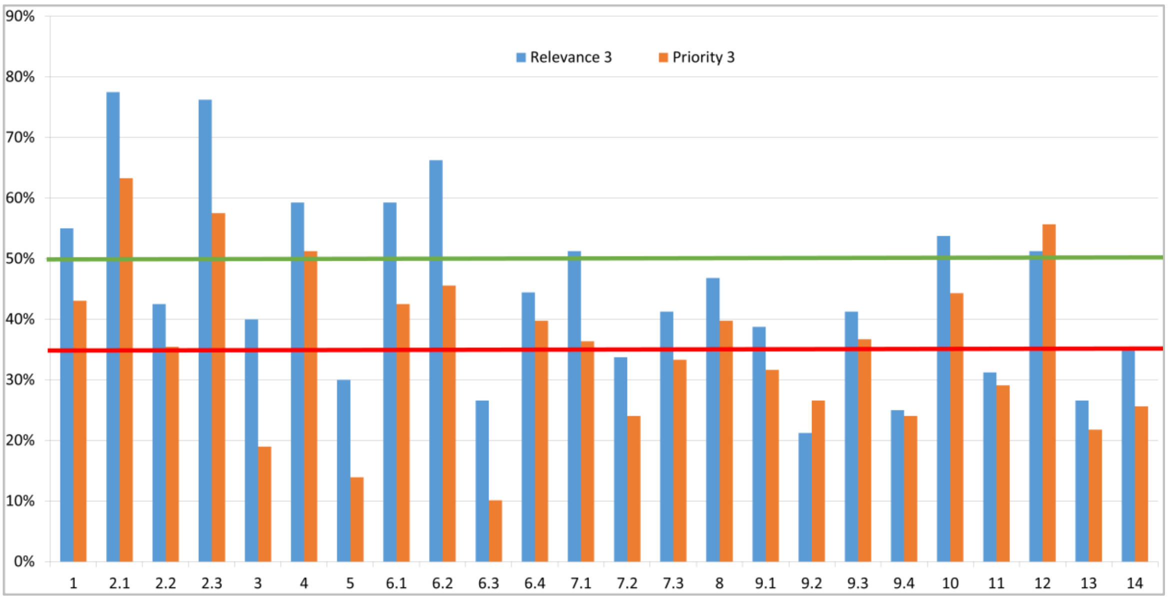


Figure 9: Results by relevance and priority

The results derived from the participating stakeholder responses to the OCEANERA-NET questionnaires can be compared to the priority themes developed by the IEA-OES members in the 2017 Vision paper. In their report, the OES identifies the following development themes as important to the sector:

- Reliability improvement,
- Cost reduction,
- Performance improvement.

Technology development areas requiring attention include:

- Structures and prime movers,
- Foundations and moorings,
- Power take-offs and control systems,
- Array systems and subsea connections,
- Installation, operational maintenance and recovery.

And finally, primary R&D subjects needing attention in order to surmount technology challenges are as follows according to the OES report (areas mentioned in both the OES and OCEANERA-NET reports are underlined):

- **Commercial Deployment:**
    - Offshore grid design & optimization,
    - Multi-device electrical system,
    - Sub-sea electrical system,
    - Multi-device interaction analysis,
    - Offshore umbilical/wet MV connecters,
    - Reliability demonstration (commercial deployment level).
- **Sub-systems or components:**
    - Control systems,
    - Intelligent predictive maintenance systems,
    - Power take-off,
    - Power electronics,
    - Device structure,
    - Hydraulic systems,
    - Cooling systems,
    - Bearings, foundations & moorings.
- **Device and systems deployment:**
    - Performance data collection,
    - Knowledge transfer & dissemination,
    - Economic installation methods,
    - Economic recovery methods,
    - Connection/disconnection techniques,
    - Pre-commercial multi-device sea trial,
    - Vessels,
    - Reliability demonstration (device & components).
- **Design optimization and tool development:**
    - Device modelling tools,
    - Failure modes & conditioning monitoring techniques,
    - Environmental impact assessment tools,
    - Site characterization techniques,
    - Resource analysis tools,
    - Large scale design & modelling tools,
    - Techno-economic analysis tools.

Returning to the OCEANERA-NET questionnaire results, and by taking into account the aggregated data of those answers scoring from medium to high in relevancy and priority, we can add to the previous selection the following thematic areas, as can be seen in Figure 10:

- Resource Evaluation and Environmental Understanding: Modelling Tools (1)
- Design tools (2.2)
- Deployment - Infrastructures; Grid Connection and Power Systems (6.1)
- Deployment - Infrastructures; Subsea issues, Foundations, Moorings (6.2)

- Installation, Marine operations (7.1)
- Monitoring Systems (7.3)
- Economic Issues and Feasibility; LLOE Optimisation, CAPEX&OPEX reduction (8)
- Risk Reduction (Technical, Economical, etc.) (10)

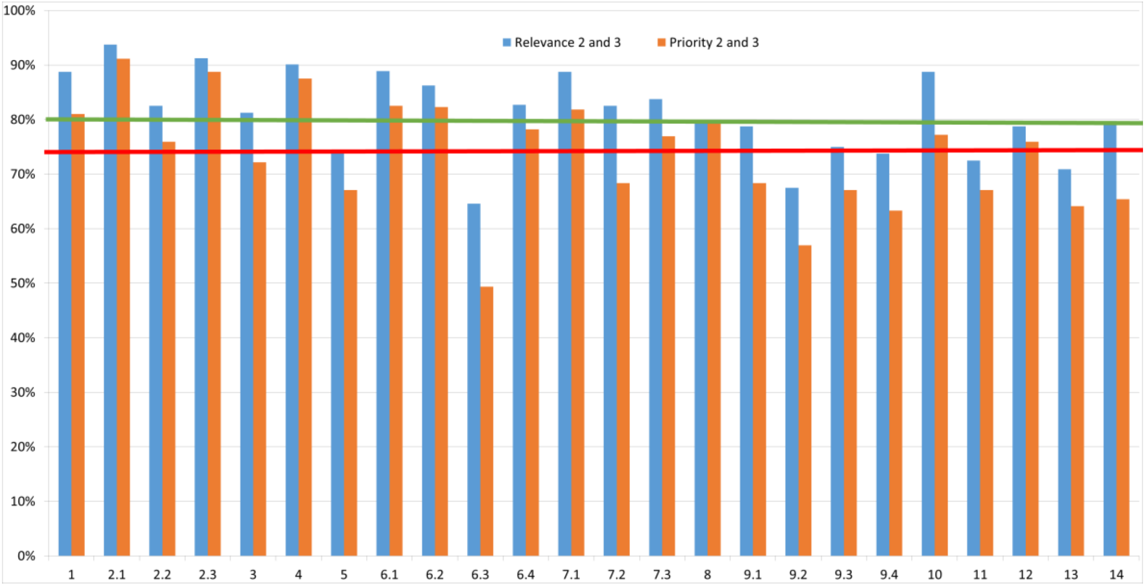


Figure 10: Aggregated results by relevance and priority

As in the year 2014, the first listing of thematic areas (Table 2) is primarily related to the devices themselves and in certain grade, to the government support and policy.

The second extracted list (Figure 8) represents areas of research and development on the periphery of the device itself that stakeholders consider important such as modelling, design, monitoring, grid connections, foundations and moorings and economics and risk reduction.

This can be interpreted to mean that the device itself, and how precisely to retrieve the energy from the ocean, is the main concern for most of the responding stakeholders but, they are increasingly thinking about other parallel topics which are crucial for the real development of the activity.

To a certain degree, this second subject listing can borrow more easily from experience garnered from other, more mature sectors (i.e. offshore wind, oil & gas, etc.). This could be the case for Grid Connection and Power Systems (6.1). Although appropriate grid infrastructure and connections will be important for ocean energy development (for an installation located 100 km from the shore, the grid component can represent up to one third of the cost) and possible restrictions may arise from onshore grids which potentially cannot absorb the electricity produced from ocean energy extraction, many similar developments have already taken place in the offshore wind sector.

Once ocean energy devices are ready to be deployed in commercial installations, risk reduction will become an extremely important issue. Operators will have to take into account the hostile marine environment and limited weather windows allowing relatively safe marine operations. These considerations will necessarily increase the construction and maintenance costs compared with similar, onshore operations. There is currently precious little experience in the maintenance of offshore, in-water facilities and costly infrastructure from the oil industry (ships, platform equipment) often has to be utilized.

From the overall questionnaire responses it can be inferred that all thematic areas are considered important by stakeholders (relevance scoring of medium or high in more than 60% of responses for every sub area, and a priority of medium and high for more than 50% of the subareas).

However, and perhaps more interestingly, the lowest scoring has been given to the following subareas:

- Manufacturing & Supply chain (5)
- Ports and harbours (6.3)
- Environmental and Social Impacts, Regulatory Framework; Cumulative impacts (incl. Climate Change) (9.2)
- Social acceptance (9.4)
- Standards and Protocols (11)
- Knowledge / Technology Transfer (particularly IPR) (13)

Challenges in infrastructure relate to the availability of suitable port services and specialised vessels, but these issues do not seem to be too much of a concern for the stakeholders participating in the survey.

This infrastructure is required for the transportation, assembly, installation and repair of devices and foundations, the installation of underwater cables and connectors, and operations and maintenance (O&M) services. Europe has a number of ports that are already being used for offshore marine energy installations in the Irish Sea and North Sea, while other ports are being remodeled to serve the offshore marine energy industry. In addition to ports, underused shipyards (mainly due to decreasing ship orders) can be used for various purposes in the ocean energy sector: manufacturing of components; building of ocean energy devices and specialised vessels; and as logistic centres for the deployment of ocean energy parks. However, suitable port facilities are often lacking in the areas where the potential for ocean energy development is the highest and therefore further investments in port facilities will be needed to help support growth and stability in the ocean energy sector.

In the case of array design, manufacturing and supply chain, vessels, ports and harbours and environmental impact, relevance is considered high for most stakeholders; however, the priority is not placed as high, probably because we are still far from the deployment of ocean energy farms with multiple devices. Currently, the sector are mainly focused in the R+D phase and there does not exist a market demand for logistics, environmental impact or manufacturing issues although, the actors do not need to face these challenges at the moment.

FORM B1 Ocean Energy Infrastructure

The number of replies gathered in 2015 has been of 3 which represents an increase of 17% related to the number obtained in 2014. The results presented is an analysis of the accumulated replies for the years 2014 and 2015.

The number of completed questionnaires is 21.
All TRLs are included, but nothing is commercial yet.

- From the replies of the stakeholders, we can conclude that there are a few full-scale demos, both Part Scale/Nursery (57%) and Full Scale (57%). There are a 19% of array demonstration and 38% in a precommercial Scale but no commercial parks/ arrays yet.

Purpose/Scale	%responding
Full-Scale	57%
Part-Scale / Nursery	57%
Array Demonstration	19%
Pre-Commercial	38%
Commercial	0%
Other, please specify	19% (research, wide range of probes, lab testing equipment)

Table 3: Purpose/Scale

Questions of purpose and scale for test facilities reveal answers mirroring the level of maturity of technologies in the ocean energy sector. Numerous industrial manufacturers and smaller companies developing a single technology have reached the TRL of 7-8 (full-scale prototype tested at sea) while more recent innovative concepts, especially within wave technologies, are moving through the TRL levels towards full-scale testing. Array demonstrations are just now coming to fruition with firm planning and short time-scales in place for the first multi-machine deployments in Europe.

The Technology Readiness Levels applicable in each testing environment show a concentration in midrange levels of development. A full 86% of responding testing facilities are working within the range of TRL 4 to 8, leaving a gap for pre-commercial testing and demonstration of array deployments and the possibility of observing inter-machine interactions and array connections to associated electricity networks. Responses here are in alignment with results stemming from the previous question.

In the **Table 4**, it can be seen the state of development of the technologies with reference to the Ocean Energy Systems (OES-IEA) Technology Readiness Level system:

Reference TRL for Ocean Energy (OES-IEA)	%responding
TRL 1-3 - Concept **From formulation to validation**	5%
TRL 4 - Technology Validation in Lab **Subsystem testing at intermediate scale**	29%
TRL 5-6 - Testing Operational Scaled Models at Sea **Subsystems testing at large scale**	38%
TRL 7- 8 - Full-scale prototype tested at sea	19%
TRL 9 - Pre-commercial tested at sea **Commercial demonstrator**	10%

Table 4: TRL

- New sites are under construction (32%) and 21% are into the consenting process. There are a 47% of infrastructure in different situations such as “Preparing test in realistic sea conditions”, “fully operational”, “Studying feasibility”, “Running”…
- Range – most (62%) are offshore (> 50m), a 19% are Onshore and 19% are Nearshore (10-50m from shore).
- Structure – it can be found both public and private developers/owners in the same percentage (38%) and there are a 23% of mixed public and private. There are a 18% of structures managed by Universities and non-profit organizations.
- Ocean Energy Technologies – Wave and tidal current are the main ones. There is less being carried out on tidal range, OTEC and salinity gradient; Besides, there is a 18% of different options such as fixed & floating offshore wind, marine operations, cables, tailored full scale structural testing etc as can be seen in **Table 5**:

Ocean Energy Technologies tested	% responding
Wave	55%
Tidal Stream (currents)	55%
Tidal Range	9%
OTEC	14%
Salinity Gradient	5%
Other, please specify	18% fixed & floating offshore wind, marine operations, cables, tailored full scale structural testing, environmental conditions, corrosion, fatigue, marine growth

Table 5: Tested technologies

Stakeholders continues having most interest in wave and tidal stream technologies given the higher maturity of these technologies and given that there are not many suitable sites for the exploitation of OTEC, salinity gradient and specially tidal range in Europe.

Respondents utilising the “other” field help to emphasize the fact that peripheral technologies to ocean energy exploitation are also being tested. Research, development and testing are ongoing and necessary in fields such as corrosion, marine growth (bio-fouling), structural testing, cables, marine operations, etc.

- Priority research areas – all topics are covered. Reliability and survivability of materials and structures scored the highest, followed by device and modelling, sub-systems, foundations and mooring as can be seen in **Table 6**:

Priority Research Areas covered	% responding
Reliability & Survivability of Materials and/or Structures	80%
Subsystems - Foundations & Moorings	60%
Environmental Impacts & Modelling	60%
Device Modelling	55%
Subsystems - Power Take Off	50%
Enabling Technologies	50%
Resource Evaluation and Environmental Understanding	45%
Grid Connection and Power Systems Integration	45%
Subsystems - Hydraulic Systems	40%
Subsystems - Control & Electronic Systems	35%
Array Modelling	30%
Subsystems - Others	25%
Other, please specify	15% Marine corrosion, biofouling, marine growth

Table 6: Priority research areas

The currently targeted areas for research show the importance of testing in real-world environmental conditions (in-sea testing). Focus is dedicated to large units of the developed technologies (foundations, moorings, power take off systems) and to device modelling and enabling technologies.

Current Limitations or Barriers to overcome

Those responding to open questions concerning limitations/barriers and opportunities/future improvements provided the following information:

- Adaptive blade pitch control
- The technology is in need of funding for installation of 3 existing wave pumps for co-acting delivery and documentation from realistic sea conditions
- EU State aid regulations & UK interpretation of those regulations
- Complexity of finding funding for specific and common industry challenges.
- Need to continue to grow staff in order to compete in a more international marketplace.
- Need greater awareness of our testing structure’s capabilities and a greater willingness by academics to make use of our capabilities

Opportunities and Future Improvements

- Array modelling
- After current demonstrations the concept will be well prepared for a commercial take-off
- Looking to building capacity for combined wave and current testing in addition to wave
- Assessment and mitigation of the marine corrosion and bio-fouling effects in real sea conditions
- R&D activities supported by a technological centre and academia
- Better political support for MRE in the UK, including at the RDI level and realising that it is not all about rushing to get steel in the water
- A better prospect of actually being able to work with projects and companies in France - i.e. a less 'French only' position
- More staff will allow greater throughput of work at the testing facility. (this is already in hand).
- The PCM-Engine will challenge the existing OTEC technologies and has the potential to offer cost effective and simple OTEC systems.

Public / Private Collaboration Agreements

Nine respondents answered positively to the question concerning participation in public/private collaboration agreements. The expressed the agreements the have signed with other institutions which are related with finding the complementarities to move forward in the development of technical solutions.

FORM B2 Infrastructure: Operational farms / Plant deployments

The number of replies gathered in 2015 has been of 3 which represents an increase of 14% related to the number obtained in 2014. The results presented is an analysis of the accumulated replies for the years 2014 and 2015.

The number of completed questionnaires 10.
It must be recognised that this number of replies make impossible to reach major conclusions. In order to counter this fact, the majority of the indicated conclusions are translations of answers received in the questionnaires relating to the state of the art of marine energy technologies.

- 4 respondents are from France, 2 are from Sweden, 1 is from Scotland, 1 is from Belgium, 1 is from Spain and the other one is from Netherlands.
- 80% of the respondents are located in offshore infrastructure (> 50 m water depth).
  As happened in 2014 report, this fact suggests that the future of large-scale renewable marine energy deployments lies more offshore than in coastal waters.
- 44% of infrastructure (operational farms / plants) is under construction (mainly electricity production facilities), 22% are into the consenting process and 33% are operational.
- In 2015, the clear frontrunner is tidal stream with horizontal axis turbines leading the list of potential technological deployments. The questionnaire indicates that there are two wave energy plants and four tidal stream plants. The primary objective for these kinds of technologies is improved robustness.
- Most farms in operation today are located offshore at a distance of more than 50 metres from the shore, are privately owned (70%), 44% of which are under construction and include mainly electricity production facilities. When applicable, all of them have carried out an environmental assessment report. The technology focuses mainly on tidal stream currents with 100% horizontal axis turbines. Where wave energy is applicable, detailed technology classifications used included Point Absorber and Oscillating Water Column (OWC). The installed capacity varies from 1 to 16 MW, the majority had 1 sub-station and a range of between 1 and 36 converters. Water depth was in the range of 30 to 55 m, area in km2 ranged from 0.04 to 5 km and site distance from the shore ranged from onshore to 15km offshore.

When asked about opportunities and future improvements, the following were mentioned:

- Expansion of the facility to 10MW in phase II;
- Development of a production unit at 1.4 MW with sub-sea interconnection hub; ▶ Additional convertors.
- Cost reduction.
- Important improvements in the Technology making it more cost effective, reliable and environmental friendly.
- Upgrading with higher capacity devices in the near future.

FORM C National / Regional stakeholders in Technology Advancement

The number of replies gathered in 2015 was 5, representing an increase of 16% related to the number obtained in 2014. The results presented are an analysis of the accumulated replies for the years 2014 and 2015.

The number of completed questionnaires is 36.

The main conclusions[1] of the questionnaires can be drawn as follows but the reduced number of replies does not allow to extract strong conclusions:

- Projects works within small budgets. A 64% of the projects have a Budget bellow 0.5M€, a 23% of the projects have a Budget in the range 0.5-1M€ and a 14% are in the range 1-5M€.
- 2 are from Sweden, 3 is from Scotland, 2 is from Belgium, 12 is from Spain and 2 from Portugal.
- Small teams of ocean energy researchers, with a 70% in the range of 1 – 10, and with a 26% in the range 11-50.
- Most structures are public research institutes with a percentage of 54% versus private research institute with a percentage of 42%. The mixed public – private research institutes represents 4%.
- Activities mainly focused on wave energy technologies (63%): only 4% tidal currents and no tidal range / OTEC / or salinity gradient technologies;
- The main research priorities and areas of in-house capacity include: device modelling, testing and validation (74%), designing of tools (60%), sub-systems (power take-off, hydraulics, control and electronic systems, foundations and moorings) (61%), Resource evaluation and environmental understanding (48%) environmental and social issues, etc.

[1] NB: Any conclusions drawn here are necessarily influenced by the high percentage of Spanish responses to the survey.

▶

Research areas/Capacities within ocean energy issues	Response rate
Technology Development - Device Modelling, Testing and Validation	74%
Design Tools	61%
Technology Development - Subsystems (Power Take Off, Hydraulics, Control&Electronic Systems, Foundations&Moorings, other)	61%
Resource Evaluation and Environmental Understanding	48%
Reliability & Survivability of Materials or/and Structures	48%
Environmental & Social Issues	48%
Infrastructures - Subsea Issues, Foundations, Moorings	39%
Infrastructures - Installation, O&M, Retrieval	39%
Array Design, Integration and Plant Balance	35%
Infrastructures - Grid Connection	35%
Risk Reduction	35%
Standards and protocols	35%
Enabling Technologies	26%
Economic issues & Feasibility	22%
Infrastructures - Ports & Harbours	9%
Manufacturing	4%

Figure 11: Research areas and capacities within context of ocean energy themes

▶ Fields of expertise include ocean energy technology developers followed by ocean energy project developers, ocean engineering, naval architecture, structural engineering, etc. as can be seen in Figure 12.

Fields of expertise	Response rate
Ocean Energy Technology Developer	16%
Ocean Energy Project Developer	16%
Ocean Engineering	16%
Naval Architecture	11%
Strutural Engineering	11%
Environmental Assessment or Monitoring	11%
Design and Simulation Tools	11%
Control and ICTs (Information and Communication Technologies)	5%
Other, please specify (marine planning)	5%

Figure 12: Fields of expertise within the ocean energy sector

- The main technology developed is wave energy. Capacity in MW was in the range of 0.001 to 5 MWs for all technologies.

Technology developed	Response rate
Wave Energy	47%
Other, please specify	47%
Combination of wind farms, with tidal and wave energy	
Modelling	
Mooring and Anchoring Systems	
Tidal Stream	6%

Figure 13: Development of technologies

To the question: “Why do you consider this project to be successful and please indicate achievements and learning points”, the following were mentioned:

- Based on the replication of theoretically predicted irrotational flows over moving blades, a specifically designed Darrieus VAWT has been parameterised, simulated and manufactured. The implementation of adequate blade-pitching laws allow a wake-free operation at various regimes, along with an efficiency maximisation. The operating range of the blade pitching strategy in terms of dynamic stall and power extraction has been identified;
- High applicability in the study region, enhancing the aquaculture industry in the Macaronesian region;
- Power delivered to shore. More than three years of accumulated data from sea trials. Three WECs and one substation operational simultaneously. One WEC in uninterrupted operation for 9 months. Next step is grid connection in 2015;
- As part of the Marine Renewables Commercialisation Fund (MRCF) consortium there are a developing enabling technology for the mooring of wave and tidal arrays. A key part of this is technology qualification. More representative modelling of mooring systems using design tools demonstrate the significant benefits of nylon based mooring systems;
- A first prototype was tested at sea in 2008 being the first wave energy device in the water in Spain. The technology has been improved and a new concept is expected to be tested at Bimep in 2016.
- The objectives achieved are described below, for some it was not needed to start from scratch due to previous group experience:
    - Summarise the various theories of the waves, and application of the most appropriate according to the characteristics of the location of the OWC drive system, improving the existing model in the group so as to allow study for different wave parameters coupled with the behaviour of the system formed by capture camera and Wells turbine as faithfully as possible.

- Description of the Wells turbine with its main features to improve the model after considering its implementation in the NEREIDA MOWC (ocean wave converter technology). Justify the choice of doubly-fed induction generator (DFIG) as a linking element between the Wells turbine and the distribution network, explaining its operation, equations and model to use. Analyse the back to back converter used, designing and adapting its different elements and in particular the rotor side converter (RSC), DC-link and network side converter (GSC) ○ Designing advanced to satisfactorily resolve some of the issues, such as behaviour Wells turbine loss or overcoming gaps in the mains voltage, proposing new and different solutions. Implement control algorithms needed to overcome the previously defined issues, carrying out pre/actual experimentation through necessary simulations to validate its good performance both in the wave tank and benches group as in real plant NEREIDA MOWC Mutriku

- The project will contribute to unlocking new deep-water areas for wind farms by doing enabling research on very large, floating offshore wind turbines
- The project addresses critical issues of offshore WT technology such as extreme reliability, remote maintenance and grid integration with particular emphasis on floating wind turbines, where weight and size limitations of onshore designs can be overcome (N.B.: wind energy is not a focus of the OCEANERA-NET consortium but ancillary cross-sector technologies are of interest such as the aforementioned reliability, O&M, grid, etc.,)
- This project has tested successfully its technology in the PLOCAN marine test site.
- The system has been installed and remains operational. There have not been Health and Safety incidents. The Project was completed in Schedule and led onto a number of spin off R&D applications.

Quick Survey

One of the main objectives of the survey is to allow a better alignment of future OCEANERA Joint Calls.

The questionnaire has two main sections.

- The first one has been structured in 23 topics, where stakeholders have been asked about the interest on them.
- The second one aims to identify the Technology Readiness Levels (TRL) of interest for each topic pointed above.

A total of 89 questionnaires have been received. Form A in the 2014 questionnaire was completed by 61 stakeholders. This means that 45% more responses have been completed. The result is very relevant and the fact of having conducted this survey in a more stream-lined questionnaire process has allowed to collect the increase in the interest of stakeholders in the field of marine renewables.

A summary of the information requested is shown in Table 7: Topics of interest. For each topic, it was asked to evaluate them **by priority** (in terms of urgency), and TRL level needed for each topic. The thematic areas are the same than in Form A (see table 1) although the respondents were asked to indicate the level of interest in each subarea and the TRL of their technology related with the thematic areas.

Topics of interest		Interest				TRL of interest
		No interest	Low Interest	Medium interest	High interest	TRL from 1 to 9
1	Resource evaluation, environmental understanding, site selection: modelling tools					
2	Components and prototypes of marine renewable devices: mechanical components, control systems, power take-off….					
3	Tools for design, monitoring and modelling systems (Device and components)					
4	Testing and validation in real conditions					
5	Array design and integration. Balance of plant					
6	Reliability and survivability of materials and structures					
7	Manufacturing and supply chain					
8	Grid connection and power systems					
9	Subsea issues, foundations and moorings					
10	Ports and harbours					
11	Marine operations. Installation and Decommissioning					
12	Marine vessels					
13	Monitoring systems					
14	Economic issues and feasibility. LCOE optimisation, CAPEX and OPEX reduction					
15	Impact on marine environment and wildlife					
16	Cumulative impacts (incl. Climate change)					
17	Conflicts of use and marine spatial planning					
18	Social acceptance					
19	Risk reduction (Technical, Economical….)					
20	Standards and protocols					
21	Government issues. Policy and support					
22	Knowledge/Technology Transfer					
23	Enabling Technologies and Cross-Sector Opportunities					
24	Other topics of interest (Please indicate and its relevance)					

Table 7: Topics of interest

Figure 14 shows the results obtained for each topic of interest from topic 1 to topic 24:

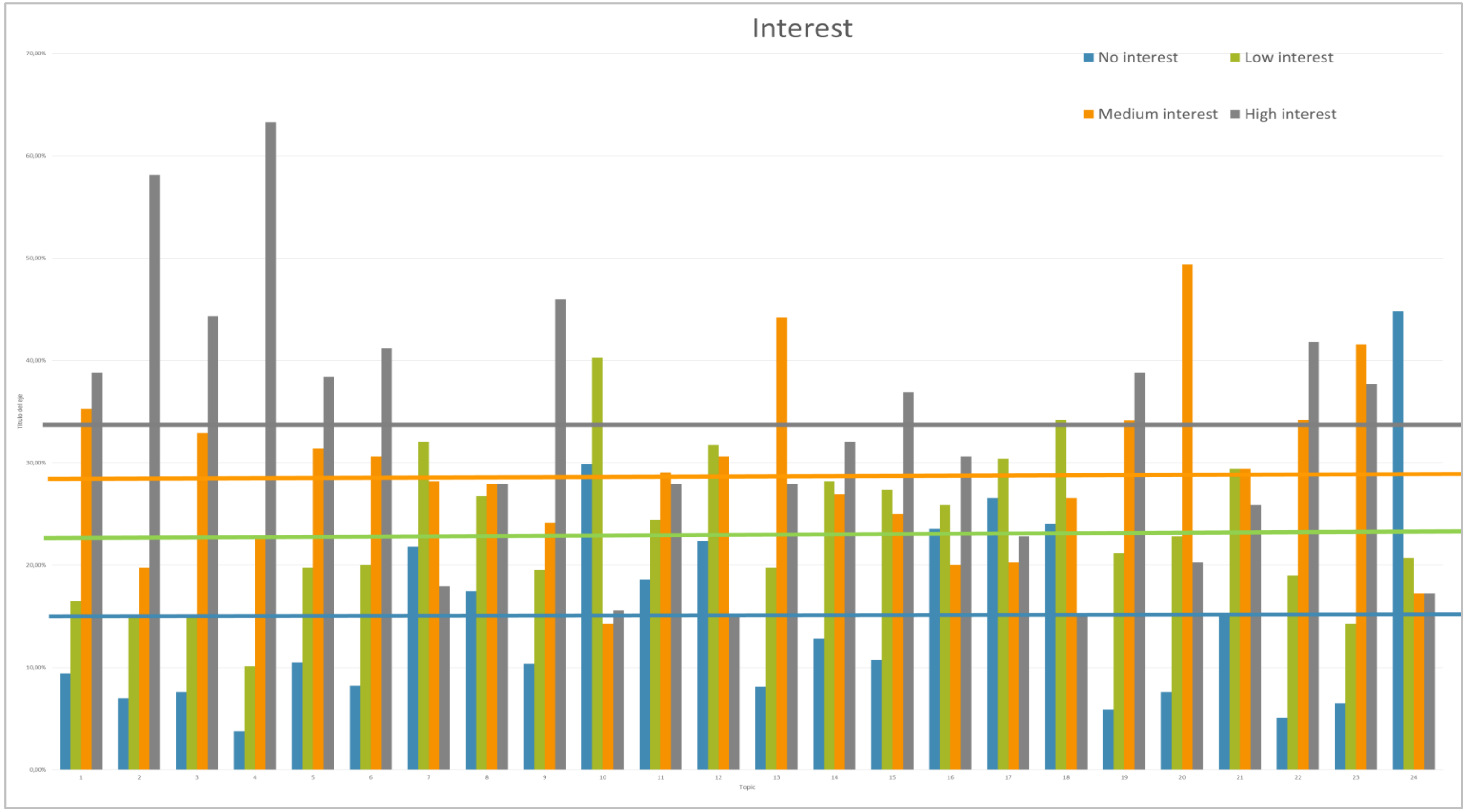


Figure 14: Topics of interest

In **Figure 15** are shown the results of the survey (aggregated data in % of answers by each topic). Additionally are shown two columns with the sum of answers corresponding to no interest and low interest on one column and the sum of answers corresponding to medium and high on other column.

It has been highlighted:

- In dark green those topics in which the sum of “medium and high interest” answers are above 70% of the total.
- In light green those topics in which the sum of “medium and high interest” answers are between 60 and 70% of the total.
- In yellow those topics in which the sum of “medium and high interest” answers are between 40 and 60% of the total.
- In red those topics in which the sum of “medium and high interest” answers are below 40% of the total.

	Priority					
	No interest	Low interest	Medium interest	High interest	No & low interest	Medium & high interest
Testing and validation in real conditions	3,80%	10,13%	22,78%	63,29%	13,92%	86,08%
Enabling Technologies and Cross-Sector Opportunities	6,49%	14,29%	41,56%	37,66%	20,78%	79,22%
Components and prototypes of marine renewable devices: mechanical components, control systems, power take-off….	6,98%	15,12%	19,77%	58,14%	22,09%	77,91%
Tools for design, monitoring and modelling systems (Device and components)	7,59%	15,19%	32,91%	44,30%	22,78%	77,22%
Knowledge/Technology Transfer	5,06%	18,99%	34,18%	41,77%	24,05%	75,95%
Resource evaluation, environmental understanding, site selection: modelling tools	9,41%	16,47%	35,29%	38,82%	25,88%	74,12%
Risk reduction (Technical, Economical….)	5,88%	21,18%	34,12%	38,82%	27,06%	72,94%
Monitoring systems	8,14%	19,77%	44,19%	27,91%	27,91%	72,09%
Reliability and survivability of materials and structures	8,24%	20,00%	30,59%	41,18%	28,24%	71,76%
Subsea issues, foundations and moorings	10,34%	19,54%	24,14%	45,98%	29,89%	70,11%
Array design and integration. Balance of plant	10,47%	19,77%	31,40%	38,37%	30,23%	69,77%
Standards and protocols	7,59%	22,78%	49,37%	20,25%	30,38%	69,62%
Impact on marine environment and wildlife	10,71%	27,38%	25,00%	36,90%	38,10%	61,90%
Economic issues and feasibility. LCOE optimisation, CAPEX and OPEX reduction	12,82%	28,21%	26,92%	32,05%	41,03%	58,97%
Marine operations. Installation and Decommissioning	18,60%	24,42%	29,07%	27,91%	43,02%	56,98%
Grid connection and power systems	17,44%	26,74%	27,91%	27,91%	44,19%	55,81%
Governement issues. Policy and support	15,29%	29,41%	29,41%	25,88%	44,71%	55,29%
Cumulative impacts (incl. Climate change)	23,53%	25,88%	20,00%	30,59%	49,41%	50,59%
Manufacturing and supply chain	21,79%	32,05%	28,21%	17,95%	53,85%	46,15%
Marine vessels	22,35%	31,76%	30,59%	15,29%	54,12%	45,88%
Conflicts of use and marine spatial planning	26,58%	30,38%	20,25%	22,78%	56,96%	43,04%
Social acceptance	24,05%	34,18%	26,58%	15,19%	58,23%	41,77%
Ports and harbours	29,87%	40,26%	14,29%	15,58%	70,13%	29,87%

Figure 15: Results by priority

According to the survey, the thematic areas show higher priority for stakeholders are:

- Testing and validation in real conditions
- Enabling Technologies and Cross-Sector Opportunities
- Components and prototypes of marine renewable devices: mechanical components, control systems, power take-off….
- Tools for design, monitoring and modelling systems (Device and components)
- Knowledge/Technology Transfer
- Resource evaluation, environmental understanding, site selection: modelling tools
- Risk reduction (Technical, Economical….)
- Monitoring systems
- Reliability and survivability of materials and structures
- Subsea issues, foundations and moorings

Comparing the results of the surveys obtained in 2014 and 2015, the only topic that is has not been classified as of "high priority" is the grid connection one. Probably, the reason is the "type" of stakeholders who have answered the survey because we understand this issue is still of high priority for the sector.

A key point is the consideration of the topic "Enabling Technologies and Cross-Sector Opportunities" as one of the most ranked. In some of the meetings of OCEANERA partners with other ocean energy sector stakeholders this point has been raised and a joint activity is foreseen to address this issue.

As in the 2014 survey (FORM A), infrastructural challenge related to the availability of suitable port services and specialised vessels don't seem to be so relevant for the stakeholders participating in the survey, although these are required for the transportation, assembly, installation and repair of devices and foundations, the installation of underwater cables and connectors, and operations and maintenance (O&M) services.

In the case of array design and other areas such as environmental impact, ports and harbours, vessels or manufacturing and supply chain, the result is similar to the 2014 survey (FORM A), the priority is not so high, probably because there are not many companies in the situation of setting up of farms.

Regarding the TRL's, in Figure 16 are shown the results of the survey (aggregated data in % of answers by each TRL level). Additionally are shown four columns with the sum of answers corresponding to basic research, technology development, technology demonstration and system testing and operation.

For doing this, it has been assumed the following criteria:

- Basic research. TRL 1 and 2
- Technology development. TRL 3, 4 and 5.
- Technology Demonstration. TRL 6 and 7
- System testing and operation. TRL 8 and 9

	TRL												
	Basic research		Technology development			Technology Demonstration		System testing and operation					
	TRL1	TRL2	TRL3	TRL4	TRL5	TRL6	TRL7	TRL8	TRL9	Basic research	Technology development	Technology Demonstration	System testing and operation
Testing and validation in real conditions	4,62%	1,54%	4,62%	13,85%	21,54%	20,00%	20,00%	1,54%	12,31%	6,15%	40,00%	40,00%	13,85%
Enabling Technologies and Cross-Sector Opportunities	9,43%	13,21%	5,66%	13,21%	22,64%	3,77%	15,09%	3,77%	13,21%	22,64%	41,51%	18,87%	16,98%
Components and prototypes of marine renewable devices: mechanical components, control systems, power take-off….	5,63%	4,23%	14,08%	25,35%	21,13%	12,68%	7,04%	1,41%	8,45%	9,86%	60,56%	19,72%	9,86%
Tools for design, monitoring and modelling systems (Device and components)	7,94%	6,35%	11,11%	25,40%	19,05%	11,11%	7,94%	3,17%	7,94%	14,29%	55,56%	19,05%	11,11%
Knowledge/Technology Transfer	13,04%	2,17%	8,70%	4,35%	15,22%	15,22%	17,39%	2,17%	21,74%	15,22%	28,26%	32,61%	23,91%
Resource evaluation, environmental understanding, site selection: modelling tools	11,11%	3,17%	7,94%	14,29%	19,05%	12,70%	12,70%	4,76%	14,29%	14,29%	41,27%	25,40%	19,05%
Risk reduction (Technical, Economical….)	6,67%	6,67%	4,44%	6,67%	17,78%	11,11%	8,89%	11,11%	26,67%	13,33%	28,89%	20,00%	37,78%
Monitoring systems	9,09%	5,45%	9,09%	5,45%	21,82%	7,27%	14,55%	12,73%	14,55%	14,55%	36,36%	21,82%	27,27%
Reliability and survivability of materials and structures	7,81%	3,13%	7,81%	15,63%	29,69%	9,38%	15,63%	1,56%	9,38%	10,94%	53,13%	25,00%	10,94%
Subsea issues, foundations and moorings	1,64%	6,56%	8,20%	14,75%	21,31%	21,31%	14,75%	0,00%	11,48%	8,20%	44,26%	36,07%	11,48%
Array design and integration. Balance of plant	8,20%	4,92%	11,48%	16,39%	21,31%	13,11%	8,20%	3,28%	13,11%	13,11%	49,18%	21,31%	16,39%
Standards and protocols	11,11%	7,41%	5,56%	20,37%	20,37%	14,81%	7,41%	0,00%	12,96%	18,52%	46,30%	22,22%	12,96%
Impact on marine environment and wildlife	5,77%	3,85%	5,77%	17,31%	21,15%	7,69%	17,31%	3,85%	17,31%	9,62%	44,23%	25,00%	21,15%
Economic issues and feasibility. LCOE optimisation, CAPEX and OPEX reduction	12,24%	4,08%	6,12%	16,33%	16,33%	16,33%	16,33%	0,00%	12,24%	16,33%	38,78%	32,65%	12,24%
Marine operations. Installation and Decommissioning	11,11%	5,56%	5,56%	14,81%	20,37%	9,26%	12,96%	5,56%	14,81%	16,67%	40,74%	22,22%	20,37%
Grid connection and power systems	12,73%	1,82%	5,45%	9,09%	23,64%	14,55%	16,36%	5,45%	10,91%	14,55%	38,18%	30,91%	16,36%
Governement issues. Policy and support	14,58%	4,17%	4,17%	10,42%	20,83%	8,33%	12,50%	4,17%	20,83%	18,75%	35,42%	20,83%	25,00%
Cumulative impacts (incl. Climate change)	8,33%	6,25%	6,25%	14,58%	20,83%	4,17%	14,58%	8,33%	16,67%	14,58%	41,67%	18,75%	25,00%
Manufacturing and supply chain	18,00%	6,00%	6,00%	6,00%	22,00%	10,00%	16,00%	4,00%	12,00%	24,00%	34,00%	26,00%	16,00%
Marine vessels	12,24%	6,12%	6,12%	14,29%	20,41%	10,20%	8,16%	4,08%	18,37%	18,37%	40,82%	18,37%	22,45%
Conflicts of use and marine spatial planning	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Social acceptance	6,82%	4,55%	11,36%	6,82%	25,00%	6,82%	9,09%	11,36%	18,18%	11,36%	43,18%	15,91%	29,55%
Ports and harbours	19,51%	0,00%	7,32%	12,20%	19,51%	7,32%	14,63%	2,44%	17,07%	19,51%	39,02%	21,95%	19,51%

Figure 16: Results for technology readiness level

Most of the topics are considered to be in the technology development and demonstration phase, although there is still much basic research to be done, and, compared with the last survey, many stakeholders consider the system testing phase is needed for many topics.

5. Proposal of priorities for future OE MRE Joint Calls

From the responses gathered from the questionnaires, the OCEANERA Project can extract valuable information which will serve to build a set of recommendations about the priorities of the marine renewable energy sector.

This set of recommendations will be considered during the Joint Call Committee sessions to design on a yearly basis, the general structure of the Calls and to select the Topics of the Call.

Although the increasing effort to gather bigger number of responses may give positive results in terms of number of replies obtained, it is expected not to reach an enough size of the sample to consider the results of the questionnaire decisive, so these recommendations will serve as a guide in the process of laying down the topics of the call.

To get the set of recommendations, it has been used the results of the Quick Survey. As commented before, it was completed by almost 90 stakeholders.

The Quick Survey was available online during 2 months (October and November 2015) through a specialized website. Every partner of the project was in charge of making the dissemination campaign to collect the replies of the stakeholders. To do that, they had different options: using the links to the survey website to give to the main stakeholders, making telephone calls or personal interviews. The Quick Survey was disseminated in events in which marine renewable energy sector were present. It was used the OCEANERA project Website and Social Networks to make the general dissemination of the questionnaire.

The results of the Quick Survey have been already presented in previous section but the analysis of the results and the final conclusions are carried out in this section.

To try to get the most accurate result to the stakeholders preferences related to the main topics of interest and the TRL which is of interest for companies, the data were processed by running different weighting scenarios for the criteria which allowed to compare more results.

5 scenarios were analised:

- Scenario 1 (SC1): Ranked by assigning different weights of each criterion:

0: No interest   1: Low interest   2: Medium interest   3: High interest

- Scenario 2 (SC2): Ranks by assigning different weights of each criterion:

1: No interest   2: Low interest   3: Medium interest   4: High interest

- Scenario 3 (SC3): Ranked by normalised weights:

1: No interest   3: Low interest   6: Medium interest   9: High interest

- Scenario 4 (SC4): Ranked by selection of best results for each criterion:

- Scenario 5 (SC5): Ranked by selection of "high interest" response only.

The next figure shows the ranked results for every scenario.

SC1	Topics of interest and priorities for the OCEANERA-NET Joint Call 2015	SC2	Topics of interest and priorities for the OCEANERA-NET Joint Call 2015	SC3	Topics of interest and priorities for the OCEANERA-NET Joint Call 2015	SC4	Topics of interest and priorities for the OCEANERA-NET Joint Call 2015	SC5	Topics of interest and priorities for the OCEANERA-NET Joint Call 2015
1º	Components&prototypes of marine renewable devices: mechanical components, control systems, PTO....	1º	Components&prototypes of marine renewable devices: mechanical components, control systems, PTO....	1º	Components&prototypes of marine renewable devices: mechanical components, control systems, PTO....	1º	Components&prototypes of marine renewable devices: mechanical components, control systems,PTO....	1º	Components&prototypes of marine renewable devices: mechanical components, control systems, PTO....
2º	Testing and validation in real conditions	2º	Testing and validation in real conditions	2º	Testing and validation in real conditions	2º	Testing and validation in real conditions	2º	Testing and validation in real conditions
3º	Risk reduction (Technical, Economical....)	3º	Subsea issues, foundations and moorings	3º	Subsea issues, foundations and moorings	3º	Subsea issues, foundations and moorings	3º	Subsea issues, foundations and moorings
4º	Subsea issues, foundations and moorings	4º	Risk reduction (Technical, Economical....)	4º	Risk reduction (Technical, Economical....)	4º	Reliability and survivability of materials and structures	4º	Reliability and survivability of materials and structures
5º	Resource evaluation, environmental understanding, site selection: modelling tools	5º	Resource evaluation, environmental understanding, site selection: modelling tools	5º	Resource evaluation, environmental understanding, site selection: modelling tools	5º	Risk reduction (Technical, Economical....)	5º	Tools for design, monitoring and modelling systems (Device and components)
6º	Reliability and survivability of materials and structures	6º	Reliability and survivability of materials and structures	6º	Reliability and survivability of materials and structures	6º	Tools for design, monitoring and modelling systems (Device and components)	6º	Risk reduction (Technical, Economical....)
7º	Array design and integration. Balance of plant	7º	Array design and integration. Balance of plant	7º	Array design and integration. Balance of plant	7º	Resource evaluation, environmental understanding, site selection: modelling tools	7º	Resource evaluation, environmental understanding, site selection: modelling tools
8º	Knowledge/Technology Transfer	8º	Monitoring systems	8º	Monitoring systems	8º	Array design and integration. Balance of plant	8º	Array design and integration. Balance of plant
9º	Monitoring systems	9º	Knowledge/Technology Transfer	9º	Knowledge/Technology Transfer	9º	Knowledge/Technology Transfer	9º	Knowledge/Technology Transfer
10º	Tools for design, monitoring and modelling systems (Device and components)	10º	Tools for design, monitoring and modelling systems (Device and components)	10º	Tools for design, monitoring and modelling systems (Device and components)	10º	Impact on marine environment and wildlife	10º	Impact on marine environment and wildlife
11º	Enabling Technologies and Cross-Sector Opportunities	11º	Impact on marine environment and wildlife	11º	Enabling Technologies and Cross-Sector Opportunities	11º	Enabling Technologies and Cross-Sector Opportunities	11º	Enabling Technologies and Cross-Sector Opportunities
12º	Impact on marine environment and wildlife	12º	Enabling Technologies and Cross-Sector Opportunities	12º	Impact on marine environment and wildlife	12º	Economic issues and feasibility. LCOE optimisation, CAPEX and OPEX reduction	12º	Economic issues and feasibility. LCOE optimisation, CAPEX and OPEX reduction
13º	Standards and protocols	13º	Marine operations. Installation and Decommissioning	13º	Marine operations. Installation and Decommissioning	13º	Monitoring systems	13º	Monitoring systems
14º	Marine operations. Installation and Decommissioning	14º	Grid connection and power systems	14º	Grid connection and power systems	14º	Cumulative impacts (incl. Climate change)	14º	Cumulative impacts (incl. Climate change)
15º	Grid connection and power systems	15º	Governement issues. Policy and support	15º	Standards and protocols	15º	Marine operations. Installation and Decommissioning	15º	Grid connection and power systems
16º	Economic issues and feasibility. LCOE optimisation, CAPEX and OPEX reduction	16º	Standards and protocols	16º	Economic issues and feasibility. LCOE optimisation, CAPEX and OPEX reduction	16º	Grid connection and power systems	16º	Marine operations. Installation and Decommissioning
17º	Governement issues. Policy and support	17º	Economic issues and feasibility. LCOE optimisation, CAPEX and OPEX reduction	17º	Governement issues. Policy and support	17º	Governement issues. Policy and support	17º	Governement issues. Policy and support
18º	Cumulative impacts (incl. Climate change)	18º	Cumulative impacts (incl. Climate change)	18º	Cumulative impacts (incl. Climate change)	18º	Conflicts of use and marine spatial planning	18º	Conflicts of use and marine spatial planning
19º	Marine vessels	19º	Marine vessels	19º	Marine vessels	19º	Standards and protocols	19º	Standards and protocols
20º	Conflicts of use and marine spatial planning	20º	Conflicts of use and marine spatial planning	20º	Conflicts of use and marine spatial planning	20º	Marine vessels	20º	Manufacturing and supply chain
21º	Manufacturing and supply chain	21º	Manufacturing and supply chain	21º	Manufacturing and supply chain	21º	Manufacturing and supply chain	21º	Marine vessels
22º	Social acceptance	22º	Social acceptance	22º	Social acceptance	22º	Social acceptance	22º	Social acceptance
23º	Ports and harbours	23º	Ports and harbours	23º	Ports and harbours	23º	Ports and harbours	23º	Ports and harbours
24º	Other topics of interest. (Please indicate and its relevance)	24º	Other topics of interest. (Please indicate and its relevance)	24º	Other topics of interest. (Please indicate and its relevance)	24º	Other topics of interest. (Please indicate and its relevance)	24º	Other topics of interest. (Please indicate and its relevance)

Figure 17: Ranked Results by scenario

Looking at the table and comparing by pairs, it is easy to verify that the results are not very different from one scenario to the other globally and taking into account that topics would be grouped in wider thematic areas to include them as topics for the Call, can be said that in general, the results remain stable in all scenarios.

For this reason and considering the Best Results Scenario (SC4) as a quite accurate approximation to the market requirements, it was selected this ranking to be used as recommendations for the Topics of the Call. Taking this into account, the list of priorities are shown in the next table:

Ranking 2015	Topics of interest and priorities for the OCEANERA-NET Joint Call
1º	Components & Prototypes of marine renewable devices: mechanical components, control systems, PTO….
2º	Testing and validation in real conditions
3º	Subsea issues, foundations and moorings
4º	Reliability and survivability of materials and structures
5º	Risk reduction (Technical, Economical….)
6º	Tools for design, monitoring and modelling systems
7º	Resource evaluation, environmental understanding, site selection: modelling tools
8º	Array design and integration. Balance of plant
9º	Knowledge/Technology Transfer
10º	Impact on marine environment and wildlife
11º	Enabling Technologies and Cross-Sector Opportunities
12º	Economic issues and feasibility. LCOE optimisation, CAPEX and OPEX reduction
13º	Monitoring systems
14º	Cumulative impacts (incl. Climate change)
15º	Marine operations. Installation and Decommissioning
16º	Grid connection and power systems
17º	Government issues. Policy and support
18º	Conflicts of use and marine spatial planning
19º	Standards and protocols
20º	Marine vessels
21º	Manufacturing and supply chain
22º	Social acceptance

23º	Ports and harbours

Table 8: Ranking of topics of interest

Although the replies to other topics of interest is in the last position of the ranking, it could have some relevance to know about which other thematics are of interest for the stakeholders.

In this sense, the responses obtained are:

- Funds for feasibility studies after specialist assessment for novelty and efficacy. Too much time is wasted in finding funds and usually results in low levels of funds;
- Ecosystem services, soil ecosystems, political ecology;
- Turbulence studies and uncertainties in the evaluation of resources;
- Influence of waves on current devices;
- Instrumentation and surveys;
- Materials reliability in harsh environment (sea water is harsh environment for all man-made structures) corrosion, fouling etc. ;
- Semipermeable Membranes for Direct Osmosis 'PRO';
- Physical modeling studies.

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