Ocean Energy Forum

OCEAN ENERGY STRATEGIC ROADMAP
BUILDING OCEAN ENERGY FOR EUROPE

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WEBSITE https://webgate.ec.europa.eu/maritimeforum/en/frontpage/1036

ACKNOWLEDGEMENTS

This Strategic Roadmap was commissioned by the European Commission Directorate-General for Maritime Affairs and Fisheries, Directorate C: Atlantic, Outermost Regions and Arctic, and produced in collaboration with the Ocean Energy Forum.

The Ocean Energy Forum was set up to bring together stakeholders to develop a shared understanding of the problems faced by the Ocean Energy sector and to collectively devise workable solutions.

The Forum is formed of three workstreams: Environment & Consenting, Finance and Technology. Each workstream has a Steering Committee and a Chair. The three workstreams allow consensus building to take place at a topic-specific level.

The Forum is supported by a Secretariat, appointed April 2015, whose main role is to help ensure the production and timely delivery of the Strategic Roadmap. The Secretariat services form part of a Programme whose implementation has been delegated to the Executive Agency for Small and Medium-sized Enterprises (EASME).

Grateful thanks are extended to all those involved in the production of the Strategic Roadmap, for their continued support and input.

Special thanks to Michael Bullock, Director of Renewable Risk Advisors, for his significant input into the Insurance and Guarantee Fund design option paper.

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Sustainable Marine Energy • Tocado • Wello Oy • Wave Hub Ltd AW Energy

Document to be cited as

Ocean Energy Forum (2016). Ocean Energy Strategic Roadmap 2016, building ocean energy for Europe.

CONTENTS

EXECUTIVE SUMMARY

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Ocean Energy: a sizeable prize

Ocean energy is abundant, geographically diverse and renewable. Under favourable regulatory and economic conditions, ocean energy could meet 10%[1] of the European Union's (EU) power demand by 2050. Europe's seas and oceans could therefore play an important role in addressing one of the EU's biggest current challenges; an energy transition from a system based on imported fossil fuels to a flexible and interconnected system based on clean, renewable and infinite domestic resources.

European Policy has very successfully taken the first generation of renewable energy technologies, such as solar and wind, to commercially competitive levels. The EU will, however, need other technologies to further diversify its low-carbon generation capacity, if it is to meet its objective of reducing greenhouse gas emissions to 80–95% below 1990 levels by 2050[2]. By 2050 power generated by the ocean energy sector could avoid the equivalent of 276m tonnes of CO_2 emissions annually[3].

As a unique chance to create a new industrial sector, created in Europe, generating jobs in its regions throughout the local supply chain, Europe needs continued investment and support to ocean energy. Spurred by ambitious renewable energy policies, the European ocean energy sector is a world leader today, home to the most advanced technology so far. This technological advantage, and the need to stay close to the resource to reduce costs, ensures that manufacturing remains European.

Ocean energy can be an EU industrial success story. With favourable support over the coming decade, Europe will obtain leadership in a global market, worth a potential €653bn between 2010 and 2050[4], and an annual market of up to €53bn, significantly benefiting the European economy. The successful development of a competitive European ocean energy industry would also place the European industry in a prime position to seize export opportunities in the global market.

Supporting technological development from the early stages

Ocean energy technologies are at varying phases of development in Europe; each uses a different ocean resource and each has its own specific electricity production pattern. To reach the phase where ocean energy technologies can be rolled-out industrially and to truly reap the rewards of Europe's early investments, the technologies need to go from R&D and prototype through to demonstration and pre-commercial phases.

As ocean energy technologies progress through each development phase, they must overcome similar challenges. Technology demonstration and validation is fundamental to the sector's development as commercial lenders and financiers are often reluctant to invest in unproven or little understood technologies. This is even more important today, as power producers have moved from making strategic investments in new technologies to focusing purely on immediate returns.

1 Ocean Energy Europe has estimated that 100GW of ocean energy capacity could be deployed in Europe by 2050, producing around 350TWh of electricity. The European Commission's EU Energy, transport and GHG emissions: trends to 2050 reference scenario 2013 estimates total EU power generation in 2050 at 3.844TWh.

2 European Commission 2012. *Energy Roadmap 2050.* Luxembourg: Publications Office of the European Union 2012. [Online] https://ec.europa.eu/energy/sites/ener/files/documents/2012_energy_roadmap_2050_en_0.pdf.

3 Calculations based on Ocean Energy Europe and European Commission's *EU Energy, transport and GHG emissions trends to 2050 reference scenario 2013.* [Online] http://ec.europa.eu/transport/sites/transport/files/media/publications/doc/trends-to-2050-update-2013.pdf.

4 Carbon Trust (2011). Marine Renewables Green Growth Paper.

The European Technology and Innovation Platform for Ocean Energy (TP Ocean)[5] identified six essential priority areas to be addressed to improve ocean energy technology and decrease its risk profile. These areas were the starting point for the Ocean Energy Forum, bringing together more than 100 ocean energy experts over two years, to develop the Strategic Roadmap.

- *Testing* sub-system components and devices in real sea conditions.
- Increasing the *reliability and performance* of ocean energy devices allowing for future design improvements.
- Stimulating a dedicated *installation and operation and maintenance* value chain, to reduce costs.
- Delivering *power to the grid*, with hubs to collect cables from ocean energy farms and bring power to shore.
- *Devising standards and certification*, to facilitate access to commercial financing.
- *Reducing costs and increasing performance* through innovation and testing.

In this Roadmap, ocean energy development is broken down into five main development phases.

These phases have been used throughout the Roadmap as a pathway to the final industrial roll-out phase. For each phase of development, different technological, financing and regulatory challenges must be overcome to address the six priority areas above. These challenges require bespoke actions from all stakeholders and fit-for-purpose public and private funding and financing solutions.

This Roadmap, therefore, puts forward four key Action Plans focused on maximising private and public investments in ocean energy development by de-risking technology as much as possible, ensuring a smoother transition from one development phase to another on the path to industrial roll-out and a fully commercial sector.

R&D and Prototype phases: ensure that enough technologies reach demonstration stage to maintain healthy competition and Europe's technology leadership

Further device innovation and component improvements, plus rigorous testing are required before larger investments can be made. Several technologies have reached this stage of development. R&D and prototype projects offer little revenue in terms of electricity sales and thus require grant funding.

Early R&D can be funded from companies' balance sheets and research grants, but larger budgets are required to leverage enough private capital for prototypes. To ensure that enough technologies reach demonstration stage and that Europe's technology leadership is maintained, public authorities need to supply appropriate levels of funding.

Public funding ensures collaboration between otherwise competing companies, and data and knowledge sharing to the benefit of the entire European sector, accelerating the pace towards industrial roll-out. The EU and national governments therefore need to build-up or maintain an appropriate level of innovation and R&D support.

As test centres for R&D and prototypes are spread across the EU, a common language for test results is required. EU-wide standardised testing would help developers access finance by enabling investors to compare the different technologies based on objective measurable criteria. The ocean energy industry therefore, needs to define and adopt standards for testing devices and components.

5 TP Ocean brings together more than 200 experts within the ocean energy sector to define a clear pathway for technology research http://www.oceanenergy-europe.eu/tp-ocean.

Action 1 – Industry and Member States to establish a European phase-gate scheme to validate sub-systems and early prototypes in the less mature ocean energy technologies.

Demonstration and Pre-Commercial phases: bridging the 'Valley of Death[6]' through innovative finance in insurance and investment support

During demonstration and pre-commercial phases, single ocean energy devices will have been tested and their functioning better understood by potential investors. Yet uncertainties on production levels and maintenance requirements for farms and larger plants remain. These uncertainties imply a higher financial risk, preventing access to commercial bank loans and private equity and calling for investment support.

The high CapEx-intensity of ocean energy projects requires investment support schemes to include a strong component of upfront finance, to help projects leverage private finance and reach financial close.

To be successful, investment schemes should focus on two innovative instruments:

- a €70m Insurance and Guarantee Fund; and
- a €250m Investment Support Fund.

An *Insurance and Guarantee Fund* – the currently higher risk inherent to innovative technologies cannot be fully borne by either device or project developer, nor insured commercially as insurers lack knowledge of the sector and appetite for high risk/low premium insurance schemes. An Ocean Energy Insurance and Guarantee Fund could cover some part of the risks (for example installation, breakdown, electricity production) and mutualise them over a portfolio of projects. The balance of the risk would remain with the device or project developer, so that those with the ability to mitigate the risks remain suitably incentivised to do so. This could enable significant investments with a relatively low pot estimated around €50m-€70m for the first 10 projects.

An *Investment Support Fund* – addressing the difficulty of sourcing private capital for projects. Today, the risk remains too high for commercial debt providers, in a market without long-term visibility and where the traditional investors – power producers – are no longer strategically investing in innovative renewables. Such a Fund should provide finance flexibly (grant, debt or equity) to suit the diverse profiles of projects while requesting a strong due diligence, reducing risks for the Fund itself and providing a seal of approval helping to access further private finance at reduced cost.

Revenue support in the form of feed-in premiums or CfD[7]s, will not help investments, but it can give a long-term visibility to market actors and solve one of the above mentioned challenges whilst helping leverage private capital. Finally, European state aid guidelines will need to better accommodate the funding requirements of emerging technologies such as ocean energy.

Action 2 – EU and National Authorities should set up a €250m Investment Support Fund providing flexible capital and enabling further private capital to be leveraged.

Action 3 – EU and National authorities should set up a €50m-€70m Insurance and Guarantee Fund for ocean energy demonstration and pre-commercial projects, covering risks that are currently not covered by either insurance products or manufacturers guarantees.

6 Moore (1991). Crossing the chasm: marketing and selling disruptive products to mainstream customers.

7 The UK «Contract for Difference», a support system for low carbon technologies providing stable revenue over the duration of the contract.

Both Funds should aim at helping enough projects to get the various technologies to a stage where revenue support is enough to pursue commercial deployment and the Funds are no longer required. Both should rely on strong due diligence criteria and processes.

Improving planning, consenting and environmental permitting to speed up projects delivery

Social acceptance of ocean energy is currently strong. However, forward planning is necessary to prevent future conflicts with other sea users and to ensure minimal impact of ocean energy deployment on the marine environment. To ensure a sustainable sector, it is imperative that communities who host development realise tangible benefits from the development of ocean energy.

Obtaining consent for an ocean energy project can be time consuming and costly. Consenting processes need to be tailored and proportionate. A risk-based approach to ocean energy licensing, using the findings from existing studies and deployed projects, should be used. Strategic research should also be initiated to address gaps in our knowledge and more efficient decision-making.

Licensing should also take into account the size, socio-economics and environmental context of projects and devices to ensure small-scale projects are not overburdened with irrelevant procedures. Good practice suggests that a one stop approach to consenting is preferable.

Action 4 – Relevant planning and consenting authorities to de-risk environmental consenting through an integrated programme of measures that will develop guidance on planning, consenting, research, socio-economics and demonstration. This guidance will ensure that best practice and experience in consenting ocean energy projects is shared and used to improve and streamline processes.

Industrial roll-out: using proven technology to reduce costs and access commercial finance

As ocean energy technologies develop industrially, project costs will fall, generating cheaper electricity. With enhanced knowledge, ocean energy deployments will increasingly be financed on the basis of revenues from the sale of electricity. Public support, therefore, can shift from upfront investment support to power production-based support such as green certificates or feed-in premium tariffs.

Industry can reduce its balance sheet investments as the technologies are better understood by commercial lenders. Public support schemes will help leverage commercial loans at competitive rates.

Further actions to ensure a smooth and cost-effective industrial roll-out of ocean energy and its transition to a fully commercial industry include:

- Industry developing guidance and standards on optimal device performance and farm lay-out as more farms are put in the water.
- Industry to cooperate with insurers and finance institutions to develop appropriate financial products.
- Governments to establish stable long-term revenue support schemes ensuring predictability of income for ocean energy projects.

In summary, the EU, Member States and the ocean energy sector should work together to urgently implement the four Action Plans outlined in this Roadmap. This will ensure Europe's economy seizes the prize that is represented by a new potential industrial sector, firmly anchored in Europe, creating jobs and wealth whilst providing energy security at a reasonable cost. It will help the ocean energy industry transform into a mature, cost-efficient industry that can compete on world markets. It will furthermore contribute significantly to delivering climate change, health and environmental objectives the EU set itself.

SECTION 1
INTRODUCTION

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1.1 Europe needs ocean energy

The Ocean Energy Strategic Roadmap reflects the common vision of the ocean energy sector, and was produced through a series of meetings, workshops and open-session conferences of the Ocean Energy Forum, which was set up in April 2014 following the European Commission's adoption in January 2014 of the communication 'Blue Energy – Action needed to deliver on the potential of ocean energy in European seas and oceans by 2020 and beyond[8]'.

The Strategic Roadmap identifies a path forwards, building on European leadership in ocean energy, and developing technologies that can meet a significant amount of Europe's power demand over the next 35 years.

TECHNOLOGY LEADERSHIP AND INDUSTRIAL SUCCESS

Ocean energy is abundant, geographically diverse and renewable. Developing technology to exploit its potential offers opportunities for Europe to develop a new industrial sector, create jobs and capitalise on its first mover status to cultivate significant export opportunities.

The industry association, Ocean Energy Europe, estimates that 100GW of wave and tidal energy capacity can be deployed in Europe by 2050[9]. This industry target is consistent with recent studies[10] on the practical[11] deployment potential of ocean energy in Europe.

The global market for ocean energy could see 337GW[12] of installed capacity by 2050, a third of this would be in Europe.

Today 45% of wave energy companies and 50% of tidal energy companies are from the EU[13]. The EU is in need of industrial success stories, and ocean energy can be one. The right support over the coming decade will enable Europe to maintain leadership in a global market, worth a potential €653bn in investments between 2010 and 2050[14], and an annual market of up to €53bn, hugely benefiting the European economy.

OCEAN ENERGY WILL BRING MUCH NEEDED INVESTMENTS AND JOBS TO THE ECONOMY

The ocean energy supply chain is truly pan-European, with both leading companies and supply chain SMEs spread across the EU's Member States, including landlocked countries like Austria, with long experience in hydro-equipment manufacturing.

8 http://ec.europa.eu/maritimeaffairs/policy/ocean_energy/index_en.

9 Target ambition estimated by members of Ocean Energy Europe, stated in European Ocean Energy Association (2013). Industry Vision Paper, 2013.

10 Calculations by Ocean Energy Europe based on Ocean Energy Centre – Chalmers University of Technology (2012) estimate that 120GW of wave capacity can be deployed in the EU, 9GW of which in Sweden alone. DCENR (Department of Communications, Energy and Natural Resources (2014). Offshore Renewable Energy Development Plan: http://www.dccae.gov.ie/energy/en-ie/Renewable-Energy/Pages/OREDP-Landing-Page) estimates that 14GW of wave and 3GW of tidal stream capacity can be deployed in Ireland alone. In a scenario where France is powered exclusively with renewable electricity in 2050 by ADEME (Agence de l'Environnement et de la Maîtrise de l'Energie (2016). Un mix électrique 100% renouvelable ? Analyses et optimisations: http://www.ademe.fr/mix-electrique-100-renouvelable-analyses-optimisations), 10GW of wave and 3GW of tidal stream capacity can be deployed. WavEC estimates (2016) there is a 5GW potential for wave energy deployment in Portugal. Pfluger *et al.*, (2011) estimate that 14GW to 26GW of wave and tidal stream capacity can be deployed in Europe, even if not all technological barriers are overcome.

11 Practical resource potential is defined as the portion of the ocean resource that is available when other constraints – such as economic, environmental, and regulatory considerations – are factored in.

12 Ocean Energy Systems 2014. *Annual Report 2013. Implementing agreement on Ocean Energy Systems.* The Executive Committee of Ocean Energy Systems. [Online] https://report2013.ocean-energy-systems.org/.

13 Joint Research Centre (2015). 2014 JRC Ocean Energy Status Report.

14 Carbon Trust (2011). Marine Renewables Green Growth Paper.

Ocean energy is deployed in coastal areas, some of which have been affected by economic restructuring in recent decades. On a local level, it is important that those immediate areas that host development are afforded employment opportunities in order to realise and support the associated economic benefits that ocean energy can deliver to coastal communities. Moreover, by putting ocean energy farms in the water, it will complement Europe's regional growth agenda by creating high-skilled jobs to support long-term sustainable economic development. Ocean energy also provides under-used ports and harbours with an opportunity to innovate and specialise as hubs for blue growth.

OCEAN ENERGY PROVIDES A SOLUTION FOR EUROPE'S OVER-RELIANCE ON FOSSIL FUEL IMPORTS

The EU is in a precarious energy position. The bloc continues to rely on imports for 53% of its energy needs, costing €400bn a year[15]. Dependence on a handful of exporting countries is becoming increasingly problematic.

Renewables are the only viable source to power Europe in the coming decades. Based on projections, ocean energy has the potential to generate 350TWh of electricity meeting up to 10% of Europe's demand by 2050[16].

OCEAN ENERGY CAN PLAY A CENTRAL ROLE IN THE TRANSITION TO A LOW-CARBON ECONOMY AND THE FIGHT AGAINST CLIMATE CHANGE

Policy in Europe has been very successful in taking the first generation of renewable energy technologies, such as solar and wind, to commercially-competitive levels. The EU will however need other technologies to further diversify its low-carbon generation capacity, if it is to meet its objective of reducing greenhouse gas emissions to 80–95% below 1990 levels by 2050[17]. Power generated by the ocean energy sector could avoid the equivalent of 276m tonnes of CO_2 emissions annually[18] by 2050.

OCEAN ENERGY CAN LEVERAGE EXTRA VALUE BY EXPLOITING SYNERGIES AND KNOWLEDGE TRANSFER ACROSS THE BLUE ECONOMY

Other marine sectors have both a lot to offer and a lot to gain from the development of the ocean energy sector. Today, companies from sectors such as naval construction, offshore oil & gas, offshore wind and dredging are amongst the leading players in the ocean energy sector. These companies are creating extra value from their existing knowledge by using it to exploit new growth opportunities in the emerging ocean energy industry.

OCEAN ENERGY CAN REDUCE ISLANDS' DEPENDENCE ON COSTLY GENERATION

The remoteness of small islands and other locations can mean high electricity costs due to reliance on oil generators; ocean energy can provide a viable, more competitive solution. The higher price paid for electricity in these locations, will allow ocean energy to be deployed with less support whilst ensuring a return on investment.

15 European Commission 2012. *Energy Roadmap 2050.* Luxembourg: Publications Office of the European Union 2012. [Online] https://ec.europa.eu/energy/sites/ener/files/documents/2012_energy_roadmap_2050_en_0.pdf.

16 Ocean Energy Europe has estimated that 100GW of ocean energy capacity could be deployed in Europe by 2050, producing around 350TWh of electricity. The European Commission's EU Energy, transport and GHG emissions: trends to 2050 reference scenario 2013 estimates total EU power generation in 2050 at 3.844TWh.

17 European Commission 2012. *Energy Roadmap 2050.* Luxembourg: Publications Office of the European Union 2012. [Online] https://ec.europa.eu/energy/sites/ener/files/documents/2012_energy_roadmap_2050_en_0.pdf.

18 Calculations based on Ocean Energy Europe and European Commission 2013. *EU Energy, transport, and GHG emissions, trends to 2050, reference scenario 2013.* Luxembourg: Publications Office of the European Union 2013. [Online] http://ec.europa.eu/transport/sites/transport/files/media/publications/doc/trends-to-2050-update-2013.pdf.

1.2 Ocean energy: The technologies

Ocean energy comprises five distinct technologies. The variations in ocean resource and location will require different technological concepts and solutions.

Wave energy converters derive energy from the movement of waves and can be located flexibly – on the shoreline, the nearshore or offshore at depths of over 100m – to harness the available energy most efficiently. A range of full-scale prototypes have been deployed, however, further technology development, testing and demonstration are required prior to commercialisation and industrial roll-out.

Tidal stream turbines harness the flow of the currents to produce electricity. Tidal turbines can be fixed directly to and mounted on the seabed, or tethered/moored to the seabed and buoyant, floating on surface or in mid water.

Tidal range uses the difference in sea level between high and low tides to create power. Tidal range technology uses the same principles as conventional hydropower, and requires a barrier to impound a large body of water, driving turbines generating electricity. Tidal range is the more established ocean energy technology, with several projects generating power around the world.

Ocean Thermal Energy Conversion (OTEC) exploits the temperature difference between deep cold ocean water and warm surface waters to produce electricity via heat-exchangers. OTEC is suited to oceans where high temperature differences will yield the most electricity. A number of demonstration plants are being developed in EU overseas territories opening up export opportunities.

Salinity gradient power generation utilises the difference in salt content between freshwater and saltwater, found in areas such as deltas or fjords, to provide a steady flow of electricity via Reverse Electro Dialysis (RED) or osmosis. Deployment potential is significant around Europe, however, further technology development is required to bring salinity gradient to maturity.

1.3 Ocean energy outlook: 850MW cumulative capacity by 2021

Over the past 10 years the ocean energy industry has invested an estimated €1bn in capital to move concepts from the drawing board to deployment in EU waters. It is estimated that ocean energy deployment will reach a cumulative capacity of 850MW by 2020, which will require further investment to be unlocked.

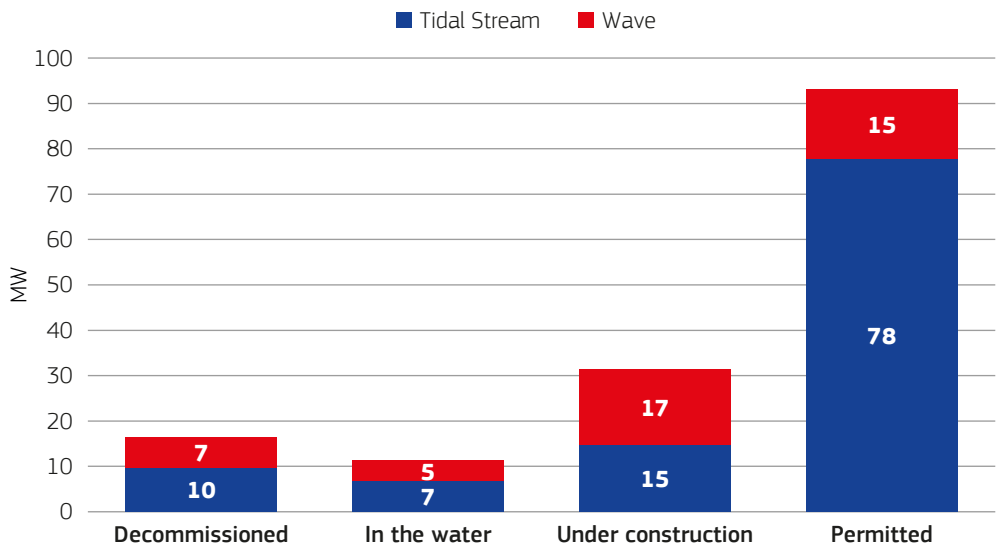
Ocean energy's first deployment in Europe was in 1966 when a 240MW tidal range project was built in La Rance, France. For three decades there was little deployment of ocean energy technologies until 1999, when a wave energy device was tested in Portugal[19].

By mid-2016, 17MW of tidal stream and 12MW of wave energy had been deployed, bringing cumulative deployed capacity to 269MW. If we exclude machines that have been decommissioned (17MW) (since they were deployed primarily for testing and validation purposes), the cumulative deployed capacity is 252MW. Nevertheless, the learnings from these projects are important to improve future devices and bring the entire sector forward.

19 WavEC Oscillating Water Column Pico Power Plant, Azores, Portugal.

A further 32MW of tidal stream and wave capacity are under construction. It is expected that most of these new devices and projects will be completed over the coming couple of years, bringing total deployment to over 270MW. With 93MW more tidal and wave capacity permitted and a pipeline of over 1.6GW ocean energy technologies are now ready to accelerate their deployment.

Figure 1. Europe – deployed tidal stream and wave capacity, capacity under construction and permitted capacity (MW) – situation at June 2016



Source: Ocean Energy Europe, Kit-in-the-water database.

In addition, over 20MW of OTEC and Salinity Gradient capacity are being tested or planned for the coming years, and a 320MW tidal range lagoon is fully permitted in Swansea Bay (UK), and expected to be completed by 2021.

National and EU funds have been instrumental in leveraging private investments in the industry. It is expected that between 2015 and 2020 the European ocean energy industry could spend a further €1bn in R&D, and €3bn to €4bn to deploy the projected capacities. This will only happen with continued support from the EU and national funds and high-risk public financing products, such as the European Investment Bank's InnovFin EDP[20].

20 InnovFin EDP was set up to provide risk financing for innovative energy technology projects in the form of loans and loan guarantees to first-of-a-kind commercial scale industrial demonstration projects in the field of renewable energy.

SECTION 2
PRIORITY AREAS FOR TECHNOLOGICAL PROGRESS

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Some technological challenges are the same across the entire ocean energy sector, others are technology-specific. Each technology will require access to public and private finance to advance. Finance must be applied appropriately to both generic and technology-specific priorities.

2.1 Main technology focus areas

The following technological aspects, relating to performance and cost reduction, must be addressed to reduce sector-specific risks.

Testing and modelling. Validation of concepts and development of high-definition modelling through to demonstration in real conditions and deployment is of prime importance for the sector's development. This step is not linear; both demonstration and modelling on sub-systems, components and the entire device in real and in controlled environments are needed at the different stages of the technology's development.

Reliability and survivability. Increasing the reliability of ocean energy devices by developing monitoring systems in real conditions will identify potential failure modes and subsequently improve designs. A high priority must be to increase the reliability and survivability of devices to protect investment and ensure long-term availability of power production and income.

Installation and logistics. There is significant scope for utilising existing infrastructure (such as harbours, vessels, power cables, grid connection) and processes (including training, health and safety) from other marine industries. However, a new generation of waterborne and sub-sea solutions is needed to match the specificities of ocean energy devices and reach the targeted costs per kWh.

Power generation and grid. Devices, farms and plants must be able to deliver grid compliant electricity. A key missing technological component, fundamental to the development of ocean energy on a large scale, is a central power electronic hub to collect and efficiently transmit electricity from multiple devices to shore through an export cable.

Standardisation of the industry leading to certification. De-risking industrial roll-out and accessing finance will be enabled through the availability of suitable standardisation processes, building on existing guidelines and sector knowledge.

2.2 Technology-specific priorities

The objective for all ocean energy technologies is to become competitive energy sources. As ocean energy devices are rolled-out on an industrial basis, the cost of producing electricity should begin to decrease and tend towards €100 per MWh. The speed at which cost reductions occur will depend upon how much ocean energy capacity is installed.

2.2.1 Wave: Innovation to deploy large farms by 2030

Wave energy converters (WECs) have progressed significantly over the last decade, from scaled testing to full-scale prototypes. Field demonstrations have shown the importance of further R&D focussing on subsystems and components with an increasing number of innovative concepts.

A minimum of 10MW of full-scale wave energy converter prototypes should be deployed by 2020. The learnings from this phase will allow the development of whole wave energy systems through improvements of sub-systems and components. Subsequently, the most promising consolidated concepts should be demonstrated in farms for a total of a further 100MW by the mid-2020's.

- Prioritise subsystems and components. Research, development and innovation in wave energy should focus on key components and sub-systems, tested both individually and as part of the whole device.
- Power take-off (PTO) systems. PTO systems require near full-scale demonstration in real sea conditions for validation.

2.2.2 Tidal stream: Competitive from 2030, bolstering EU worldwide leadership

Tidal stream technology is at a stage along its development path which requires full-scale demonstration projects supported by the right policy and economic conditions. It is expected that the demonstration farms phase will be underway by 2020, by which time around 100MW of capacity could be deployed in Europe alone. The tidal stream sector should therefore strive to deploy ten farms of 20MW to 30MW with devices laid out in several arrays across Europe by the mid-2020s.

- Prioritise deployment. Increase reliability of devices through testing and deployment, permitting the certification of sub-systems and components.
- Focus research, development and innovation efforts on technologies and processes necessary to develop and optimise farms such as sub-sea power hubs, lay-out optimisation, and characterisation of the environment.

2.2.3 Tidal range: Ready for roll-out in Europe

The Swansea Bay Tidal Lagoon project (320MW), expected to be operational in 2021 but currently under the UK government review, will set the standard for future development in tidal range projects. The lagoon set-up is novel but the power generating technology is well understood as it has been used in early tidal range projects such as La Rance, France and is informed by traditional hydro-electricity projects.

With the accumulated know-how from past projects and a successful project in Swansea Bay, tidal range technology will be ready for industrial roll-out. A further full-scale project of between 1GW and 2GW would start tidal range on the path to significant energy cost reductions.

Tidal range's main challenge is not the power producing technologies *per se*, but rather how the individual aspects to build and operate the project fit together and the overall economics of upfront capital expense and long-term payback of up to fifty years. There are also consenting challenges that require innovative approaches to facilitate project development.

- Support research and demonstration including environmental approaches.
- Promote enabling policy frameworks to streamline and facilitate consenting processes.

2.2.4 Ocean Thermal Energy Conversion (OTEC): Exporting European technology

The construction of a 14MW OTEC project (NEMO) in Martinique, France, demonstrates the potential for the EU to develop a technology and know-how for export around the world's tropical regions. Moreover, the potential for high average availability factors could rapidly lead to significant reductions in cost of energy.

The OTEC sector should connect up to 20MW of scaled prototypes by the early 2020s, leading to the demonstration of full-scale power plants of around 100MW.

Subsequently, OTEC technology could be rolled-out industrially taking advantage of the export markets.

- Focus efforts on improving heat exchangers for OTEC use.
- Develop materials and manufacturing processes to significantly scale-up the power plant, notably the cooling pipes' dimensions, to allow a better yield.

2.2.5 Salinity gradient: First large plant by 2030, demonstrating EU state-of-the-art

Salinity gradient is in the R&D phase, with up-scaling to megawatt prototypes expected around 2020. While still research driven, the technology could grow rapidly and become increasingly commercial.

The development of a 50MW demonstration plant by mid-2020s is a necessary step towards subsequently deploying a first full-scale (200MW) plant. If successful, module salinity gradient storage solutions could be developed and used worldwide in combination with other renewable energy systems by 2030.

- Focus research on membranes, stacks, materials, pre-treatment and system design.

2.3 Timeframe for creating a new power industry

Moving a new power generating concept to an industrial reality, and feeding substantial amounts of electricity into the grid, requires decades of investment, innovation and applied learning. Ocean energy development has advanced significantly, and follows a similar development timeline to that of other energy industries.

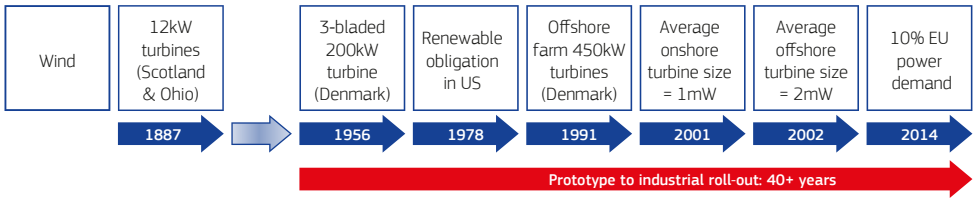
As an example, the technology that underpins modern wind turbines was developed in a basic form in the late 1950s then improved upon. It began commercial deployment in the mid-1970s after further stimulus from the oil crisis. In 2014, almost 40 years later, installed wind turbines in the EU met around 10% of EU electricity demand[21]. During this period many different models of wind turbine were tested (with government and industry support), until finally the familiar three-bladed 'Danish concept' turbine proved itself dominant in the market. It did so following many iterations and improvements by technology experts in industry and government. Even today, there are significant variations between some models of this kind of wind turbine, and these variations allow the cost-efficient deployment of wind turbines in different conditions. Ocean Energy Europe expects similar penetration of ocean technologies on the power market by 2050–some 50 years after the sea tests for the first wave energy device and 40 years after sea tests for the first tidal stream device.

Currently wind turbines up to 8MW are commercially available. Global-installed wind energy capacity at the end of 2015 was 432GW. The process of technological and commercial maturation occurred through a learning process based on establishing small-scale working generators and then scaling up via a process of innovation and learning by companies supported by national governments. The average size of wind turbines in 1991 was 224kW, and it took until 2001 for the average deployed turbine to reach 1MW. Similarly, the first offshore wind turbines deployed in 1991 had a rated capacity of 450kW. Eleven years later, in 2002, the average size reached 2MW.

Test conditions for marine energy technologies are much tougher in many regards than for wind energy. To address this and to harness different resources viably, the ocean energy industry is developing a range of concepts, including: small wave devices for calmer seas such as the Mediterranean; smaller tidal turbines for slower currents or near-shore areas; and devices that can be attached to harbour walls, dams, bridges and other existing infrastructure. A range of ocean energy devices must be developed to take into account the range of different sea conditions. This process will require time and investment to move forward the technology, as well as an approach to policy and regulation that addresses barriers to developing, deploying and expanding new capacity.

21 http://www.ewea.org/fileadmin/files/library/publications/statistics/EWEA-Annual-Statistics-2014.pdf.

Figure 2. Development of wind turbines, from early experiments to industrial roll-out



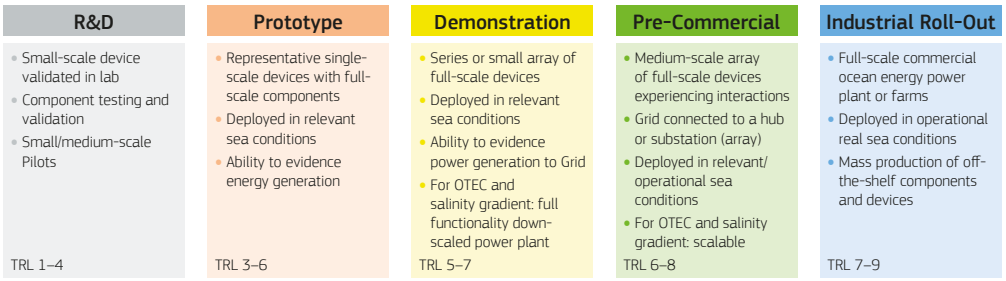
Source: Ocean Energy Europe, adapted from European Wind Energy Association, Danish Wind Industry Association, US Office of Energy Efficiency and Renewables.

2.4 A phased approach to technological progress

Technological and commercial maturation occurs over several phases, or Technology Readiness Levels (TRL)[22], from concept design to commercial deployment at sea.

Moving from one phase to the next requires increased deployment, leading to technological and hence economic improvements. To assess and analyse the different steps to industrial roll-out, the following phases and criteria have been identified.

Figure 3. Phases of Technology Readiness Levels



Source: Ocean Energy Europe. Generated through consultation with Ocean Energy Europe and the Ocean Energy Forum.

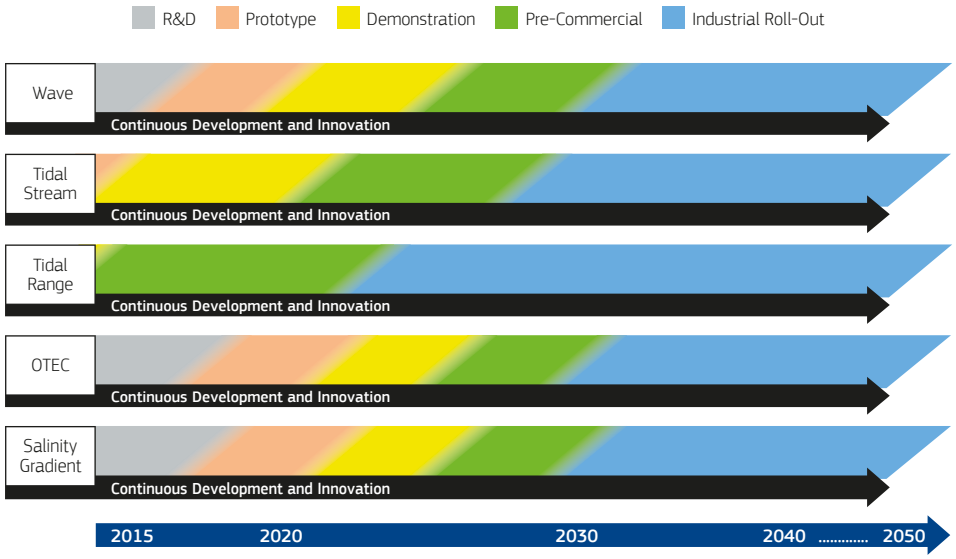
A timeline for the development (see Figure 4) of the five ocean energy technologies throughout these phases has been developed. It gives guidance as to where technologies currently are and when they could reach the next phase of development.

It is essential to understand that this timeline is highly dependent on overcoming the barriers faced by ocean energy developers, the level of public support offered in the short- and medium-term by the EU, Member States, and regional authorities.

Addressing the current barriers to project deployment, while providing significant short- and long-term stable and predictable investment conditions are essential. Inaction will delay industrial roll-out, or in a worst case scenario result in a loss of accumulated knowledge and jeopardise Europe's global leadership position in ocean energy.

22 European Commission 2014. *HORIZON 2020 – Work Programmes 2014-2015.* General Annexes to the main WP. Part 19. V. 2.2. Technology readiness levels (TRL). [Online] http://ec.europa.eu/research/participants/portal/desktop/en/funding/reference_docs.html#h2020-work-programmes-2014-15-annexes. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified. http://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf.

Figure 4. Timeline for the development phase of ocean energy technologies



Source: Generated through consultation with the Ocean Energy Forum.

SECTION 3

OVERCOMING THE CHALLENGES: MOVING OCEAN ENERGY THROUGH THE PHASES TO INDUSTRIAL ROLL-OUT

SECTION 3 OVERCOMING THE CHALLENGES: MOVING OCEAN ENERGY THROUGH THE PHASES TO INDUSTRIAL ROLL-OUT

Barriers to technology development and deployment are diverse. These barriers can be specific to both technology and phases of development, and often overlap. They include:

- financial, economic, and market (including access to finance, ability to access markets, etc.)
- political and governance
- consenting and environmental (including positive and negative impacts)
- social (such as public acceptability and resource conflict).

Approaches can be developed to address and overcome these barriers, however it is important that projects continue to be developed, consented and commissioned in parallel with the recommendations made in this report.

3.1 Specifics of ocean energy and cross-cutting challenges to deployment

3.1.1 High capital expenditure (CapEx) requirements call for upfront capital availability

Ocean energies, like most renewables, are CapEx-intensive: the cost of the device, infrastructure and installation represent a very high share of the kWh cost. This contrasts with gas-fired power stations, for example, where the plant itself represents just 25% of the electricity cost, the remainder coming mostly from gas purchases. Whilst different for each ocean energy technology, total CapEx (including costs of capital) is estimated at 60–80% of the final cost of energy.

This means that developers need access to high levels of funding upfront, before any electricity – and therefore revenue – is generated. Support schemes for the first arrays and plants must, therefore, include a high proportion of upfront finance, whether debt-, grant- or equity-based.

3.1.2 Uncertainties inherent to innovative projects require technology demonstration to lower risks and cost of finance

All energy projects bear investment risks – market, technological and regulatory risks – all of which have a direct impact on project revenue. The greater the risk, the greater the cost of financing the project or insuring the risk.

Ocean energy technologies are at early developmental stages and operate in a harsh marine environment, all of which create specific additional uncertainties and risks. Risks can be linked to both installation and operation.

To improve access to finance, and decrease the cost of both capital and insurance, the understanding of risks must be captured and communicated. Formalisation of knowledge and experience from installation and operation of projects is required to make these risks measurable and predictable. The data required are currently lacking and will only be gathered progressively, as more devices are put in the water.

3.1.3 Financing ocean energy in today's energy market with a limited pool of potential investors

The pool of available investors for emerging technologies has dramatically reduced due to the economic crisis. It is therefore increasingly difficult to help technological development of emerging technologies in the absence of Member State support.

Ocean energy technologies are insufficiently mature to take advantage of the financing sources and mechanisms used for other renewable technologies wind energy deployment in the last 10 years. Original equipment manufacturers' (OEM) balance sheets are constrained by their clients' lack of demand which hampers their appetite for developing emerging technologies. Venture capitalists and business angels have entered and left the ocean energy sector due to lack of market visibility and resulting inadequate risk/return ratios.

Combined with global low energy prices and the economic downturn the investment conditions will require new and innovative financing models. Public support for new technologies and first farms and plants will be critical to success or failure of the sector. This follows the pattern for other renewable energy technologies such as wind and solar.

3.1.4 Planning and licensing frameworks are required which afford confidence to industry, regulators and stakeholders

For ocean energy development to move forward in a sustainable manner, current practices in the areas of consenting and licensing, planning, and research and monitoring must be reviewed and enhanced.

Consenting and licensing procedures are an often cited barrier to the development and progress of ocean energy. From a regulator's perspective sufficient evidence on which to base their licensing decision and to ensure compliance with the relevant legislative regime(s) and the application of EU environmental Directives is required.

Clarity and consistency in Environmental Impact Assessment (EIA) and Appropriate Assessment (AA) obligations and application under the Habitats Directive, as well as their associated costs and the requirements for a precautionary approach placed on small-scale or single-unit deployments, are the main concerns.

These issues should be addressed in advance of technology and project development to ensure that the necessary processes and systems are in place to support developers through the consenting process.

A pan-European sustained research and monitoring agenda to tackle environmental effects of devices would greatly benefit addressing high level strategic questions, regarding, for example, population level effects, cumulative impacts and ecosystem models, in addition to specific environmental effects. This should be accompanied by a robust operational level research and monitoring programme that enables better assessment of broad scale effects of ocean energy and other marine related activities. Collaboration between industry, public bodies and academia, will yield the most effective use of resources in reducing uncertainty through multi-scale investigations.

The implementation of the Maritime Spatial Planning (MSP) Directive across the EU presents an opportunity for improving planning and consenting processes for ocean energy. Improvements can be achieved through (among others) rationalisation of existing requirements, increasing transparency and certainty for developers, better consideration of cumulative impacts and co-location opportunities, and more effective inclusion of stakeholders in decision-making processes.

3.1.5 Mutualise the cost of extending grid lines to areas where ocean energy projects will be deployed

The best ocean energy resource is often far from main power lines, leaving the cost of connecting to the project developer. For projects at demonstration or pre-commercial stage, grid connection and cable infrastructure can represent up to 40% of total project costs. This cost is prohibitive compared to the cost of the ocean energy devices themselves and, more importantly, compared to revenue generated which is usually quite low for such projects. This adds to the total capital cost of projects, making them harder and riskier to finance.

In certain EU countries (such as Germany or Denmark) the cost of connecting to the grid, whether built by the project developer or not, is worked into the overall cost of running the public power grid and, therefore, mutualised between all users of the grid; electricity producers and consumers. This method ensures that the cost of grid connection does not compromise the economics of demonstration and pre-commercial ocean energy farms, and that first movers in the sector do not carry the whole burden of grid upgrades for future deployments.

This will also enable a more focused use of innovation funds, which can focus on the innovative part of projects rather than help to fund non-innovative technology such as cables.

The ocean energy industry can help grid operators and public authorities identify the areas where grid extension or reinforcements are necessary to enable future ocean energy farms to connect to the grid.

CASE STUDY 1: Tidal Energy – MeyGen Phase 1A; 6MW

The MeyGen (www.meygen.com) project is the largest tidal current project under development in Europe. When fully constructed, the project will deliver 398MW of tidal power. In its first stage (Phase 1A) the project will deliver the installation of four 1.5MW turbines offshore as well as the construction of the onshore infrastructure. Three of the turbines will be supplied by Andritz Hydro Hammerfest and one Lockheed Martin-designed turbine supplied by Atlantis. The project finance was secured through a mix of debt, grant and equity finance (see table).

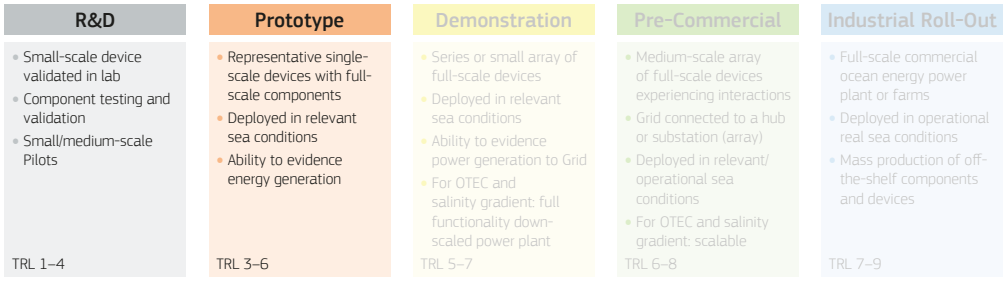
Project CapEx	**Value**
Overall Capital Expenditure (CapEx)	€51.3 million
Project size	6MW
Specific CapEx	€8.55 million/MW
Finance	**Value**
Debt	€17.5 million (34% share of total CapEx)
Grants	€13.3 million (26%)
Equity	€20.5 million (40%)
Of which developer share	€10.8 million (21%)

CASE STUDY 2: Wave Energy – CEFOW Wello; 3MW

The Clean Energy From Ocean Waves (CEFOW) project aims to deploy 3MW of installed capacity. The project is lead by Fortum and delivered in cooperation with a consortium of industry and academic partners. The project is largely financed through a EU Horizon 2020 grant (see Table Case study 2).

Project CapEx	Value
Overall Capital Expenditure (CapEx)	€24.7 million
Project size	3MW
Specific CapEx	€8.2 million/MW
Finance	**Value**
Grants	€17 million (69% share of total CapEx)
Equity (developer and project partners)	€7.7 million (31%)

3.2 R&D and Prototypes: Financing early development



3.2.1 Financing full-scale prototypes with grant solutions

Not all ocean energy technologies are 'first-farm-ready'. Some, for example wave energy, require further rigorous single device testing before they can reach the next phase in their development. Exhaustive full-scale demonstration makes technological and economic sense. It is also understood that R&D will continue to advance as the device goes through its development stages.

Financing instruments for such development phases are predominantly and appropriately grant-based, e.g. the EU's Horizon 2020 or national research programmes. Grants are and have been provided, though not always at levels enabling the EU to stay at the forefront of technological development. The estimated cost of taking an ocean energy device from drawing board to prototype ranges from €50m to €100m, depending on technology and scale. To keep the future market competitive, several devices in each technology should have the opportunity to develop through to prototype, which would require higher innovation investment than would otherwise be available.

Grants have the advantage of fostering collaboration between companies and providing access to project data, both of which can be requirements for the financial award, and which in turn can then benefit the entire sector, justifying the public expenditure.

- Public authorities should build up or maintain significant levels of grant funding to enable testing, demonstration and improvements of prototypes.
- TP Ocean, together with the Commission and national governments (possibly via the SET Plan discussions) should examine the adequacy of funding schemes for early stage ocean energy devices and sub-systems, and make further recommendations.

3.2.2 Standardised testing to make technology comparable

To be considered successful, a prototype must undergo tests in real sea conditions. Different testing centres in different countries do not always generate comparable data, creating a challenge for investors selecting technologies for demonstration phase projects.

EU-wide standardisation could help generate comparable data, building on existing work, such as the standards developed by the International Electrotechnical Commission (IEC) Technology Committee (TC) 114 Marine Energy[23] initiated by the European Marine Energy Centre (EMEC). The industry needs to develop and share guidelines on optimal device operation and farm layout requirements. This is an essential step towards the development of industry-wide standards, permitting the certification of ocean energy devices, that are an important support to financial institutions when judging project risks and making investment decisions. See also Section 3.4.2.

- The ocean energy sector should develop EU-wide standards for testing of full-scale prototypes.

3.2.3 Approach to deliver rational prototype development

To reduce the risk of significant device failures in the demonstration phase, device sub-systems and components should be tested and effectively validated prior to use on full-scale devices. To address this, Wave Energy Scotland put in place a programme for wave devices allocating funding through a phase-gate process: each stage of development is only funded once the stage before is fully tested and validated.

A similar approach could be used at EU level to stimulate advances in less mature ocean energy technologies that are not yet demonstration ready, by funding critical component and early stage device development and testing before full-scale demonstration.

- Establish a phase-gate procedure for sub-systems and devices – 2018 to 2025 – whereby public funding is only made available once clear performance indicators, determined by an independent multi-disciplinary panel of experts from a variety of stakeholders, have been achieved.

ACTION 1

23 IEC Technology Committee Standards website http://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID,FSP_LANG_ID:1316,25.

3.2.4 Licensing and consenting priorities

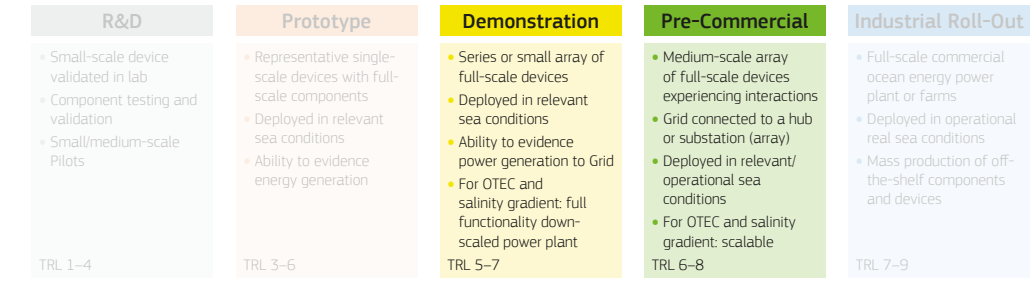
RISK-BASED APPROACH TO CONSENTING

To ensure that prototype deployments can proceed without unnecessary regulatory delays, a proportionate consenting process is required, in which the level of impact assessment is based on the environmental constraints of the site, technology risk profile and scale of deployment. The development of this proportionate approach would enable single device deployments which would have minimal impacts on the surrounding environment to be fast-tracked through the consenting process.

PRE-CONSENTED DEMONSTRATION SITES

Access to testing at sea for device developers will be facilitated by the provision of pre-consented demonstration test sites. These will allow developers faster access to testing facilities by bypassing the need for individual device consenting.

3.3 Demonstration and Pre-Commercial: Getting the first projects in the water



The demonstration stage is characterised by multiple grid-connected devices or fully functional down-scaled plants deployed in real sea conditions. Usually considered "R&D Phase 2", this is the demonstration phase and does not have to be commercially viable. OTEC and salinity gradient plants at this stage will be scalable.

From this stage onwards, wave and tidal devices are installed as pre-commercial arrays suitable to inform future large commercial farms. These arrays optimise space usage and resource extraction, and should be connected to a hub or substation feeding electricity to the shore.

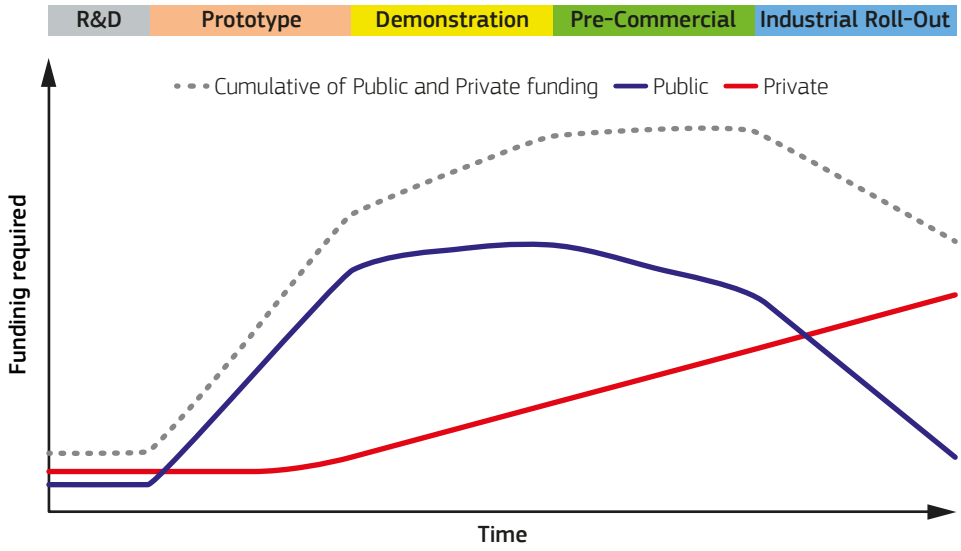
3.3.1 Focusing on investment support rather than pure revenue support

In the demonstration and pre-commercial phases, considerable uncertainty about both revenue from power production and maintenance costs means financial risk remains high and transition to a pure revenue support dominated mechanism is premature. Upfront capital to support investments therefore, remains essential.

This upfront capital no longer needs to be grant-only. It can take the form of public equity, public debt, repayable loans or even access to low cost finance (e.g. zero or low interest loans) provided lending criteria are suitable for high-risk projects.

Revenue-based support schemes can and should commence to give long-term visibility and confidence to investors and reduce the cost of capital. Short-term or short-lived support schemes do not give market players the visibility required for long-term energy investments.

Figure 5. Indicative share of private and public funding for an ocean energy concept per development phase



Source: Generated through consultation with the Ocean Energy Forum.

A combination of both private and public funding can be considered, provided it ensures both the upfront capital requirements of early stage projects and the medium-term visibility to entice investors to consider a new and promising technology and market.

Figure 5 outlines the share of private and public capital in total costs of bringing an ocean energy device from early R&D to industrial deployment in a farm or full-scale power plant.

- Investment support must remain an essential part of support schemes for each specific technology until the industrial roll-out phase is reached. If withdrawn too early in favour of revenue-support mechanisms, the technology might not have reached the required maturity to make use of the scheme.
- Investment support can come in the form of equity, debt, grants or repayable grants, or capital guarantees.

3.3.2 Keeping public financing schemes flexible to account for changes inherent to innovation

Innovative projects are by nature subject to planning uncertainties. Financial mechanisms put forward by both EU and governments need to keep pace with advances in the ocean energy sector and respond quickly to new developments, delays, or small changes in project parameters. Several ocean energy projects did not proceed or risked failure (such as Skerries or some NER300-funded projects) due to the inability of support schemes to adapt to delays.

- While some framework and reporting is required to ensure good use of public funding, innovations schemes should aim at being least bureaucratic, most flexible and most responsive as possible, to match the fluid nature of innovative technology development.

3.3.3 Applying State aid rules to better enable ocean energy projects

EU State aid rules should allow Member States to adequately support new technologies as they emerge and move through demonstration and pre-commercial stages to reach industrial roll-out. An explicit distinction needs to be made between support for mature technologies and support for emerging technologies.

Emerging technologies such as ocean energy require investment- or project-specific support rather than pure revenue support. Even with the more restrictive *Guidelines on regional State aid for 2014-2020*[24] it is still possible for national governments to set up adequate revenue support schemes to incentivise ocean energy production. However, for investment and project-specific (individual) support, EU State aid guidelines remain burdensome and restrictive.

This could be achieved, for example, by increasing the notification thresholds for individual and investment aid for emerging technologies to €30m. Eligible costs caps (percentages) should also be increased for emerging technologies, using the same logic as that applied to projects developed in European regions with low per capita GDP.

- State aid rules should be more flexible for emerging technologies and provide increased thresholds for eligible costs and notification.
- National authorities should offer guidance on combining diverse sources of funding into a successful investment support for projects.

3.3.4 A more risk-friendly culture at public investment banks

Commercial debt will not be available in the short-term for ocean energy projects given their current risk profile. Some technologies will require more time than others to reduce risks to a bankable level. Consequently, the European Investment Bank's (EIB) current low-risk investment stance is inadequate both for the ocean energy sector and for Europe's industrial development in general.

The new InnovFin Energy Demo Projects (EDP) scheme, with an initial envelope of €100m for all renewables, is an important step towards more risk-taking, though budgets are clearly misaligned with the financial needs of the demonstration and pre-commercial phase: ocean energy projects in those phases are likely to cost each in the range of €40m to €100m. The European Fund for Strategic Investments (EFSI) should also become relevant for ocean energy as budgets are at more appropriate levels.

- National investment banks, the EIB and European Investment Fund should support the industry's progress to the next phase of development by unlocking risk capital.

3.3.5 Solutions to deliver the first demonstration arrays and plants

Technology-specific demonstration projects will be required, as learnings from a given pilot farm or plant cannot be transferred from one ocean energy technology to another. For these early projects, risks cannot be insured and are too high for a single player, calling for public backing.

Before the ocean energy sector can reach bankability and commercial viability necessary for industrial roll-out, the first ocean energy pilot projects must reach financial close. Demonstration and pre-commercial farms and plants require a specific financing solution, as high levels of uncertainty and risk make them unsuitable for commercial debt or pure revenue-based finance.

24 European Commission 2014. *Guidelines on regional State aid for 2014-2020.* [Online] http://ec.europa.eu/competition/publications/cpb/2014/014_en.pdf.

- Creation of an Investment Support Fund for ocean energy farms: EU and National Authorities should create a Fund providing flexible capital, and enabling further private capital to be leveraged.

ACTION 2

- Creation of an EU Insurance and Guarantee Fund to underwrite various project risks: This would be targeted at the first ocean energy projects to cover risks such as availability, performance, unforeseen events, failures, etc. A common reserve fund available to multiple projects in the initial farm or plant roll-out, to spread the risk and reduce the cost of providing guarantees.

ACTION 3

3.3.6 Licensing and consenting priorities

3.3.6.1 Guidance on application of EU Directives

Although each Member State is responsible for its own licensing and consenting processes, these must all comply with EU Directives including EIA, Habitats and Birds Directive and the Marine Strategy Framework Directive (MSFD). Often the manner in which they have been translated into national legislation presents hurdles, which can be difficult to surpass where there is significant uncertainty. There needs to be a comparative review of how Directives (e.g. Habitats) are transposed across Member States, and how national regulations are implemented, as there must be lessons to be shared between countries. Clear guidance on the application of these Directives to ocean energy developments will enable a more consistent approach to consenting across Member States and enable existing best practice to be shared.

3.3.6.2 Marine spatial planning

Enhancing knowledge of the marine environment is crucial to better inform plans and more efficient licensing. Initiatives are therefore required to better inform the deployment of ocean energy in the most sustainable and effective locations within the EU marine area. This will also address issues concerning ongoing facilitation of future ocean energy development such as the provision of grid infrastructure.

3.3.6.3 Environment research agenda

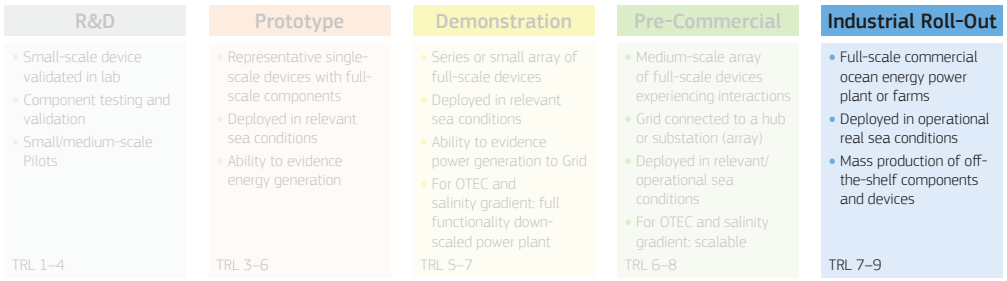
The development and deployment of demonstration and pre-commercial devices, arrays and plants will provide a key opportunity to validate predicted environmental impacts. A data gap analysis will be required to identify priority issues, enabling a strategic research agenda to be established to cover emerging gaps in knowledge. A research agenda should focus on addressing key consenting issues and risks whilst gathering information and data to help inform the planning and consenting of larger scale projects. Existing strategic research programmes such as the UK's Offshore Renewables Joint Industry Programme for Ocean Energy (ORJIP) could play a key role in the development of an EU strategic research agenda for ocean energy.

3.3.6.4 Environmental monitoring and data sharing

A strategic broadscale monitoring programme on highly mobile species such as birds and mammals would greatly assist decision makers in ensuring obligations under environmental Directives are met. From the developer's perspective, a common structure for project monitoring should be established focusing on likely environmental impacts and seeks to progress projects through a risk-based approach. This will provide guidance for determining project baseline characterisation requirements and developing project environmental management plans that are proportionate to the level of risk posed by any specific proposed ocean energy project. A review of the environmental impacts

associated with new and emerging technologies on an ongoing basis will ensure that the best and most up-to-date information and data regarding the potential impacts of ocean energy projects are available to decision makers, developers and stakeholders. Sharing data from monitoring programmes will both facilitate future project consenting and reduce duplication of effort. Existing platforms and programmes for data sharing could play a key role in data sharing and dissemination including the International Energy Agency (IEA) Ocean Energy Systems' Annex IV programme (along with its Tethys database) and the Crown Estate's Wave and Tidal Knowledge Network.

3.4 Industrial Roll-out: Reducing costs and planning deployment



For industrial roll-out the main thrust of policy should aim to create a stable financial support, market and consenting environment.

3.4.1 Reducing financing costs while moving towards revenue-based support

3.4.1.1 Ensuring stability of income in the industrial roll-out phase

Industrial roll-out enables a shift from investment support to revenue support via instruments such as feed-in tariffs or renewable energy certificates. It is essential that this transition is tailored to the specific needs of the given technology as not all ocean energy technologies will reach this phase at the same time even with the same energy source strand. Attempting to shift the policy environment too soon is likely to result in a collapse of demand, slowing of deployment, even a potential halt. This would delay the growth of the technology and the learning opportunities, and may mean the collapse of even leading companies resulting in a loss of knowledge and opportunities.

When designed properly, revenue-based schemes have been shown to drive innovation, deployment and cost reduction in renewable energy technologies, such as in Denmark for onshore wind in the 1990s. Revenue-based schemes should be suitably targeted, predictable and stable. Revenue support can also be gradually and predictably reduced in time to adapt to cost reductions and avoid over-compensations, possibly linked to the total volume of technology that comes online or its estimated cost.

Regulatory uncertainty in revenue support, such as during the Electricity Market Reform (EMR) debate in the UK, greatly contributes to a reduction in market confidence and therefore increases the cost of capital. In the worst cases such as retro-active changes to renewable support in Spain, it may lead to market slowdown and reduction of industrial development.

- Stable, long-term revenue support schemes will ensure the predictability of income, thus reducing risk and reducing the cost of accessing capital, taking account of the size and quality of the resource, with objective and defined criteria.
- Governments should strive to achieve cross-party support for policy initiatives relevant to ocean energy. This could reduce the potential for destabilising the policy environment following changes in administration and act to reduce political risk to the support schemes, hence lowering the cost of capital.

3.4.1.2 Reducing insurance costs

Insurance for ocean energy projects is currently expensive, with high deductibles and limited cover. The insurance sector's experience with ocean energy is very limited, particularly with regard to marine operational issues.

In the ocean energy sector, operating data and credible estimates of potential claims costs are still being developed. The number of players in the sector with relevant credible experience is limited but growing. The ocean energy sector must identify and exploit opportunities to accelerate insurers' confidence in, and knowledge of, the sector, its technology and the likely costs of claims. This will allow for insurance costs to be managed.

- Set up a working group with developers (including representatives of all stages of device development), contractors, etc. and insurers/brokers, to derive a contract structure model with risk options and strategies, codes of best practice, certification standards for marine deployment, moorings, cabling, sea fastenings, vessels, studies of weather risk etc., and use it to engage with the insurance industry.
- Develop mechanisms for co-operation between the ocean energy sector and the insurance sector with a view to enabling protected access to data.
- TP Ocean to review ways and means of providing warranties and performance guarantees for 'first-farm-ready' devices, sub-systems and components which have successfully passed through the stage-gate process outlined at 3.2.3, but which do not have the balance sheet strength required by utilities and site developers.

3.4.1.3 Providing loan guarantees

At the current stage of development of the ocean energy sector, the risk profile of projects means that there is limited or no availability of commercial debt, with commercial models relying on equity and grant funding. Market analysis suggests that there is limited availability of equity from venture capital sources or the public equity markets due to low project returns. The use of loan guarantees might enable public authorities to leverage more finance into the ocean energy sector than would otherwise be the case were it simply to provide direct grant support.

Loan guarantees can cover the risk of default as well as the cost of the scheme. Pricing this risk is critical and the responsible public sector bodies must have the required commercial expertise to undertake the necessary due diligence.

These instruments are more fitting for the post demonstration phase, yet work on their design needs to begin now so that they are available when needed. This will also give technology developers and funders a line of sight to future funding opportunities and so incentivise near term CapEx funding.

- Establish a working group between ocean energy industry and private and public finance institutions on loan guarantee design.

3.4.2 Certification and standards

Bespoke standards and certification practices are required for ocean energy to progress towards industrial roll-out. Equipment and methods developed as well as information and data gathered during the phases leading up to industrial roll-out is fundamental to moving the standardisation process forward; project developers and investors need to have guarantees on machine reliability.

Building on existing work, such as the standards developed by the International Electrotechnical Commission (IEC) Technology Committee (TC) 114 Marine Energy[25], the industry needs to develop and share guidelines on optimal device operation and farm lay-out requirements. This is an essential step towards the development of industry-wide standards permitting the certification of ocean energy devices, that are an important support to financial institutions when judging project risks and making investment decisions. See also Section 3.2.2.

3.4.3 Licensing and consenting priorities

3.4.3.1 Reviewing licensing guidance

As projects grow in both size and number, more information on environmental impacts will become available helping cost reductions via the ability to promote best practices. Guidance on the environmental assessment of ocean energy projects during the licensing process should be prepared and updated as required.

3.4.3.2 Engagement with other marine stakeholders

With industrial roll-out, the potential for conflict with other stakeholders in relation to access to marine resources, aesthetics and visual amenity, noise, and other factors will require particular consideration. Good practice in outreach to other ocean stakeholders should be developed and shared. Strong and well informed dialogue and communication with all interested stakeholders will be important to the continued development of the sector. Marine spatial planning has a key role to play here.

3.4.3.3 Promoting benefits of ocean energy

Regional support will be vital for the long-term development of ocean energy. The economic and social benefits of development should be highlighted and communicated at a local level to ensure community endorsement and support. The potential benefits of ocean energy at a Member State, regional and EU level should also be established and communicated to stakeholders.

3.5 Governance

3.5.1 Increasing co-operation between Member States

Different Member States and regions will have interests in different ocean energy technologies depending on their natural resources and the state of their industry. There is, however, substantial potential for co-operation between authorities on both common issues and individual technologies. Developing a common understanding of the sector's technological, policy and financing needs at the different stages of development will facilitate dialogue and co-operation.

25 IEC Technology Committee Standards website http://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID,FSP_LANG_ID:1316,25.

The ocean energy industry launched TP Ocean – the Technology and Innovation Platform for Ocean energy – to identify challenges and research priorities and produce a detailed Strategic Research Agenda (SRA).

- Publish and communicate a comprehensive Strategic Research Agenda, identifying and prioritising research and development areas to accelerate ocean energy development.

- Dialogue with industry to take into account the priorities identified and all the possibilities offered by EU research, infrastructure and development funds.
- Make full use of knowledge developed by the ocean energy sector and co-operative research frameworks such as the European Energy Research Alliance and EU Integrated Strategic Energy Technology (SET) Plan to concentrate efforts on priority areas and avoid replication of research and wastage of public funds.

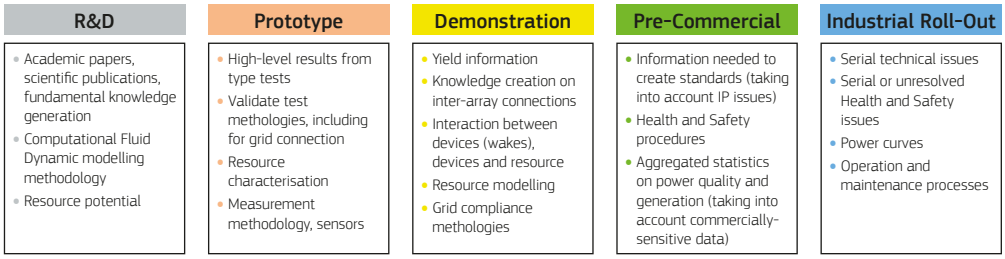
- Leverage available Member States and EU (co-)funding and facilitated co-operation opportunities to run multi-Member State ocean energy innovation and demonstration programmes.
- Identify and promote good practice in simple approaches to consenting, in stakeholder consultation and involvement in maritime spatial planning, in the application of financial policies and disseminating the knowledge gained from publicly available R&D findings to facilitate the expansion of ocean energy.

3.5.2 Sharing knowledge

Knowledge and data sharing mechanisms across the industry will help to both facilitate the consenting process and leverage learnings from each project, reducing possible duplication of efforts in both research and deployment, particularly in environmental monitoring and impact assessment, supply chain, processes and health and safety. The ocean energy industry needs to commit to participate in structured knowledge and data sharing mechanisms. These can play a significant role in accelerating the cost reduction pace and achieving a more competitive cost of energy. However, data sharing mechanisms need to take full account of businesses' commercially sensitive information, to minimise any risk of seeing a reduced appetite for investment in innovation.

Not all types of data can or need to be shared at all stages of a technology's development. Examples of useful data sharing in the different development phases are shown below.

Figure 6. Examples of data sharing in development phases



Source: Generated through consultation with the Ocean Energy Forum.

CASE STUDY 3: Strategic collaboration leverages stronger competitiveness for Swedish developers on the European market

One third of the economy of Sweden is based on export of products – predominantly machines, vehicles and electronic equipment – with 70% going to the European market. Sweden does not have significant tidal or wave resources; consequently, developers collaborate from the outset in building strategies for competitiveness, innovation and productivity outside Swedish boundaries. This entrepreneurial behaviour needs strong support in business-friendly regulation, physical and intangible infrastructure and inclusiveness.

Collaboration is built upon trust and openness and experience sharing. The nkt low voltage cable project (part of the Waves4Power deployment) is one of many supported by the Swedish Energy Agency, and is built on this principle. The project is built upon human elements linked together to tackle the technical challenges.

In order to drive costs down, a single common challenge needs to be established. Thus, new ways of developing products have been created by building on consensus and identifying key deliverables. The nkt low cable project is successful by identifying a market need; working only on a few key components; utilising the latest academic research; and developing a strong client/customer relationship.

European funding and national funding need to complement one another; in a similar way collaboration is needed between Member State and the national funding to underpin these possibilities and lead the sector in each country. Sweden has no other choice but to go down this path due to budget restrictions and resources. The OCEANERA-NET[26] project links these funding sources into the future.

3.5.3 Implementing strategic planning approaches

To facilitate ocean energy developments in the most sustainable locations within the EU marine area, a clear focus on strategic planning is required, supported by effective communication and consultation. At a local level, decision-makers and the public should be provided with information regarding the potential for social and economic, as well as environmental, benefits. At an EU level, strategic planning is required to ensure that the most effective areas for the deployment and demonstration of emerging and established technology are brought forward. This will also enable grid-related issues to be addressed, including the strategic marine grid, connections to the existing grid, grid/interconnector upgrade and alternative approaches where grid solutions prove prohibitive in the short- to medium-term.

26 OCEANERA-NET is a network to co-ordinate funding programmes between European countries and regions to support research and innovation in the ocean energy sector http://www.oceaneranet.eu/pages/new-page-5.

- Identify and promote benefits of ocean energy development, providing decision makers and the public with information regarding the potential for local socio-economic and wider environmental benefits, and ensuring that relevant information is available to inform strategic planning and project consenting.
- Develop guidance on the implementation of EU environmental Directives and strategic planning to ensure robust and informed planning approaches at Member State level.
- Develop a 'Communications and Consultation Strategy' to provide outline processes for effective communication with regulators, statutory stakeholders, NGOs, communities and key representatives from other marine sectors.

3.5.4 Maximising economic development through ocean energy roll-out

Ensuring regional support and community endorsement is critical to the long-term aspirations of ocean energy and to maximising Blue Growth for Europe. There is a need to understand the onshore planning implications and associated skills and supply chain requirements relating to the construction, operation and maintenance requirements of ocean energy developments. This will help ensure the maximisation of potential social and economic benefits.

- Develop regional manufacturing/industrial plans through Member State scenario mapping. This will identify the onshore planning implications and related skills and supply chain requirements relating to the associated construction, operation and maintenance and decommissioning requirements of ocean energy projects.

3.5.5 Enhancing approaches to environmental planning and assessment

Enhancing knowledge of the marine environment is crucial to better inform plans and more efficient licensing for all marine related activities. This should be informed by the strategic and project environmental assessment under the Strategic Environmental Assessment (SEA), EIA, Natura 2000 and MSF Directives. Ongoing review of environmental impacts associated with new and emerging technologies will ensure that the best and most up-to-date information is available to decision-makers, developers and stakeholders. A key component will be the establishment of a strategic environmental research programme to address key consenting issues and emerging gaps in knowledge. The UK's ORJIP for Ocean Energy has shown how industry, regulators and researchers can collaborate to identify and address the priority challenges.

A framework for strategic broadscale monitoring which is focused on likely environmental impact and seeking to progress projects through a risk-based approach will provide guidance for determining project baseline characterisation requirements and developing project environmental management plans that are proportionate to the level of risk posed by a project.

- Investigate the possibility and best means of expanding the remit of ORJIP Ocean Energy to inform the development of strategic research plans for the EU and Member States.
- Explore the ORJIP model and consider how it could be expanded to cover all Member States.
- Establish a working group to develop a common framework for project monitoring and environmental management.

CASE STUDY 4: Environmental Monitoring Activities: WaveRoller Technology in Portugal

The WaveRoller technology, developed by the Finnish company AW-Energy Ltd, utilises the surge phenomenon to convert wave energy into power. Although device prototypes were tested elsewhere, the Portuguese coast was identified as the most suitable location to demonstrate the first power plant. Prototype sea trials took place off the coast of Peniche during 2007 and 2008. In 2012 and 2014, the sea trials of a grid connected demonstration project took place in the same location. A new version of the device, with an installed capacity of 350kW, is now being prepared to be deployed and tested in 2017 and the first farm is planned shortly afterwards.

The environmental licensing was managed by the regional authority (CCDR; Co-ordination Committee on Regional Development) and an EIA was carried out in 2011. A conditionally favourable Environmental Impact Statement (EIS) was issued with several conditions to be fulfilled before, during and after the device deployment.

Two monitoring plans were required for approval by the authorities:

1) monitoring of the marine growth on the device moorings and flap and effects of the project on the marine seabed communities in and around the device location;
2) monitoring the effects of the project on the local marine mammal populations.

In addition to the legally required monitoring activities, the WaveRoller developers decided to carry out a monitoring programme for the analysis of the project effects on the underwater acoustic conditions particularly on sensitive species such as marine mammals.

Following results of several marine mammal monitoring campaigns, the authorities approved the discontinuance of these monitoring activities since no relevant impacts were detected. Regarding marine seabed communities, some differences observed were most likely related to the strong hydrodynamic characteristics of the area. Acoustic surveys results indicated that more measurements at longer distances from the device are needed to assess at which distance Sound Pressure Levels (SPL) decay to the ambient values.

3.5.6 Developing efficient risk-based licensing processes

The development of fit-for-purpose, effective and efficient licensing systems for ocean energy projects across Member States is crucial to building momentum in the European ocean energy sector. Consenting processes and requirements should be proportionate to the potential environmental risk posed by a specific development. Providing EU-level guidance to Member States addressing common licensing issues will ensure that best practice and experience gained in consenting ocean energy projects by regulators, agencies and developers is shared throughout the EU and used to inform future decisions and processes.

CASE STUDY 5: Leveraging wider environmental benefits from early starters – Environment and Consenting

The Scottish Government has a target for the equivalent of 100% of Scottish demand for electricity to be met from renewables by 2020. The Pentland Firth and Orkney area offer massive potential for generating electricity through tidal power, and the MeyGen Project is the first commercial (array) to install tidal turbines within this area.

The Project was granted consent for an installation of up to 86MW with Phase 1 consisting of four 1.5MW tidal turbines. Phase 2 will allow the monitoring techniques that have been developed through Phase 1 to be deployed concurrently with the tidal turbines.

MeyGen are deploying site-specific monitoring as part of their consent conditions. However, the Scottish Government is also taking forward strategic research intended to facilitate the development of the industry as a whole, which is not the sole responsibility of one developer. Of particular interest is the fact that harbour seals are known to use the site.

A strategic research project will therefore seek to deploy the monitoring equipment alongside the operating turbine for an extended period (12 months), throughout which, active and passive acoustic data and video surveillance data would be collected, archived and analysed. Simultaneously, harbour seals caught locally will be fitted with acoustic pingers and GPS tags which will provide a picture of the seals' fine-scale and wider spatial movement patterns respectively.

By extending the work developed in MeyGen Phase 1, this strategic research provides a unique opportunity to improve understanding of the movement patterns of marine mammals and how they respond to an operating turbine. Furthermore, it will provide important calibration data for collision risk models that will not only assist Marine Scotland in the consenting of future marine renewable developments, but also assist European developers by providing a protocol through which data can be collected in the future to characterise the nature of impacts.

Without this progressive research, it could prove challenging to consent to further marine renewable developments where there is potential for significant marine mammal interactions, without onerous restrictions on developers which have a risk of making projects unviable.

The project is a good example of where co-ordinated planning, licensing and science can work together to development a sustainable ocean energy sector.

ACTION 4

- Develop a set of EU guidance notes highlighting best practice in consenting and licensing processes; use of marine spatial planning; and approaches to site specific monitoring and assessment to address the constraints relating to the environment and consenting.
- Utilise the outputs from the Horizon 2020 RiCORE[27] project to explore legal and regulatory approaches to developing a risk-based licensing approach.
- Identify and share good practice in consenting, for example, the adoption of 'one stop shop' approaches to the consenting process.
- Utilise EU guidance notes to inform national guidance and decision-making.

27 http://RICORE-project.eu/. The aim of the RiCORE project was to establish a risk-based approach to consenting where the level of survey requirement is based on the environmental sensitivity of the site, the risk profile of the technology and the scale of the proposed project.

SECTION 4
AN IMPLEMENTATION PLAN FOR OCEAN ENERGY

SECTION 4 AN IMPLEMENTATION PLAN FOR OCEAN ENERGY

This section provides more detail on the four Actions identified in Section 3. The Actions are fitted to the phases of development identified and used throughout this Strategic Roadmap, rather than being specific to any one technology. All ocean energy technologies are expected to go through each phase, some earlier than others. These Actions, therefore, will apply across the sector as each technology advances towards industrial roll-out.

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

ACTION PLAN 1

4.1.1 Rationale

When a technology or concept is unproven, it is difficult to stimulate private investment for demonstration projects due to the perception of unreliability. Accessing such risky private capital is particularly problematic amidst an unprecedented financial crisis.

Taking a device to demonstration in real sea conditions with greater certainty over the capabilities of the critical sub-systems and how they interact within the device, reduces the risk of the latter failing and, therefore, reduces risk perception for investors.

Reducing the risk of demonstration device failures and, therefore, reassuring private investors is key for less mature ocean energy technologies – such as innovative wave energy concepts, OTEC and salinity gradient – and for game-changing innovations in the better understood wave concepts and tidal technologies.

To this end, before a device is demonstrated at full-scale in real sea conditions, it is important to ensure that critical sub-systems are tested and effectively validated. In parallel, validation of the interaction of the subsystems in the full-scale device as a whole, needs to progress at the same pace.

4.1.2 Proposed action

4.1.2.1 Setting Performance Indicators

A phase-gate process determines steps in the testing and development of sub-systems and prototype devices setting clear performance indicators that need to be met before moving from one step to the next. The indicators should cover the full range of technical success criteria that need to be met to deliver valid technology: performance in power generation, availability, survivability, affordability, installability, and so forth.

Until and unless the performance indicators are achieved, resources for further stages of development or demonstration of the sub-systems are not engaged. Consequently, defining the right indicators is critical to the process. The indicators will be built upon existing industry standards.

Once the sub-systems have met all their performance indicators, the chances of the full-scale prototype being successful increase. This will, therefore, reduce investors' perception of technology risk.

A matrix with the relevant phases for sub-systems and devices per ocean energy technology should be developed by an expert committee. The phases will range from early feasibility to proof of concept and are akin to a due-diligence process. Below is an example of such a matrix.

Table 1. Example of phase matrix: due-diligence process

	Feasibility	Experimental modelling	Laboratory testing	Controlled/ sheltered sea test	Relevant sea condition	Validated concept	Full-scale device
Medium-scale device							
Small-scale device							
Key sub-systems							

Funding for the project proposals should be made available if there is:

- Co-operation between research centres and industry to test sub-systems and prototypes;
- a willingness to make lessons learnt public (the information to be shared should be determined by an industry expert committee, excluding IP-related information); and
- a commitment by the project partners to using their IP, or making it available on the market at commercial rates within 4 years.

Furthermore, to promote the use of best concepts and practices from across the supply chain. Incentives for strong collaboration between technology developers and supply chain companies should be encouraged.

4.1.2.2 Keeping the process on the right track

Investor Committee: It is fundamental that the phase-gate process meets the requirements of future investors. Therefore, it is appropriate that an Investor Committee composed of investors and potential investors in the ocean energy sector (ie, power producers, public and private finance institutions) be constituted.

This committee will help determine which technological issues should be included in the process to improve the attractiveness of the various ocean energy technologies.

Discussions in the committee should be guided by The European Technology and Innovation Platform's (TP Ocean) Strategic Research Agenda and the Integrated SET Plan process.

Industry Expert Committee to determine sub-systems and indicators: The recommendations of the Investor Committee should be used by an Industry Expert Committee, composed of experts from across the ocean energy value chain (industry and academia) with a proven track record in industry and research in the various ocean energy technologies and their sub-families.

The European Commission procures a first performance indicator document using existing certification standards as a starting point. On the basis of this first analysis, the Industry Expert Committee precisely defines phases and the performance criteria that need to be met before a concept can move from one phase to another. The focus of the phase-gate procedure should be on the likelihood of a concept achieving its end goal.

The Expert Committee also suggests how much funding is required for each phase for each sub-system or device. Early phases generally requiring less funds than later phases.

4.1.3 Expected Outcomes

Phase-gate processes for ocean energy technologies are already in place in a handful of countries; notably, in the United Kingdom through the creation of Wave Energy Scotland. However, despite the latter's success, meeting the challenges posed by rigorous testing and validation for a variety of sub-systems and prototypes and the variety of ocean resources devices are intended to be deployed in, cannot be easily achieved by one process in one country.

Running such a process across several countries with different ocean resources to comparable measures and performance indicators will allow learnings to be shared across the European industry and comparability of results. Critical to this is collaboration across European countries and test centres ensuring findings are shared and technology developers collaborate.

Therefore, setting up and co-ordinating such a process at EU-level will ensure better value for public monies spent and acceleration of technology development.

4.1.4 Interdependencies/links to other processes and initiatives

The EU-wide phase-gate process should take full account of existing similar programmes, to ensure coherence and comparability of results. Wave Energy Scotland has developed a phase-gate process and, therefore, developed performance indicators for its calls. The latter were developed with EERA, ERA-NET, the US Department of Energy and the IEA OES TCP[28].

The EU scheme's performance indicators and calls should take account of these existing programmes and build on them to ensure complementarity.

4.1.5 Potential funding source

A Fund should be constituted by the European Commission, ideally with contributions from Member States. This should cover a significant share of eligible project costs, but require participating companies to commit the rest.

Not all sub-systems or concepts will require the maximum amount of funding, nor would they need to go through all the gates. Public contributions to any one project, therefore, would be on a sliding scale.

4.1.6 Timeline

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

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

ACTION PLAN 2

4.2.1 Rationale

Ocean energy projects are inherently innovative and, in the current state of development, often first-of-a-kind. Uncertainties in installation times, maintenance patterns or average electricity production imply a significant level of technical and, thus, financial risk, preventing project developers from accessing debt from commercial banks and private equity.

For the industry to go forward public support is required to take on some of those risks that operators alone cannot carry nor insure, and stimulate participation of private financiers.

Furthermore, different projects will have different financing needs as developers don't have the same access to own or private investment and national/EU support. A Fund with the flexibility to either provide directly, or help source elsewhere, different types of finance (debt, equity, grant, etc) will be able to cater for the needs of more projects and, thus, be more successful at pushing the industry towards commercialisation. It will also ensure the best possible use for public finance by avoiding pure grant funding where a repayable instrument can be used.

Both the MeyGen and the Raz Blanchard ocean energy projects, which are among those closest to delivering tidal electricity, are using different sources and types of finance, subject to different rules and reflect well this need for flexibility in public finance.

28 International Energy Agency Ocean Energy Systems https://www.ocean-energy-systems.org/about-us/ Technology Collaboration Programme.

4.2.2 Proposed action

Create a Fund for financing single demonstration/pre-commercial projects, able to provide different types of finance and able to help developers access other financing sources, whether public or private. The Scottish Renewable Energy Investment Fund (REIF)[29] is a good example and precursor of this idea and could provide significant learnings on how to design such a Fund to guarantee best use of public money.

The Fund would provide investment support as upfront capital, and ideally be able to mix grant, equity, and debt. Grants can be repayable, pending the right repayment conditions. Revenue support is best provided after the demonstration/pre-commercial phase, as a roll-out support and thus not suitable for this instrument.

The Fund would be made available to projects after thorough due diligence, ideally from a recognised body (eg, EIB, National Investment Bank, certification company) to help leverage additional private capital and reduce the finance costs.

4.2.3 Considerations

4.2.3.1 Incremental and finite funding

The Fund would not require full financing from day one, as spending would occur as technologies/projects mature. The Fund should aim at making itself obsolete for a given technology: funding projects until a technology has been de-risked enough to be able to source commercial debt/private equity without it.

4.2.3.2 Learnings for EU companies

Learnings from publicly funded projects need to be made available to the funding authorities and the industry broadly while preserving IP as necessary. While this Fund can be set up at national level, creating an EU Fund would ensure that learnings from previous funding rounds across Europe are taken into account.

The Fund could be packaged as a Public-Private Partnership; an approach that has been successful in developing other industries in the past.

4.2.4 Expected outcome

4.2.4.1 Starting a commercial EU ocean energy industry

Such an Investment Support Fund will enable several demonstration/pre-commercial farms beyond the MeyGen and Raz Blanchard first phase projects to be built, helping the industry past the Valley of Death[30] of finance and proving that current technologies have a commercial future.

4.2.4.2 Risk reduction

Once in operation, those farms should generate sufficient information on average electricity production, installation processes and operation patterns to reduce technology risks significantly or enable insurers to put a – reasonable – price on them for the first time.

4.2.4.3 Increase access to commercial debt, private finance and lower the cost of capital

Increased understanding and interaction with ocean energy actors will increase financiers' investment appetite to supply the sector with commercial debt. Lower risks will equally lower cost of capital.

29 https://www.scottish-enterprise.com/services/attract-investment/renewable-energy-investment-fund/overview.

30 Moore, G.A. 2006. *Crossing the chasm: marketing and selling disruptive products to mainstream customers.* Harper Business, New York. 211pp.

4.2.5 Indicative budget

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

The total budget for the Fund would ideally be determined by the market: as soon as commercial funding is available for a given technology, the appropriate number of projects will have been funded and the Fund can stop considering that technology.

As an example, experience suggests that for large tidal (turbines around the MW-scale) that 5 to 10 projects would be sufficient to identify the technologies most likely to be commercially attractive and to reduce their associated risks enough to attract commercial debt/private equity.

The current estimated Fund budget is based on the number of projects needed to:

- reach a risk level where private finance becomes available at a reasonable cost;
- ensure the best technologies become commercial, rather than only the first ones funded;
- keep a healthy market competition, ensuring continued cost reduction and innovation;
- de-risk several markets, accounting for differences in resource or local regulations.

4.2.6 Potential funding source

Member States budgets, national revenue from the Emission Trading System, EU structural funds, EU demonstration programmes such as ERA-Net co-fund, Innovation Fund, European Fund for Strategic Investments.

4.2.7 Timeline

Further discussion is required with relevant industry stakeholders and financial institutions, with an ambition for the Fund to start in 2018.

4.2.8 Design options for an Investment Support Fund:

An extensive paper[31] has been drawn up by the Ocean Energy Forum, looking at design options for such a Fund.

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

ACTION PLAN 3

4.3.1 Rationale

Because of their innovative nature, ocean energies bear a higher technological and, thus, financial risk than more mature energy technologies. As with all early stage technologies, it is difficult to predict electricity production accurately enough to guarantee financial returns. Equally, assessing how often operations at sea, which have significant impacts on costs, are required, can only be achieved by installing more ocean energy devices and farms and gathering data from the projects.

At current stages of deployment, such data is lacking, resulting in a paradoxical situation where reducing risks will only come from taking risks.

At project level, this risk is currently overwhelmingly borne by the project developers, both limiting their pool of potential equity finance and making it difficult to leverage their funds to access commercial project finance.

31 Annex 1: online version of Strategic Roadmap, available at https://webgate.ec.europa.eu/maritimeforum/en/node/3962.

Project developers could attempt to cover risks, either by asking the device manufacturer to shoulder some himself, which he might do to a certain extent, or by insuring them on the market. Yet solutions for innovative technologies are only offered as technology matures as insurers equally require an idea of the risks to estimate insurance premiums. Currently no insurance product exists for ocean energy covering risks adequately, at a reasonable price.

Table 2 below presents a summary of the main risks for ocean energy projects as well as which types of cover might be available from device manufacturers or the insurance market, with a view to exposing the gaps and creating an Insurance and Guarantee Fund able to target them specifically.

Table 2. Gap matrix between existing and required insurance products for ocean energy

Risk	Project Developer & Financiers need	OEM/Supplier obligations	Project Insurance availability	Risk Gap to achieve "bankability"
Construction & Procurement Phase				
Delivery of turbines/ WECs , support structures, etc	Timely commissioning (eg, after 30 days successful running in situ) to initiate revenue generation phase.	Performance Bonds & Liquidated Damages (LDs) often subject to caps, and NB credit risk	Limited to accidental damage in transit or construction and consequent loss of revenue/Business Interruption (BI).	Revenue shortfall protection over and above amount of LDs, etc, in the event of an uninsured delay in acceptance of turbines. (May be more relevant to smaller technology suppliers rather than major OEMs)
Operational Phase (in first, eg, two to five years of demonstration project – ie, until adequate data established)				
Availability of power generation equipment, etc	Plant needs to be available to operate for minimum percentage of each year to achieve revenue targets.	Warranty may include LDs/penalties based on increasing availability over time. LDs capped to % of contract value.	Not normally insured for inefficacy, mechanical breakdown or defect. Some insurer support may become available once "proven"	Loss of revenue over and above the amount provided by any LDs plus excess costs to rectify faults – eg, marine operations, transit, weather delays
Performance against expected power curve	When operating, the plant needs to generate the expected MWh given the wave/ tidal resource.	Warranty may include a static power curve guarantee.	Not insured, although some specialist insurers may offer some support.	Loss of revenue expected given the actual site conditions in excess of any LDs based on static power curve calculations. Method of calculation of any loss will require expert input
Machinery breakdown & defective parts	Protection against costs of repair as well as delay.	Warranty generally covers replacement of parts for limited period. Some may contribute to marine ops costs.	Replacement costs & consequences normally excluded. Cover should widen after, eg, two years of satisfactory operations.	Loss of revenue over and above the amount provided by any LDs plus excess costs to rectify faults – eg, marine operations, transit, weather delays
Decommissioning Phase				
Inadequacy of sinking Fund at termination	Bond-like instrument in lieu of having to fully cash collateralise decommissioning costs at time of financing.	No contractual liability after takeover certificate issued other than through any LDs	Only covered for BI following insured perils during the project.	Build-up of adequate sinking Fund requires several years of successful revenue generation. Sustained uninsured failure of multiple devices would be problematic.
Financiers may also perceive a performance risk on the warranty, availability and power curve obligations (eg, of smaller suppliers) which may need insuring.				

4.3.2 Proposed action

The Ocean Energy Forum proposes for EU and Member States, in collaboration with the ocean energy sector, to create an Insurance and Guarantee Fund to support deployment of the first demonstration and pre-commercial farms. This Fund would not be a permanent construct, and would aim to generate enough knowledge and commercial coverage of risks to make itself obsolete.

The Fund would insure project revenues in the early years – three to five years at most. Once enough knowledge for a given project or technology is generated, the project developer would be in a position to leverage commercial debt or re-insure his project commercially, thus freeing the insurance and Guarantee Fund award for the next project, and creating a revolving fund.

By focusing on the gaps in existing guarantee/insurance cover from device manufacturer or the insurance market, and for the necessary periods required to bring projects up to commercial project finance standards, a relatively small amount of risk underwriting capital should be able to leverage a considerably larger amount of finance into the projects.

Such a Fund underwriting project risk would cover risks such as availability, output performance, mechanical breakdown and defect. It could also provide long-term decommissioning bonds. It would be subject to suitable acceptance, risk-sharing and criteria, using the annexed matrix as starting point.

To avoid a free for all approach, a premium would be requested from project developers, though at a reasonable rate to avoid defeating the purpose of the Fund. Limits, self-insurance levels, premium rates and distribution mechanisms all to be agreed upon set up of the Fund.

It is to be noted that while this product would target the Demonstration and Pre-Commercial stages, a similar approach targeting prototypes could in certain cases reduce the need for – or size of – grant allocations, part of which is used to cover risks. A different, specialised insurance product could also be developed to that end.

4.3.3 Expected outcomes

Such a product would have three main impacts:

- to help lever additional private finance
- to increase the understanding of risks
- to help develop commercial guarantees/insurance offers

An Insurance and Guarantee Fund would make projects considerably more investable, as insuring technological/operational risks will reduce financial risks, increasing the ability to leverage additional private finance, as well as lower the cost of capital and ease access to finance at minimum cost.

Data and knowledge about production patterns for each device, and operations requirements will be generated by the first projects insured. This will inform future projects using the technologies in the medium term freeing them from the need for the Insurance and Guarantee Fund. With the first farms in the water, insurers could be drawn into the design or management of the Fund once created. This would sensibly increase their understanding of ocean energy technologies and their risks and most likely lead to the development of commercial insurance products, as has been the case in several other sectors such as wind energy. Similarly, the re-insurance market support would grow in time, as data availability and spread of risk improves.

4.3.4 Indicative budget

A Fund in the order of €50m to €70m of underwriting risk capital should be sufficient for use and potential re-use across multiple projects. This estimate is based on the finances and risk profiles of existing projects such as MeyGen or Raz Blanchard. A sectoral pan-EU approach, covering many demonstration and pre-commercial farms could absorb a large share of the risks and help those project realise.

4.3.5 Potential funding source

Such a budget could be made available from various sources such as: National (Green) Investment Banks, EIB, Member States budgets, national revenue from the Emission Trading System, European Fund for Strategic Investments. EIB programmes such as NER300, InnovFin EDP, or EFSI.

4.3.6 Timeline

2016 Search for interested parties

2017 Design options

2018 Launch

4.3.7 Design options for an Insurance and Guarantee Fund

An extensive paper[32] has been drawn up by the Ocean Energy Forum, in collaboration with the insurance industry, looking at design options for an Insurance and Guarantee Fund.

ACTION PLAN 4

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

4.4.1 Rationale

The Roadmap has identified a number of development challenges relating to Environment and Consenting for the ocean energy sector. These challenges include:

- lack of planning advice/tools to aid developers select sites, including statutory and or spatial policy support;
- lack of clarity and efficiency within consenting/licensing processes, including the need for risk based processes;
- need for improvements to the licensing process to aid new developers / first time users with limited understanding of the licencing process;
- requirement to develop science to underpin project consent applications and a single database portal to share research and monitoring reporting;
- need for identification of socio-economic benefit potential for communities, regions and Member States hosting development, and the EU, to maintain political support and public backing;
- need for socialised empirical data collection and analysis of micro, meso and macro marine wildlife interaction with ocean energy development; particularly around single devices and first arrays.

In response to providing solutions for the above, five projects have been developed.

4.4.2 Proposed action

To address these constraint issues a set of environment and consenting projects is included within the Roadmap as its Action Plan to facilitate sustainable developments addressing key consenting issues, both currently and in the future as the industry develops and the first arrays are built out.

These projects have been specifically designed to be focussed on individual issues and the delivery risks are therefore low.

32 Annex 2: online version of Strategic Roadmap, available at https://webgate.ec.europa.eu/maritimeforum/en/node/3962.

4.4.2.1 Project 1: Planning

Review planning processes to establish advice on how marine spatial planning can be applied to facilitate development site selection and infrastructure provision to minimise risk of projects not being able to achieve environmental consents/licences. In addition, consider what EU regulatory requirements need to be addressed to allow ocean energy sectors to emerge in the EU and how to best use strategic assessment techniques in line with Directive requirements as planning tools. Consider how to site developments alongside high energy user industries and establish ocean energy development alongside other forms of development to help reduce emissions and provide energy in areas of no or weak grid.

Project 1 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.

4.4.2.2 Project 2: Consenting

Consider how to best explain assessment technique requirements and processes to aid developers' progress and secure applications. Identify requirements at screening, scoping, baseline site survey, assessment, audit, consultation, post-construction monitoring, on-going research and post-consenting condition discharge stages. Explore potential efficiencies using a 'one stop shop' approach, use of manuals and guidance notes, use of processing or programming agreements to provide clarity on rate of progress at assessment, decision-making and post-consent stages and use of consultation/gap analysis methods. In particular review the need for risk based consenting techniques using outputs from the RiCore[33] study and the Commission streamlining environment assessment[34]. Ascertain ability of risk based approaches to satisfy requirements of EU Directives, specifically the Habitats and Birds Directives. Explore benefits/drawbacks of other licensing strategies used in each Member State. Consider how to integrate compliant risk based consenting with an environmental demonstration strategy to facilitate risk based consenting with increasing confidence.

Project 2 expected outcome: Guidance promoting best practice techniques based on review of consenting and licensing processes. Building on existing work in Spain, the guidance will address issues through the use of specific case examples.

33 http://RICORE-project.eu/. The aim of the RiCORE project was to establish a risk-based approach to consenting where the level of survey requirement is based on the environmental sensitivity of the site, the risk profile of the technology and the scale of the proposed project.

34 http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:C:2016:273:TOC.

4.4.2.3 Project 3: Research

All interested parties (developers, regulators, statutory advisers, stakeholders and the public) need to understand the potential impacts on the environment and designated habitats and species so they can submit fit for purpose consent applications. In the case of ocean energy these sectors propose to deploy new technologies with little or no existing examples of commercial scale development from which to understand levels and significance of impacts. It is therefore essential that developers, member states and the Commission seek to facilitate site-based and strategic environmental monitoring and undertake research required to generate a growing body of empirical data and sound science to underpin applications and help secure consent. Strategic monitoring and research is required where and when sectoral planning is required. To reduce scientific uncertainty at site level, it is important that developers and regulators have, where required for certain impacts, a relevant baseline to assess potential impacts against. However, it is also of paramount importance to get devices/installations in the water so we can consider micro, meso and macro interactions between marine animals and devices, especially at the small/medium commercial array level. As information, data and assessment reports are being produced it is essential that a mechanism is available to allow effective data sharing.

Project 3 expected outcome: Guidance describing the approaches to secure delivery of site specific planning and monitoring, research and assessment. The guidance will consider how this can be co-ordinated within the EU to aid developers and regulators. Furthermore, it will consider how reporting can be accessed and shared through an existing or newly constructed publicly accessible portal. Specifically, the outputs should identify and share good practices in the licensing process and, in particular, impact assessment techniques. This should explore the various phases of project development through:

i) pre-application, including site characterisation requirements and public consultation;
ii) application stage, presentation techniques of impact assessment methods, appropriate mitigation measures;
iii) post-consent and monitoring with review and release of data and analysis to inform future projects.

4.4.2.4 Project 4: Socio-economics

The emerging Ocean Energy sectors have the potential to bring significant benefits to the communities which host the development and contribute towards the EU's Blue Growth agenda. The use of lease allocation, tariff provision and consenting processes provide the opportunity to explore value chain potential stemming from ocean energy development. Developers need to know that they have access to a supply chain, infrastructure and services to manufacture, install, operate and maintain their development. EU member states need to know what the benefits are from ocean energy projects and what types of interventions will maximise jobs and economic value coming from these forms of development. Ocean energy developers will continue to attract political and community support if they are able to demonstrate socio-economic benefits stemming from their projects.

Project 4 expected outcome: An advice note reviewing the supply and value chain methods, industry plans, scenario mapping and master planning techniques and tariff and lease award processes to establish the best techniques to benefit developers, communities and the EU economies through the justified provision of infrastructure, manufacturing and services to maximise socio-economic benefit. It 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.

4.4.2.5 Project 5: Demonstration Strategy

Given the lack of existing ocean energy commercial projects it is essential that we consider interactions between devices and marine wildlife. There are a number of techniques which have been developed to assess impacts, such as collision risk models. However, assessment techniques and models are of limited value unless they are underpinned by empirical data. It is therefore essential that the early ocean energy developments are progressed under an effective risk based consenting regime and the potential impacts monitored through coordinated strategic research initiatives. It is essential that we understand marine animal interaction behaviour with ocean energy developments at the macro, meso and micro scales. We also need to consider if we do begin to observe impacts how effective practical mitigation techniques will be to address site and cumulative impact concerns. Further information on the Demonstration Strategy project[35], including potential sites for consideration, can be found in the Annexes section.

Project 5 expected outcome: An Environmental Demonstration Strategy which will take advantage of first arrays. It will use these for intensive monitoring purposes and minimise the burden on the first mover developers by socialising the costs. It is important that intensive monitoring information is made available to regulators, stakeholders, researchers and other developers as soon as possible to facilitate better informed applications and decision-making. The Strategy must consider different technologies and geographic considerations.

4.4.3 Indicative budget

Indicative budgets are €200k to €250k each for Projects 1 to 4, and €600 to €750k for Project 5.

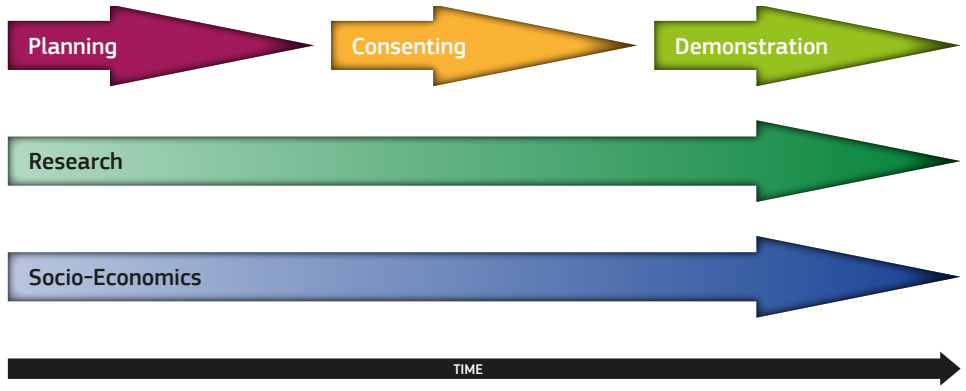
4.4.4 Timeline

Projects should commence in early 2017 for delivery from late 2017 to end of 2018.

4.4.5 Overview of the five environmental and consenting projects

Figure 7 provides an overview of the five projects, noting that some will happen in parallel, whilst others are continuous. Research and Socio-Economics underpin the other (Planning, Consenting, Demonstration) three, and their activity will increase with time.

Figure 7. Overview of the five environmental and consenting projects



35 Annex 3: online version of Strategic Roadmap available at https://webgate.ec.europa.eu/maritimeforum/en/node/3962.

SECTION 5
ACTIONS SUMMARY

SECTION 5 ACTIONS SUMMARY

Table 3. Summary of Actions

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	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.
Prototype					
ACTION PLAN 2 SECTION 4.2	**TIMELINE: 2018-2025**				
Demonstration	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.
Pre-Commercial					
ACTION PLAN 3 SECTION 4.3	**TIMELINE 2016-2018 PREPARATION & DESIGN; 2018 - LAUNCH**				
Demonstration	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.
Pre-Commercial					
ACTION PLAN 4 SECTION 4.4	**TIMELINE: 2017-2018**				
R&D	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.
Prototype					
Demonstration					
Pre-Commercial					
Industrial Roll-out					

SECTION 6
REFERENCES

SECTION 6 REFERENCES

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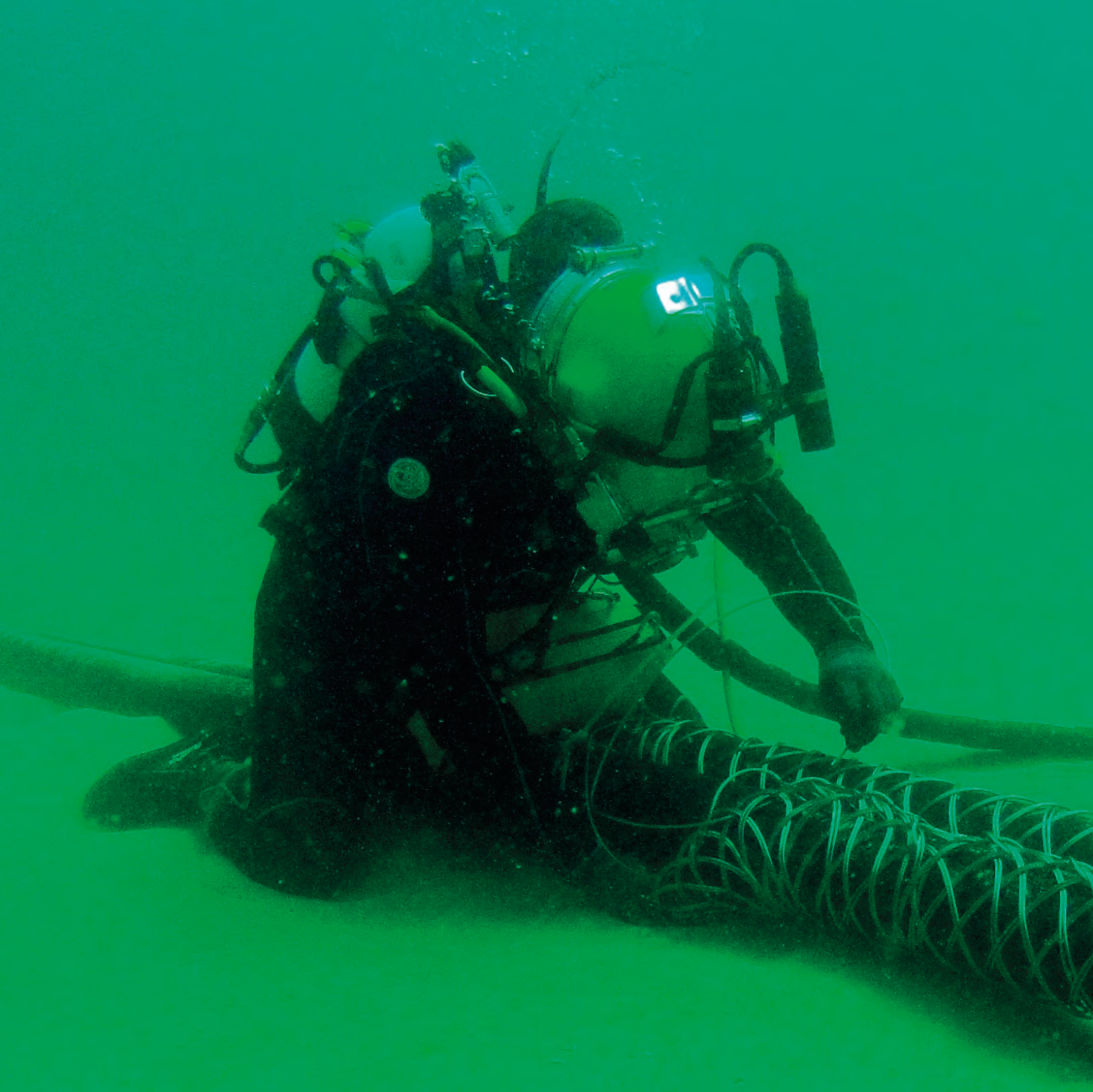


SECTION 7
GLOSSARY

SECTION 7 GLOSSARY

AA	Appropriate Assessment
Availability	The percentage of time a device, farm or plant is available to produce power.
CapEx	Capital Expenditure
Controlled environment	Hydrodynamics facilities (like a wave, flume tank), waves, tides, salinity and any other parameters are determined in advanced and fully controlled.
EFSI	European Fund for Strategic Investments
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMEC	European Marine Energy Centre
EMR	Electricity Market Reform
ERA-NET	European Research Area Network
GDP	Gross Domestic Product
Horizon 2020	EU Research and Innovation programme
IEA OES	International Energy Agency Ocean Energy Systems https://www.ocean-energy-systems.org/about-us/
IP	Intellectual Property
kW	Kilowatts
LCoE	Levelised Cost of Electricity
MeyGen project	Tidal stream farm project under construction in the Pentland Firth (Scotland) www.meygen.com
MSFD	Marine Strategy Framework Directive
MSP	Maritime Spatial Planning
MW	Megawatts
MWh	Megawatt hour
Natura 2000	A network of nature protection areas in the territory of the European Union, designated under the Habitats Directive and Birds Directive respectively
NER300	Funding programme for innovative low-carbon energy demonstration projects based on sale of emission certificates from the EU Emission Trading System.
NER400	Programme following the NER300 for innovative low-carbon energy demonstration projects.
NGOs	Non-Governmental Organisations
O&G	Oil and Gas
O&M	Operation and Maintenance
OCEANERA-NET	Network to co-ordinate funding programmes between European countries and regions to support research and innovation in the ocean energy sector http://www.oceaneranet.eu/pages/new-page-5
OEM	Original Equipment Manufacturer
ORJIP	Offshore Renewables Joint Industry Programme for Ocean Energy http://www.orjip.org.uk/oceanenergy/about
OTEC	Ocean Thermal Energy Conversion
PPP	Public-Private Partnership
PTO	Power Take-Off
R&D	Research and development
Raz Blanchard project	Tidal stream farm project in construction off the coast of Normandy (France)
Real sea condition	Deployed at sea with no control over the environment.
RED	Reverse Electro Dialysis
REIF	The Renewable Energy Investment Fund is an innovative new €103 million fund that will support greater investment in key areas of Scotland's growing renewables sector
Reliability	Measurable probability of device/farm/plant availability in a specific environment for a given time (lifetime of the project around 25 years, or between planned O&M).
RiCORE project	Risk based Consenting for Offshore Renewables project
SEA	Strategic Environmental Assessment
SET-Plan	European Commission Strategic Energy Technology Plan
Sub-sea hub	Equipment deployed underwater connecting and conditioning electricity from several ocean energy devices
Survivability	Measurable ability of a system (sub-system, components, etc.) to be available during/after disturbances (sea-states, corrosion, biofouling, loading, etc.).
TP Ocean	The European Technology and Innovation Platform for Ocean Energy
TRL	Technology Readiness Level
TWh	Terawatt hour
WEC	Wave Energy Converter
Yield	Quantity of energy produced

TECHNOLOGY READINESS LEVELS[36]

TRL 1	Basic principles observed
TRL 2	Technology concept formulated
TRL 3	Experimental proof of concept
TRL 4	Technology validated in lab
TRL 5	Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 6	Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 7	System prototype demonstration in operational environment
TRL 8	System complete and qualified
TRL 9	Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

36 European Commission 2014. HORIZON 2020 – Work Programmes 2014-2015. General Annexes to the main WP. Part 19. V. 2.2. Technology readiness levels (TRL). [Online] http://ec.europa.eu/research/participants/portal/desktop/en/funding/reference_docs.html#h2020-work-programmes-2014-15-annexes. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified. http://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf.

SECTION 8
ANNEXES

ANNEX 1 DESIGN OPTION FOR AN INVESTMENT SUPPORT FUND

(Awaiting submission from Ocean Energy Europe)

ANNEX 2 DESIGN OPTIONS FOR AN INSURANCE AND GUARANTEE FUND FOR DEMONSTRATION AND PRE-COMMERCIAL OCEAN ENERGY PROJECTS

The creation of an EU-wide insurance fund is envisaged to underwrite risks and fill the gaps in insurance and OEM warranty structures and make projects in the Demonstration and Pre-Commercial phases (as defined in Figure 3 Phases of Technology Readiness Levels, Section 2.4 of the Roadmap) more "investable". Through in-depth discussion with the ocean energy industry and institutional stakeholders such as DG MARE and the European Investment Bank (Annex 2, Appendix 2) it was deemed that an insurance fund would indeed be beneficial to the process of financing these farms.

This paper sets out options for how such an insurance fund could be set-up, how it could function with which criteria and which private and public stakeholders would be required to participate.

2.1 Rationale, objectives and expected impacts

2.1.1 Why an insurance fund?

2.1.1.1 De-risking ocean energy projects and make them more investable.

Lack of empirical experience and deployment data results in uncertainties over ocean energy projects' operation and energy production. This means that ocean energy projects bear a higher technological and financial risk compared to more mature energy technologies.

At project level, this risk is currently overwhelmingly borne by the project developers, which limits their pool of potential equity finance and makes it difficult to leverage funds to access commercial project finance.

A fund that insures project revenues during its early years would make projects considerably more investable. A sectoral pan-EU approach, covering all demonstration and pre-commercial farms could absorb a large share of this risk element and, thereby, lower the cost of capital for ocean energy developers and ease access to finance.

The fund would underwrite project risks such as availability, output performance, mechanical breakdown and defect, and could provide long-term decommissioning bonds. It would be subject to suitable acceptance, risk-sharing and eligibility criteria. A relatively small amount of risk underwriting capital should be able to leverage a considerably larger amount of finance into the projects.

2.1.2 Objectives for maximal impact

2.1.2.1 The main objective of the fund is to bridge the risk-gap between project developers and device manufacturers planning demonstration and pre-commercial farms.

The fund aims at removing the largest possible share of risk on both sides, beyond what a commercial insurer would consider, to leave an acceptable level of risk, comparable to projects on more advanced energy technologies. Importantly, a share of risk should remain with manufacturers/operators to encourage best practice and best technology. To avoid oversubscription, a premium could be charged to the project commensurate to the level of risk in that project.

The fund should be workable for all stakeholders within the industry but also sufficiently robust to:

- encourage the European Commission and potentially the EIB to provide seed capital to the insurance fund, as a justifiable use of public monies;
- provide a recognised seal of approval to external investors and project financiers in addition to filling the gaps required for their financial approval;
- ensure that initial seed funding can be recycled after some years, as projects already insured mature, become closer to a regular power curve and can find equivalent insurance packages on the commercial insurance market (provided they will have been created);
- potentially, if judged appropriate by the sector, provide a platform to bring in private risk capital to bolster the seed capital as the number of suitable projects and thus need for risk capital expands.

2.1.3 Expected impact

Such a fund would have four main impacts:

Better use of public funds: costs of insurance and decommissioning provisions can amount to a significant part of project CapEx, up to 20% in some cases. An insurance fund would drastically reduce those costs for projects thus enabling a better use of public funding: moving away from funding insurance premiums, guarantees and other financial safeguards, to funding actual turbines in the water.

Leveraging more private finance: An insurance fund would make projects considerably more investable, as insuring technological/ operational risks will reduce financial risks, increasing the ability to leverage additional private finance, as well as lower the cost of capital and ease access to finance at minimum cost.

Generating data: Data and knowledge about production patterns for each device, and operations requirements will be generated by the first projects insured. This will inform future projects using the technologies in the medium term freeing them from the need for the insurance fund.

Creating a commercial insurance offer: Insurers could be drawn in the design or management of the fund once created. This would sensibly increase their understanding of ocean energy technologies and their risks and most likely lead to the development of commercial insurance products, as has been the case in several other sectors such as wind energy. Similarly, the re-insurance market support would grow in time, as data availability and spread of risk improves.

2.2 Plugging the gap between standard insurance products and ocean energy project needs

2.2.1 Existing insurance products on market do not cover all needs of innovative ocean energy technologies

2.2.1.1 Standard commercial project insurance:

Subject to the detailed review by the commercial insurance market, most marine energy technologies can be insured for broad “all risks” insurance for replacement cost following material damage during installation and operation. Significantly, until the necessary operating hours are achieved and suitable data produced, new technologies will not normally be covered for machinery breakdown and defect risk.

In addition to the replacement cost insurance, loss of revenue cover can normally (subject to additional insurer due diligence on supply chain / replacement times, etc.) be obtained following an insured material damage loss for a defined period. If machinery breakdown is excluded on the material damage section, it will also be excluded on the loss of revenue section.

The standard commercial insurance will also not provide cover for inefficacy / failure to perform e.g. to the power curve, and will require an insured event as a trigger.

2.2.1.2 Original Equipment Manufacturer (OEM) Warranties

The potential for any recoveries following mechanical failure, defect, or performance deficiency will therefore fall on what can be claimed back from OEM warranties, at least in the first two or three years of a demonstration/pre-commercial project. Successful demonstration will make breakdown cover and broader defect cover more readily available from commercial insurers thereafter.

Different OEM's will have different appetite for and/or ability to provide "investable" warranties. Some will for instance want to limit their exposure to a contractual damage basis, not overtly linked to the project developer's loss of revenue. On the other hand, others may be prepared to give a more closely-aligned availability guarantee.

For small firms, this may be based upon a balance sheet that is dependent upon the success of the technology. In either case, the level of availability they are prepared to guarantee is normally going to be well below levels for mature technologies, and this level will probably vary from project to project.

Power curve warranties should be available from at least some OEM's and it is understood that there may be some interest from specialist commercial insurers in underwriting the OEM's power curve performance liabilities, but again excluding the machinery breakdown exposures.

The scope of what other aspects are covered under warranties may vary: parts and labour required to repair defective parts would be normal, but the degree of sharing of retrieval costs and potential weather delay risk is likely to be more variable.

Overall, the warranty protection likely to be available from OEM's for these demonstration / Pre-commercial projects will almost certainly fall below the level required by investors

2.2.1.3 Decommissioning bonds etc.

Recent company failures have focused attention on who bears the responsibility for potential future decommissioning costs. In a successful project, these would be addressed by a sinking fund building up over time out of project revenues. In advance of the project, however, unless a parental guarantee from a major shareholder is available, which is very rare, many projects will be asked to set aside up front the full amount of potential future decommissioning costs. They will therefore need to raise that amount of finance in addition to the other project CapEx, or divert funds that could otherwise be deployed in the project, representing very poor use of capital. By contrast, the fund might, subject to robust risk acceptance criteria and to payment of a premium, make an insurance instrument available as an alternative for the first few years of the project.

An example given by an Ocean Energy Forum member is that, out of €25m grant monies awarded, €5m has to be allocated to a separate account to cover future decommissioning costs. Subject to passing the risk acceptance criteria, an insurance premium charge of, for instance, 10% of the required limit, would allow for 90% of the €5m to be otherwise deployed in the project – e.g. to increase the size of the deployed array.

On a portfolio basis, the insurance fund should be in a better position than a single project to bear the risk:

a) it would spread risk across multiple projects with different technologies each paying in a premium,

b) risk acceptance criteria might e.g. require prior demonstration of technology survivability and performance, and

c) actual exposures may be lower than the amount nominally required to be available up-front.

Individual governments should also be able to minimise the possibility of being the funders of last resort for such decommissioning activities if a suitably financed risk fund is in place.

In summary, the size and nature of the gaps are likely to vary from project to project. What is likely to be more consistent from project to project is the proposed end product from the investor's perspective: what the bottom line is for scope of cover and up to what level (e.g. what percentage availability, number of years etc.) is necessary to leverage in sufficient extra investment capital to develop these next demonstration / pre-commercial projects?

The matrix below outlines the type of risks faced by ocean energy demonstration/pre-commercial projects and the availability of cover on either side of project/device development.

Gap matrix between existing and required insurance products for ocean energy

Risk	Project Developer & Financiers need	OEM/Supplier obligations	Project Insurance availability	Risk Gap to achieve "bankability"
Construction & Procurement Phase				
Delivery of turbines/ WECs , support structures, etc	Timely commissioning (eg, after 30 days successful running in situ) to initiate revenue generation phase.	Performance Bonds & Liquidated Damages (LDs) often subject to caps, and NB credit risk	Limited to accidental damage in transit or construction and consequent loss of revenue/Business Interruption (BI).	Revenue shortfall protection over and above amount of LDs, etc, in the event of an uninsured delay in acceptance of turbines. (May be more relevant to smaller technology suppliers rather than major OEMs)
Operational Phase (in first, eg, two to five years of demonstration project – ie, until adequate data established)				
Availability of power generation equipment, etc	Plant needs to be available to operate for minimum percentage of each year to achieve revenue targets.	Warranty may include LDs/penalties based on increasing availability over time. LDs capped to % of contract value.	Not normally insured for inefficacy, mechanical breakdown or defect. Some insurer support may become available once "proven"	Loss of revenue over and above the amount provided by any LDs plus excess costs to rectify faults – eg, marine operations, transit, weather delays
Performance against expected power curve	When operating, the plant needs to generate the expected MWh given the wave/ tidal resource.	Warranty may include a static power curve guarantee.	Not insured, although some specialist insurers may offer some support.	Loss of revenue expected given the actual site conditions in excess of any LDs based on static power curve calculations. Method of calculation of any loss will require expert input
Machinery breakdown & defective parts	Protection against costs of repair as well as delay.	Warranty generally covers replacement of parts for limited period. Some may contribute to marine ops costs.	Replacement costs & consequences normally excluded. Cover should widen after, eg, two years of satisfactory operations.	Loss of revenue over and above the amount provided by any LDs plus excess costs to rectify faults – eg, marine operations, transit, weather delays
Decommissioning Phase				
Inadequacy of sinking fund at termination	Bond-like instrument in lieu of having to fully cash collateralise decommissioning costs at time of financing.	No contractual liability after takeover certificate issued other than through any LDs	Only covered for BI following insured perils during the project.	Build-up of adequate sinking fund requires several years of successful revenue generation. Sustained uninsured failure of multiple devices would be problematic.
Financiers may also perceive a performance risk on the warranty, availability and power curve obligations (eg, of smaller suppliers) which may need insuring.				

2.3 What financial exposure should the fund absorb?

The fund and its potential for raising future capital, will need to be subject to a maximum level of exposure to any one project and/or device, and/or device type. It is important to understand how much that exposure could be in terms of the gap between what investors need and OEMs can provide under warranty, added to any other risks to be insured, such as decommissioning. There will, for instance, be a large difference if investors were to require five-year availability guarantees, rather than three-year availability guarantees. This will become clearer in time, but as a working number and based on existing projects such as MeyGen or Raz Blanchard, we have assumed that a maximum level of exposure to the proposed fund might be €20m per project. More information on these calculations can be found at Appendix 1 of this Annex.

The fund exposure should not be as high as the entire "gap" for each project. Given the relatively high level of uncertainty on an individual project, any engagement by an insurance fund should also be "aligned" with a level of risk absorbed by the project sponsors. This concept of risk sharing, or "co-insurance" is discussed in principle in the chart in Appendix 2 of this Annex.

With the benefits of a spread of risk through a portfolio of projects and a spread of risk period through time, the fund would not need to be capitalised to the full level of its potential exposure for each project. Reinsurance should start to be available and a total aggregate level of €50m to €70m is being proposed as seed capital.

To avoid a "free for all" approach, a premium could be requested from project developers, though at a low rate to avoid defeating the purpose of the fund. This could be project-dependent and based on a risk assessment procedure.

2.4 Targeting pilot-farm-ready technologies, with a solid due-diligence process

Defining what technology readiness levels are acceptable and which ocean energy technologies should be considered for support by the fund will require clear criteria, based on a due diligence seen to be robust. This fund is targeted at technologies that are "pilot-farm-ready" – ie, the Demonstration and Pre-Commercial phases as defined in Figure 3 Phases of Technology Readiness Levels, Section 2.4 of the Roadmap (which can help determine the level of those criteria).

These could cover the technology itself:

- How long a prototype needs to have been deployed in an approved ocean environment;
- What modifications from the originally tested prototype are acceptable for the insurer;
- What basic level of prior certification can and should be obtained;
- Which impact of prior testing (eg, accelerated lifetime testing of drive trains);

as well as the project planning:

- Which test sites are permissible;
- Contractual risk allocation structure;
- Credit exposure to OEM warranties;
- Project contingency levels;
- Spare parts holdings, replacement lead times etc;
- Installation and repair procedures, costs and exposure to weather risk.

2.5 Remaining considerations

2.5.1 Geographical acceptance criteria

The intent is to obtain EU support to confirm the reality of the business case for emerging Ocean Energy technologies having reached the Demonstration/Pre-Commercial phase.

This public support is likely to be subject to a number of conditions, including potential geographical conditions. Where projects should be located has an impact on jobs and value creation, though experience from offshore wind shows that most EU countries can be a source for part of the supply chain of products that are inherently complex and with many components and sub-components.

"Local content requirements" for public support, are in theory discouraged; nevertheless, national and regional authorities have ways to make a location more suitable than another when trying to attract investors.

For maximum flexibility a similar model to that of the Scottish REIF should be used, targeting *"projects bearing a realistic possibility to have a positive impact on the EU economy"*. This could be, eg, job creation, implementation of company manufacturing capacity or headquarters, project in EU waters, etc". The European Fund for Structural Investments (EFSI) is using a similar approach.

2.5.2 "Insurance" fund structure

Further thinking is required with regards to the structure of such a fund. Some or all of the questions below should be explored by the group of stakeholders setting up the fund:

- Using an insurance policy or cash in escrow account (bearing in mind the ability to reduce capital requirements through portfolio and risk-sharing mechanisms)
- If an insurance, consider captive re-insurance structures to allow a well-rated insurance company to participate;
- How comprehensive a "wrap" would the insurance policy, etc, need to be? There are differences between insurance policies and warranties that would need careful thought and structuring.
- How re-insurances might be brought into play to mitigate risk;
- How to assess the appropriate risk premium in each instance;
- Governance procedures to protect the fund and ensure it is deployed in line with its objectives.

2.5.3 Similar insurance concepts for earlier stage deployments

Similar, albeit more limited, concepts could be helpful in respect of earlier stage projects, eg, to cover the decommissioning requirements for the first full-scale prototype of a technology offshore. These would be expected to represent rather smaller risk limits in each case, and would require a different set of risk acceptance criteria and premium levels, and it may be that a separate side-by-side but smaller risk fund should be established to address this potential set of exposures.

APPENDIX 1 RATIONALE AND CALCULATION FOR THE SIZE OF THE FUND

The proposed insurance fund would need to be subject to a maximum notional exposure to any one project, which nevertheless needs to be sufficiently meaningful to bring in external commercial project finance. This is targeted specifically at the ocean energy first arrays, whereas larger/later arrays using machinery with more of a proven track record should have other solutions available to them.

MeyGen Phase 1(a) (already funded) and MeyGen Phase 1(b) (yet to achieve full funding, and deploying different turbines and deployment mechanisms) represent good case studies for the larger end of the first array scale of projects which the insurance fund is intended to support:

MeyGen 1(a) approximate estimates

Detail	€m
Three years' loss of revenue for 4 turbines	21.5
Marine operations' costs to replace 4 turbines	5.0
Less contribution from OEM's under contractual penalties (assumed at 10%)	-2.65
Potential decommissioning costs for 4 turbines	1.5
Subtotal	**€25.35m**
Less "co-insurance" risk sharing by project developer assumed at 20%	-5.07
Maximum notional exposure to fund for three-year period	**€20.28m**

*The marine ops costs are considered to be a conservative estimate so this estimate can comfortably be rounded down to **€20m**.

MeyGen 1(b) is expected to result in very similar overall exposures:

a) Revenue numbers may be at the same level or slightly higher, and

b) the new structures to be used may involve higher decommissioning costs than for 1 (a); but

c) marine operations costs should be reduced given the deployment of multiple turbines on the same structure.

A number of the projects in the European marine energy pipeline will involve smaller financial exposures than the case studies above, and the methodology described in the MeyGen 1(a) estimate above could be applied in each case to derive a (lower as appropriate) insured limit for each project.

It should be noted that the demand from some commercial project financiers may be protected for up to 5 years, rather than the 3 years referenced above. Consideration should be given to the proposed fund being able to offer cover for a five-year period, but subject to an overall aggregate limit per project, eg, of €20m as described above which assumes the failure for the full three years of all deployed devices. Failure of one or two devices for the full five years could still be indemnified within the proposed aggregate limit of €20m.

APPENDIX 2 TEXT OF PRESENTATION TO DG MARE AND EIB, OCTOBER 2015

The Issues

PRIOR OPERATING DATA IS VERY LIMITED;

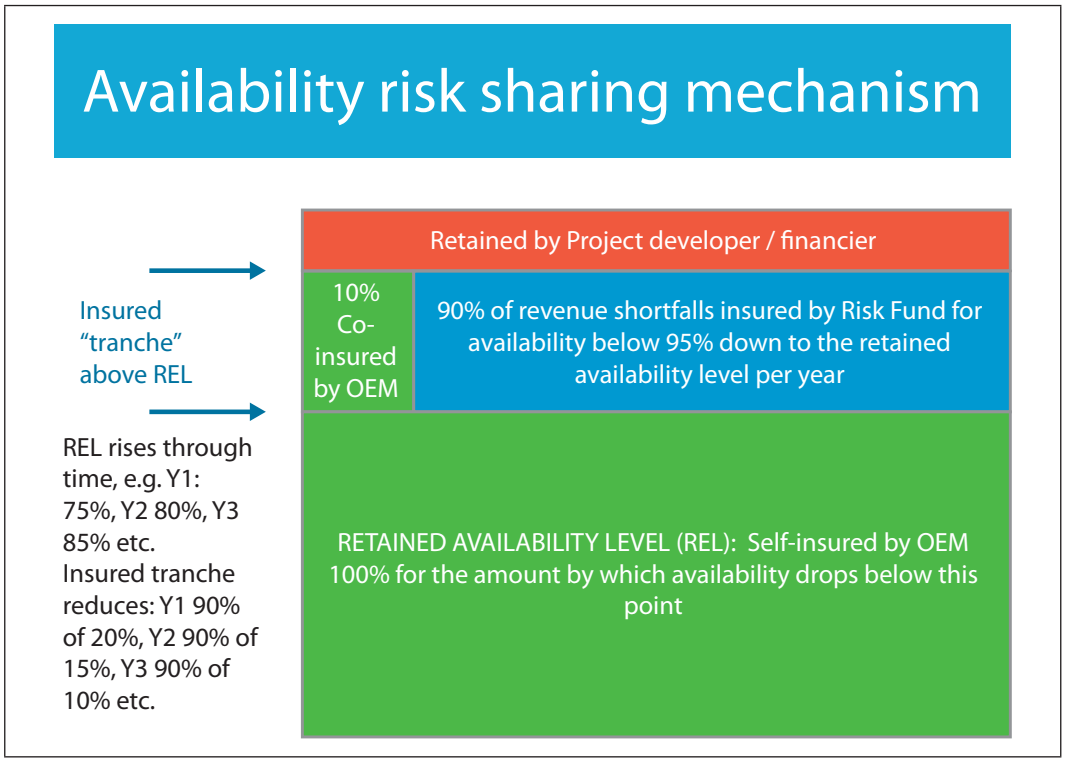
- OEM power curve & availability warranties limited or non-existent;
- Insurance excludes machinery breakdown / defect;
- Technology risk mainly falls on project developers with limited balance sheets;
- Equity investment harder to attract, commercial project finance harder still.

TIDAL POWER EXAMPLE

- Insurance ex. defect and machinery breakdown;
- Some power curve / parts warranties, risks shared on intervention cost, no availability warranty;
- Period of continuous running prior handover;
- Interventions balance: vessel costs versus revenue;
- Agreements on spares holdings;
- Project contingency funds topped up from revenue;
- Liquidated damages on performance etc
- Phase 2 broader warranties and insurance?

POTENTIAL SOLUTION AND SCALE

- Fund providing insurance “wrap” for demo projects;
- Insured events just to “plug the gaps”, potentially including decommissioning;
- Captive reinsurer using well rated insurer “front”;
- Gradual ability to add capacity via reinsurance;
- Charge premium (& claw back losses?) and recycle funds as individual projects mature;
- Limit per project tba, eg, < €20m “notional”;
- Maximum fund capital requirement, eg, €50m-70m?
- Duration 3-5 years per project - Rollovers?



POSSIBLE DUE DILIGENCE REQUIREMENTS

- Earlier "successful" full scale prototype in comparable environment/conditions; Handover criteria;
- Spares assessed versus MTBF and lead times to replace;
- Link to reliability studies via test centres etc;
- Contractual assessment: penalties, SLAs, length of warranties etc;
- Project contingency levels and top-up mechanisms;
- Agreed intervention procedures.

BENEFITS

- Structuring mitigates risk, eg, of loan guarantees;
- Criteria act as guideline for financial, contracting and spares strategies;
- Risk sharing mechanisms keep all parties involved to appropriate levels;
- Initial risk capital can stimulate other risk bearing capital and reinsurance;
- Risk bearing structure leverages much greater amount of equity investment and project finance.

NEXT STEPS

- Indication of interest;
- Refine variables to identify bottom line gaps – limits, duration, benchmark versus offshore wind, level of availability needed (difference between 95% and 75%)... liaise with financiers, reinsurers, developers, OEMs;
- Refine business plan: detailed structure, definitions of heads of cover, criteria etc.

ANNEX 3 DESIGN OPTION FOR A DEMONSTRATION STRATEGY PROJECT FOR THE ATLANTIC AREA

A demonstration strategy is a key part of an overall risk-based consenting approach as demonstration projects provide an opportunity for addressing some of the scientific uncertainty surrounding the licensing of marine renewable developments. The proposed Atlantic Demonstration Strategy outlined in this paper seeks to move the ocean energy sector from a state where there is limited or no empirical data to sound science consenting through the collection of empirical data. It will provide a long-term strategy for the demonstration of ocean energy developments in the Atlantic Area and will build on the current pioneering projects in this area and consider what support will be required to enable further demonstration projects across the Atlantic Area. The demonstration strategy should seek to provide answers to the environmental unknowns for ocean energy technologies and to promote the use of best available techniques such as use of sonars, videos, tagging and strategic survey. It should also consider support for further demonstration of monitoring techniques / technologies.

The proposed demonstration strategy will not only assist in the consenting of future marine renewable developments, but also assist future demonstration strategy projects by providing a protocol through which empirical data can be collected in the future to characterise the likelihood of collision risk impacts from tidal turbines and other ocean energy technology developments. Without this progressive research, it will prove difficult to consent with confidence further marine tidal turbine developments where there is potential for significant marine mammal interactions, without the potential for onerous restrictions which risks making future projects unviable.

Concerns with respect to the potential impact of tidal turbines and other ocean energy developments on marine mammals arise from the potential for mortality or injury through collision with turbine rotors or other moving parts within an ocean energy development array. To evaluate these risks there is a clear need to improve understanding about whether animals can perceive the impact risks associated with these devices and whether they take appropriate macro, meso and micro avoidance action to avoid collisions.

A series of geographically discrete and technology specific sites will also be considered as future demonstration strategy projects to trial ocean energy development environmental performance and/or the effectiveness of mitigation techniques such as the use of acoustic deterrent devices to deter marine mammals (and fish) from entering ocean energy arrays. See Table below for a preliminary list of potential sites for consideration.

The demonstration work, proposed at the MeyGen site in the Pentland Firth, Scotland will provide initial empirical data on animal movements which will form the basis of an understanding of close range encounters including collision and avoidance rates and an analysis of marine mammal behavioural responses to an operating tidal turbine.

The proposed strategy will provide much needed empirical information on key environmental unknowns, including the likelihood that marine mammals will avoid/collide with tidal turbines. These data will be used to produce empirically derived estimates of collision risk for operating tidal turbines at the micro and possibly meso scale which will form the basis of advice to decision makers on parameterising collision risk models for future assessments, and will ultimately inform the consenting of marine renewable developments.

Given the sector wide benefits of such learning, collaborative funding of such studies should be explored. Provision of public sector funding will, in addition, help ensure unrestricted dissemination of results and analysis reporting to establish species avoidance and other impact assessment methodology reporting. A demonstration strategy approach should reduce the burden on early or initial developers which socialises the costs of intensive monitoring, the development of monitoring devices and the collection, analysis and conversion of empirical data to underpin the production of impact models and methodologies. The overall Demonstration Strategy should also be used to better explore if meso and macro avoidance is being applied by marine animals and if mitigation techniques are required and how these can be field tested and applied.

Potential Project Sites for Consideration

Site	Technology	Scale	Location	Focus of Demonstration
Strangford Lough	Tidal array	2 (600 kw) devices	Northern Ireland	• Benthos monitoring • Marine mammal characterisation
Sound of Islay	Tidal array	10 (1 MW) devices	Scotland	• Post consent monitoring
Bluemill Sound (Nova Innovation)	Tidal array	1 device at present	Scotland	
MeyGen	Tidal array	Phase 1a 4 (1.5 MW) turbines	Scotland	• Fine-scale movements of marine mammals around an operating turbine • Active and passive acoustic monitoring • video surveillance
DP Energy	Tidal array		Scotland	• Dependant on consent
Open Hydro	Tidal array		Scotland	• Dependant on consent
WestWave project	Wave energy converters	5MW	Ireland	
Smart Bay	Monitoring equipment & sensors	N/A	Ireland	• Validation of novel marine sensors and prototype equipment
Fair Head Tidal	Tidal array	10 MW demo array & 90 MW phase 2	Northern Ireland	• Dependant on planning permission
TEL array in Ramsey Sound	Tidal turbine	1 turbine	Wales	
Pembrokeshire Demonstration Zone	Wave energy converters		Wales	
Open Hydro	Tidal array	4 turbines	Brittany, France	• Dependant on planning permission
Albatern	Tidal			• Hydrophones • Benthic monitoring

WEBSITE https://webgate.ec.europa.eu/maritimeforum/en/frontpage/1036