ETIPOCEAN

European Technology & Innovation Platform for Ocean Energy

Deliverable 8.5: Report on presentation of stakeholder engagement results workshops

This Project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement number 727483.

Document Details	
Grant Agreement Number	727483
Project Acronym	ETIP Ocean
Work Package	8
Task(s)	8.6
Deliverable	8.5
Title	Report on presentation of stakeholder engagement workshops
Authors	Shona Pennock, Noor van Velzen, Charlotte Cochrane, Kasparas Kemeklis, Donagh Cagney
File name	ETIP Ocean D8.5 Report on presentation of stakeholder engagement workshops
Delivery date	30/11/2018
Dissemination level	Public
Keywords	Ocean energy, wave energy, tidal energy, workshop, stakeholder engagement, technology, finance, environment, socioeconomics

Document Approval Record		
	Name	**Date**
Prepared by	University of Edinburgh	29/11/2018
Checked by	Ocean Energy Europe	30/11/2018
Approved by	Ocean Energy Europe	30/11/2018

Document Changes Record			
Revision Number	**Date**	**Sections Changed**	**Reason for Change**
2	29/01/2019	Workshop results for all webinar topics.	Integration of European Commission feedback

Contents

Acronyms/Abbreviations

CAPEX	Capital Expenditure
D	Deliverable
EERA	European Energy Research Alliance
ETIP	European Technology and Innovation Platform
FMECA	Failure Mode, Effects and Criticality Analysis
HIRA	Hazard Identification and Risk Assessment
IEA-OES	International Energy Agency – Ocean Energy Systems
LCOE	Levelised Cost of Energy
MRL	Manufacturing Readiness Level
O&M	Operations and Maintenance
OEE	Ocean Energy Europe
OPEX	Operational Expenditure
PTO	Power Take Off
SEA	Strategic Environmental Assessment
TRL	Technology Readiness Level
UEDIN	The University of Edinburgh
WEC	Wave Energy Converter
WES	Wave Energy Scotland
WP	Work Package

List of Tables

1. Introduction

This document summarises the outcomes of the ETIP Ocean workshops held as part of Work Package 8 (WP8). The first workshop was held during the Ocean Energy Europe (OEE) Annual Exhibition and Conference in Nantes, France on the 26th October 2017. The second workshop was held as a side event before the OEE Annual Exhibition and Conference in Edinburgh, UK on the 29th October 2018.ETIP Ocean (European Technology and Innovation Platform) is a project funded under the European Commission's Horizon 2020 research and innovation programme. ETIP Ocean organised thirteen webinars and a seminar transmitted live through webinar software between April 2017 and June 2018. Each webinar and seminar addressed a specific priority area identified in deliverable 2.1 (D2.1), "Report on an integrated framework of ocean energy sector challenges". The priority areas identified in D2.1 were classified as belonging to one of three categories:

- Technology
- Financial
- Environment and Socio-economics

The webinars and seminar followed, therefore, the same classifications. After each webinar, a report was drafted listing the topics presented, findings of the discussions including recommendations, and questions for discussion during the annual workshop.

The two annual workshops were organised to bring together a broad variety of participants in a single venue to review and build upon the results of the preceding webinars and seminar. The workshops were delivered by Ocean Energy Europe (OEE) and the University of Edinburgh (UEDIN), in association with the European Energy Research Association (EERA). Co-locating the events with the Ocean Energy Europe Conference and Exhibition gave ETIP Ocean the possibility to access a range of ocean energy stakeholders that may not otherwise have travelled to a standalone ETIP Ocean workshop. The workshops were attended by key stakeholders including the past ETIP Ocean webinar speakers, the ETIP Ocean steering committee and wider representatives from the ocean energy sector.

The workshops have designed to elicit three key pieces of information, based on the questions posed during several past technology, socio-economic and finance webinars:

- The key challenges to commercialisation for the ocean energy sector
- The key actions needed to address these challenges
- The key stakeholders to perform these actions

These webinars act as a knowledge sharing and collaboration platform discussing fourteen identified priority challenges to ocean energy commercialisation. The ultimate aim is to define a common vision for the accelerated development of the ocean energy sector and then disseminate knowledge through stakeholder engagement.

More detailed information on the workshop events can be found in the Appendices and includes the workshop agendas (Annex I), a listing of the workshop discussion table leaders (Annex II), the workshop attendance lists (Annex III), and finally a description of the format of the workshops (Annex IV).

The following sections of this report are set out as follows: Section 2 outlines the ETIP Ocean objectives in terms of the ocean energy sector challenges identified as part of the integrated framework document and the webinar topics explored during the ETIP Ocean project based on these identified challenges. Sections 3, 4 and 5 detail the workshop results for the Finance, Environment and Socioeconomics and Technology webinars respectively. Section 6 concludes with a discussion of the key themes running through the workshop round table discussions.

2. ETIP Ocean Challenges and Webinar Topics

The ultimate goal of the ETIP Ocean project is to reach a common vision for the accelerated development of ocean energy to commercialisation. ETIP Ocean is tasked with providing a hub for knowledge sharing and collaboration amongst a diverse set of ocean energy sector stakeholders. The ETIP Ocean network comprises ocean energy professionals, researchers and academics. ETIP Ocean hosts knowledge exchange events to facilitate pan-European, multi-stakeholder discussions on the key challenges facing the sector. As tabulated below, these key challenges have been collaboratively defined and ranked by importance in the D2.1 "Report on an integrated framework of ocean energy sector challenges".

Table 1 - Prioritised Ocean Energy Sector Challenges defined as part of the ETIP Ocean Integrated Framework

Priority	Category	Challenge
A	Technology	Developing novel concepts for improved power take-offs (PTOs)
		Increasing device reliability and survivability
		Investigating alternative materials and manufacturing processes for device structures
		Investigating novel devices before moving towards convergence of design
		Defining and enforcing standards for stage progression through scale testing
		Developing and implementing optimisation tools
	Financial	Providing warranties and performance guaranties
		Linking stage-gate development processes to funding decisions
		Maintaining grant funding for early TRL technologies
		Establishing long term revenue support
	Environmental and socio-economics	Enhancing social impact and acceptance
		Minimising negative environmental impacts
		Facilitating knowledge transfer and collaboration
		Implementing adaptive management systems
B	Technology	Building on existing guidelines and standards for third-party verification and testing
		Developing improved, more cost effective mooring and foundation systems
		Implementing suitable condition monitoring systems
		Improving the efficiency and cost-effectiveness of electrical subsystems and power electronics
		Optimising offshore operations and maintenance missions
		Developing dedicated vessels and tools
	Financial	Maintaining investment support
		Advancing engagement with insurance providers
		Improving cost models for ocean energy developments
	Environmental and socio-economics	Implementing training programmes
		Expanding research infrastructures
C	Technology	Developing expertise related to the manufacture of ocean energy technologies
		Scaling up from single device deployments to arrays
	Financial	Ensuring stable policy, regulation and legislation
	Environmental and socio-economics	Improving resource assessment and site selection techniques

As a conclusion to the ETIP Ocean project, an integrated strategy for the sector will be defined and published. The purpose therefore of this D8.5 dissemination workshop report is to discuss in more detail the previously held topics across technology, finance and socio-economic categories. The past knowledge exchange webinars included presentations on methods to overcome each of the fourteen priority key challenge topics from presenters with varying regional locations and commercial perspectives.

The final output of the workshop is therefore to inform the final Integrated Strategy deliverable from a common shared and discussed perspective. The session participants will primarily be the webinar presenters, with other interested industry and public body professionals from across the EU spectrum adding their valuable insights.

2.1. Webinar Topics

Table 2 shows the fourteen ETIP Ocean webinars delivered between April 2017 and June 2018. These webinars were each based on a 'priority A' challenge formed the table discussions for the ETIP Ocean stakeholder workshops. OEE had the responsibility for WP4 & WP5 Finance and Socio-Economic topics, whilst UEDIN had the responsibility for the Technology WP3 webinar topics. Post webinar reports were produced for each webinar. Each report captured the post presentation questions from attendees and posed questions for the later D8.6 dissemination workshops. These 'challenges to further development' questions were then introduced to the OEE Conference workshop sessions for discussions by a collection Ocean energy experts and 'actions' and 'stakeholder' responsibilities identified. Included in the following sections are the complete workflows for each topic, fourteen were discussed in total.

Table 2 - ETIP Ocean delivered webinars

Date	Webinar title	Priority challenge addressed	Classification
06/04/2017	Metrics and stage-gate development programmes	Defining and enforcing standards for stage progression through scale testing	Technology
25/04/2017	Warranties, guarantees and insurance	Providing warranties and performance guaranties	Financial
23/05/2017	Enhancing social impact and acceptance	Enhancing social impact and acceptance	Environment & Socio-economics
27/06/2017	Control systems for improved yield, reliability and survivability	Increasing device reliability and survivability	Technology
29/08/2017	Minimising negative environmental impacts	Minimising negative environmental impacts	Environment & Socio-economics

05/10/2017	Funding Ocean Energy Technology Development Using Pre-Commercial Procurement and Stage-Gate Development Processes	Linking stage-gate development processes to funding decisions	Financial
25/10/2017	Wave power take-off: have we cracked it?	Developing novel concepts for improved power take-offs (PTOs)	Technology
13/12/2017	Adaptive Management Systems – Don't make the same mistakes twice!	Implementing adaptive management systems	Environment and Socioeconomics
29/01/2018	Developing and implementing optimisation tools	Developing and implementing optimisation tools	Technology
27/01/2018	Maintaining grant funding for early TRL technologies	Maintaining grant funding for early TRL technologies	Finance
23/03/2018	Investigating novel devices before moving towards convergence of design	Investigating novel devices before moving towards convergence of design	Technology
16/05/2018	Market Pull – Revenue support for ocean energy	Establishing long term revenue support	Finance
08/06/2018	Alternative materials and manufacturing processes	Investigating alternative materials and manufacturing processes for device structures	Technology
29/06/2018	Knowledge sharing and collaboration	Facilitating knowledge transfer and collaboration	Environment and Socioeconomics

3. Workshop Results – Finance topics

Workshop results sections for the Finance topics are shown over the following pages. These give a general description of the topic and the webinar which took place regarding the topic, present the initial results from the webinar and the further workshop round table discussion results. The workshop results are also summarised in a table for each topic.

Finance - Warranties, guarantees and insurance

The "Warranties, guarantees and insurance" webinar was held on the 25th April 2017. Ocean energy projects have a high cost of capital, which increases the cost of these projects. This higher cost of capital reflects the higher risk of these projects, which is due to:

- The early stage of development of many ocean energy technologies;
- The lack of sufficient data from operation in real sea conditions.

Warranties, guaranties and insurances that ensure project revenues alleviate these risks. They can increase projects' viability or reduce the costs of already-viable projects. However, such products, common in other more mature industries, are not always accessible to ocean energy project developers, due to the lack of data on longer-term performance of devices. This webinar analysed the current situation and solutions for mainstreaming warranties, guarantees and insurance in ocean energy. The speakers were Michael Bullock from Renewable Risk Advisers and Rémi Gruet from Ocean Energy Europe

Learnings and questions from the webinar

Workshop participants were presented with the main learning and recommendations of the webinar:

- A public insurance fund, at European or national level, will allow a small amount of risk-bearing capital to leverage significantly more project finance and commercial debt. The fund could cover several "financing gaps" that ocean energy developers currently cannot fill, such as "bankable" warranties and insurance against technological failures.
- Risk-bearing equity is scarce in Europe. Ocean energy developers require project finance. This situation is different from when the first offshore wind farms were deployed. The latter were largely financed by utilities' balance sheets.
- To take technology risks, commercial insurers will require devices to have been operational for at least 8,000 hours, uninterrupted and in a comparable offshore environment. Any upgrade to a device, or any re-sizing or new component, will require an additional 8,000 operational hours.
- The insurance fund could also address finance for decommissioning. This would eliminate the need for developers to put up collateral upfront and reduce project financing needs. In the absence of upfront cash collateral, decommissioning funds are built-up during a project's operational lifetime through energy sale revenues. Where a project underperforms, less

revenue is generated which impacts the project developer's ability to accumulate the necessary decommissioning money. Insurance for loss of revenue (resulting from technical failures or under-performance) or a Decommissioning Fund 'pooled' across several projects could mitigate this risk.

- This can ensure more efficient use of public funds. For example, a public insurance fund can help to de-risk projects to the extent that it may reduce the level of PPA or feed-in tariff required by potential investors and financiers.
- An insurance fund reverses the public spending logic, compared to revenue support. Developers would draw on the insurance fund when the project is underperforming. As technology improves and performs better, less money is drawn from the public fund. This is the opposite logic to classic revenue support where the better a technology performs, the more public money it draws.
- Such a fund would not only be beneficial to the ocean energy sector. Its scope could be broadened to all early-stage renewable energy technologies such as floating offshore wind or deep geothermal.

Workshop results

Challenge 1 – High cost of insurance products for ocean energy projects

Insurance products are too expensive to be affordable for ocean energy projects, due to the high risk of these projects. Project developers have very limited up-front capital to spend on preliminary actions that could de-risk subsequent projects.

Actions
Implement insurance facility as recommended in the Ocean Energy Forum Strategic Roadmap. The insurance fund concept is a means to maximise support for projects by leveraging available funding. However, with or without the fund, risk will ultimately stay with the public. Therefore, the implementation of an insurance fund is ultimately a mechanism to deliver efficiency of public spending. If there is no appetite or possibility to create insurance fund then it is a case of channeling greater volumes of public funding to demonstration projects. Public funding sources could potentially bear such technical risks without the same need for filling the insurance and warranty gaps as the private sector.

Fund early-stage actions that can de-risk as much as possible, even sharing some initial up-front, high-risk project expenditure. For example, conduct extensive surveys to assess resource comprehensively, and share consenting costs.

Stakeholders
Key stakeholders here are the European Commission, regional authorities, and national authorities. Members of the SET Plan Working Group on Ocean Energy.

Challenge 2 – A lack of progress on developing an insurance fund

As outlined by the Strategic Roadmap, an insurance fund should be created. This has not been progressed since highlighted in the roadmap.

Actions
Outreach and engage with insurance sector to get them involved in the ocean energy sector. For example, organise visits to test sites or demonstration projects.

Stakeholders
Relevant stakeholders in this instance are the Insurance sector, Technology Developers, Project developers and Industry associations.

Challenge 3 - Normal commercial/contractual tension between project and technology developer can lead to a suboptimal outcome all round

Normal commercial/contractual tension between project and tech developer can lead to less-than-ideal outcome that has negative consequences for all parties involved. For example, penalties for late delivery may incentivise skipping the full testing programme.

Actions
Foster a close working relationship between developers. Try to go beyond the purely-contractual context where possible. Understand that there is a shared interest in reducing overall risk. Start the relationship at the very beginning of the project.

Stakeholders
The primary stakeholders in this case are the project and technology developers

Challenge 4 - Substantial non-technology specific risk of marine operations

The risk of marine operations can be substantial, but this is not specific to one single technology type.

Actions
Marine operations risk is not specific to one technology type. Exploit greater sharing of knowledge and experience to bring down costs for this element of insurance and apply lessons learned to reduce the cost and risk of marine operations etc.

Stakeholders
The primary stakeholders in this case are project developers and marine operations contractors.

Summary table

Table 3 below summarises the results of the workshop on warranties, guarantees and insurance.

Table 3 -summary of workshop results on warranties, guarantees and insurance

Challenge to ocean energy commercialisation	Actions	Responsible Stakeholder(s)
High cost of insurance products for ocean energy projects	-Implement an Insurance & Guarantee Fund as recommended in Strategic Roadmap -Fund early-stage actions that can de-risk projects as much as possible, even if some initial up front capital costs are incurred	European Commission Regional authorities: Responsible for energy transition, innovation, enterprise or industrial strategy. National authorities: Responsible for energy transition, innovation, enterprise or industrial strategy. Members of the SET Plan Working Group on Ocean Energy
Lack of progress on developing insurance fund	-Outreach and engage with insurance sector to get them involved in the ocean energy sector	Insurance sector Technology Developers Project developers Industry associations .
Normal commercial/contractual tension between project and tech developer can lead to suboptimal outcomes all round	-Foster close working relationship between developers from beginning of project. -Understand the shared interest in reducing overall risk and encourage action accordingly.	Project developers Technology developers
Substantial, non-technology specific risk of marine operations	-Exploit greater sharing of knowledge and experience to bring down costs for this element of insurance	Project developers Marine operations contractors

Finance - Funding ocean energy technology development using Pre-Commercial Procurement and stage-gate development processes

The "Funding ocean energy technology development using pre-commercial procurement and stage-gate development processes" webinar was held on the 5th October 2017.

Pre-commercial procurement (PCP) is an increasingly popular methodology amongst public funding organisations. PCP involves issuing contracts for research and development services, rather than supporting innovation through grant schemes. This allows public bodies to provide up to 100% funding whilst providing more precise directions to contractors than is possible through grant funding.

Stage-gate development processes when combined with specific calls are used to ensure that the right innovative technologies develop fully and efficiently. Stage-gate development processes allow the continual assessment of competing technologies against established metrics and the selection of the best performing technologies for continued support and investment. The use of such processes, often in conjunction with PCP methodologies, can be of great value to organisations looking to fund innovative technology development in the ocean energy sector.

This webinar investigated the use and value of PCP and stage-gate development processes in funding bodies operating in the ocean energy sector. The presenters were Tim Hurst and David Langston from Wave Energy Scotland, and Patrik Möller from CorPower Ocean.

Learnings and questions from the webinar

Workshop participants were presented with the main learnings and recommendations of the webinar:

- The pre-commercial procurement (PCP) model is a powerful tool for governments and funding authorities to obtain what they want quickly and efficiently.
- A procurement model allows for up-to 100% public funding, which is necessary during the R&D phase. This is because a 'matched funding' requirement can be difficult and ties developers in with the expectations of their funders - that may not be sufficiently realistic/long-term.
- PCP is therefore a good funding model for the technologies that don't exist yet.
- PCP therefore provides good access to funding to small companies.
- A traditional grant-funding model commits the project developers to undertake specific actions and produce specific deliverables, to justify drawing on the grant. In a procurement model, the actual results of the tests are what need to be delivered - not actions. This allows the project developers more flexibility, freedom and focus to achieve the required results.

- The competitive nature of the procurement process, pitting different solutions against each other, is a positive driver for the participating companies.
- Collaboration tends to occur naturally
- It is necessary for the procurement authority to specify very clearly what is expected; i.e. what should the device or component achieve at each phase of the process?
- PCP processes are exempted from the EU Procurement Directive.
- The benefits of national and EU procurement authorities using the same models and metrics against which to measure success at each phase are two-fold:
    - Greater investor and industrial confidence is created. A device that passes a phase is guaranteed to have comparable performance to any other.
    - A device or component developer can move between countries to carry out tests, optimizing use of available test facilities. As the standards are the same, all results will be comparable.

Workshop results

Challenge 1 – Requirement for a range of technical and administrative capabilities from PCP customer

PCP schemes require an 'Intelligent customer' – with both the correct technical knowledge (engineers, procurement) and administrative ability to manage the outputs and requirements of the scheme. High levels of reporting and feedback are required. IP considerations require that patent applications are in place for each competition stage.

Actions
Ensure that participants in PCP schemes have sufficient administrative capabilities and IP expertise as well as technical and engineering capabilities, to allow them to participate fully. Support participants with additional training and/or administrative support where required. PCP scheme participants should be as transparent as possible in their technical and administrative capabilities and as to where support could be required.

Stakeholders
Key stakeholders include PCP scheme developers, to ensure that scheme participants have sufficient capabilities and provide support where required and PCP scheme participants, to provide information about capabilities and requirements for support.

Challenge 2 – Investor Engagement

Investor engagement is a key challenge. PCP is a staged programme in which only some projects progress to later stages, and investors in such a programme want certainty as to where their money will be invested, and which projects are likely to progress.

Actions
Full communication with investors where possible to provide maximum foresight and transparency on scope and assessment criteria for each procurement stage.

Stakeholders
Key stakeholders include PCP scheme developers, who should provide as full communication with PCP scheme investors as possible. PCP scheme participants are also required to deliver reporting in a timely fashion.

Challenge 3 – Potential inconsistencies between different PCP schemes

Inconsistent PCP schemes around Europe could risk adversely impacting technology development, whereas consistency between schemes could allow for additional flexibility to be built in, and for projects to transfer between schemes and take advantage of additional funding sources and competition. Building in this flexibility could be a huge advantage to the development of the sector.

Actions
Setting up of further PCP schemes (e.g. in Ireland, Europe) should build on best practices and lessons learnt from previous schemes (e.g. Wave Energy Scotland). Using stage-gate metrics linked to existing standards to ensure that further PCP schemes are consistent with those already in existence. This creates the possibility for projects that reach one stage in a PCP scheme could subsequently transfer schemes for later stages.

Stakeholders
Key stakeholders include PCP scheme developers and future PCP scheme funders such as the European Commission.

Summary table

Table 4 below summarises the results of the workshop on funding early stage technology using Pre-Commercial Procurement and stage-gate development processes.

Table 4 - summary of workshop results on funding early stage technology using Pre-Commercial Procurement and stage-gate development processes

Challenge to ocean energy deployment	Actions	Responsible stakeholders
Requirement for a range of technical and administrative capabilities from PCP customer	- Ensure that participants in PCP schemes have sufficient administrative capabilities and IP expertise - Support participants with additional training and/or administrative support where required.	PCP scheme developers: National and regional authorities responsible for energy transition, innovation, enterprise or industrial strategy. PCP scheme participants: Technology developers

Investor engagement	-Full communication with investors where possible to provide maximum foresight and transparency on scope and assessment criteria for each procurement stage.	PCP scheme developers: National and regional authorities responsible for energy transition, innovation, enterprise or industrial strategy. PCP scheme investors PCP scheme participants: Technology developers
Potential inconsistencies between different PCP schemes	-Setting up of further PCP schemes (e.g. in Ireland, Europe) should build on best practices and lessons learnt from previous schemes (e.g. WES). -Using stage-gate metrics linked to existing standards to ensure that further PCP schemes are consistent with those already in existence.	PCP scheme developers: National and regional authorities responsible for energy transition, innovation, enterprise or industrial strategy. European Commission: DG RTD

Finance - Maintaining grant funding for early TRL technologies

The 'Maintaining grant funding for early TRL technologies' webinar was held on the 27th February 2017.

Supporting R&D through grant funding is a well-established means of advancing the development of innovative technologies. The model helps develop technologies to a point where they can generate revenue and attract some investment. Public and private budgets for R&D are limited however, so it is vital that funding schemes are designed to have a maximum return on investment.

In this webinar, ocean energy finance experts analysed different funding schemes and explain why some of them are more successful than others. The presenters were Peter Coyle (Marine Renewables Industry Association) and Andrew Smith (Deja Blue Consulting).

Learnings and questions from the webinar

Workshop participants were presented with the main learnings and recommendations from the webinar:

- The challenge for funding agencies is to find the optimal balance between good governance and sufficient flexibility. Clear rules are needed to ensure that public funds are accounted for and deliver the maximum benefit. Yet excessively rigid rules may inadvertently exclude valuable opportunities for innovation. This is a very challenging balance to find, and it will vary on a case by case basis.
- Typical sources of finance of OE companies at early TRLs are equity and some 'soft loans' (primarily from friends and family) and grants. Only occasionally do OE companies benefit from private investors who can afford a long–term perspective.
- Tailored instruments specifically for early TRL projects are necessary. Technology-specific funds are particularly valuable to ensure that a technological development goals are met (e.g. Ireland's Prototype Development Fund)
- Projects need different types of funding:
    - Grants are a strategic mechanism that supports progress at the right time in the right location, whereas;
    - Revenue support schemes (such as Feed-in Tariffs, UKs Contracts for Difference regime, etc) can support debt;
    - Equity is a bet by those with the strategic interest, resource and risk appetite.
- For the economic intervention agencies it is very important for recipients and indeed the sector generally to establish what the funding they provided is designed to achieve. How is the sector expected to develop? What are the wider goals - Economic growth in the region? Employment? Agencies should also consider whether the grants they offer are appropriately sized, and made conditional on the right milestones to achieve their desired outcomes – are they too large or too small? Is a co-financing or matched

funding requirement achievable by the applicant in the sector? Similarly, are attached timelines necessary and/or achievable?

- The challenge for funding agencies is to find the optimal balance between good governance and sufficient flexibility. Clear rules are needed to ensure that public funds are accounted for and deliver the maximum benefit. At the same time excessively rigid rules may inadvertently exclude valuable opportunities for innovation. This is a very difficult balance to find, as it will vary on a case by case basis.
- Besides TRL levels, consideration should be given to the potential market for a technology. Even with the best technology, private capital will not come if there is no market to apply it. One of the key elements of grant funding should be the development of a market. That speaks to the need to use grants strategically to create a number of successful companies across the sector that, together, can deliver all of the elements that the sector needs to become a real market place.

Workshop results

Challenge 1 – Balancing the needs for good governance and sufficient flexibility

Grants and funding mechanisms must incorporate good governance, fairness, and which must deliver optimal value for taxpayers. Simultaneously there must be sufficient flexibility to reflect the uncertain outcomes inherent to the 'discovery process' of early stage technology development, and the specific implementation challenges faced by wave and tidal energy developers – in particular those which are small and medium-sized enterprises.

Actions

Key actions include the incorporation of an explicit 'governance-flexibility' trade off assessment for grants and funding aimed at the wave and tidal sectors. The key funding objectives should be to produce excellent science and innovative solutions and well as focusing on climate change, economic growth, regional development and employment. Projects with wave and tidal technologies meet all of these objectives. There should be a check to confirm that grant conditions do not overly work against particular players (e.g. small enterprises) and that they can realistically allow for necessary but challenging actions (e.g. prototype assembly, sufficient tank testing).

Stakeholders

National funding authorities for ocean energy to incorporate these assessments in their grant/funding mechanisms.

Technology developers to engage with this process and clearly communicate risks and potential delays in typical early TRL research actions.

Challenge 2 – Lack of cohesion between grant bodies and commercial funders

Lack of cohesion and expectations between grant bodies and commercial funders leads to different conditions, different milestones and repetitive discussions all inside the same project.

Actions
In shaping grants and funding to support the wave and tidal sectors, set up a collaborative method amongst all funders in projects for establishing desired outcomes, common milestones and project monitoring and problem solving. This should involve coordination between commercial funders, national governments and the European commission.

Stakeholders
National funding authorities, the European Commission, and commercial funders of individual projects are all key stakeholders needing to develop a collaborative method for project funding. Coordination between these organisations can be done through the SET plan working group and through projects such as ETIP Ocean 2 which will engage with the SET plan working group to further promote collaboration and communication within the industry.

Challenge 3 – Applying the requirement for grant deadlines and time limits to ocean energy deployment actions that are dependent on many different factors and actors
Otherwise-viable innovation actions can lose out on funding due to lack of progress/delays impacting on timeline requirements. A lack of project monitoring can lead to problems going unaddressed for too long and to project failures.

Actions
Regularly monitor and review projects, to ensure appropriate progress and identify problems early. Offer a forum for solutions to ensure that unanticipated project delays do not lead to projects losing out on funding. When awarding grants and funding specific to wave and tidal projects, ensure an objective and clear discussion of timeline requirements, that incorporates a risk analysis of potential delays in the innovation action. Incorporate collaboration opportunities between funders across all projects to establish common project monitoring and problem solving strategies, and to minimize duplication of effort.

Stakeholders
Key stakeholders include national and regional funding authorities, the European Commission, project and technology developers, commercial funders of projects.

Challenge 4 – Lack of corporate capability of smaller organisations
Small companies lack the corporate capability to deal with complex grant applications.

Actions
Build corporate capability via assistance, advice and training.

Stakeholders

Key stakeholders include funding providers such as national and regional funding authorities, the European Commission. In particular, authorities with responsibility for enterprise, and the promotion of small and medium-sized enterprises.

Challenge 5 – Lack of route to market for developed technologies impacting on investment of early stage technologies

The lack of a clear path to market for developed technologies means investors are unlikely to support early stage technologies.

Actions

Market pull mechanisms for developed solutions (e.g. ringfencing in UK's Contracts for Difference regime), national deployment targets, and project finance mechanisms (for example, demonstration grants or soft loans)

Stakeholders

Key stakeholders would be National Governments, as member state government policy is key to ensuring a clear route to market for developed technologies. Specifically, national energy ministries/departments.

Challenge 6 – Brexit impacting on collaborations between UK and EU partners

Currently many wave and tidal developers are operating in the UK, and the UK is a key tidal resource within Europe. If Brexit were to result in grants and funding becoming less available to UK companies (or consortia with UK partners), all partners will be adversely impacted by the challenges to collaboration, and there would be a reduced diffusion of technological progress across Europe

Actions

UK and EU27 stated desires for continued close cooperation on research, development and innovation should be translated into specific agreements – e.g. UK participated in Horizon Europe as an 'associated country'.

Stakeholders

Stakeholders include the European Commission, EU27 national governments, and the UK government.

Challenge 7 - Pre-commercial (pilot) projects and testing at TRL 5-7 is capital intensive

Pre-commercial project development and testing for TRL 5-7 technology require dedicated support mechanisms, as these innovation activities are capital intensive. There is currently a lack of such support.

Actions

Support for front-runner technologies to deployment in real-sea conditions.

Coordinate amongst funding authorities and technology developers to fill funding gaps for specific TRL levels.

Stakeholders

Key stakeholders include Technology developers at TRL 5-7, national and regional funding authorities and the European Commission. Participants in coordination mechanisms such as the ETIP Ocean platform and the SET Plan Ocean Energy Working Group.

Summary table

Table 5 below summarises the results of the workshop on maintaining grant funding for early-TRL technologies.

Table 5 - summary of workshop results on maintaining grant funding for early-TRL technologies

Challenge to ocean energy deployment	Actions	-Responsible stakeholders
Balancing the needs for good governance and sufficient flexibility	- Incorporate explicit 'governance-flexibility' tradeoffs assessment for grants and funding aimed at the wave and tidal sectors. - Funding objectives focusing on the production excellent science and innovative solutions whilst meeting carbon reduction targets.	European Commission National and regional funding authorities supporting energy innovation actions
Lack of cohesion between grant bodies and commercial funders	-Set up a collaborative method amongst all funders in projects for establishing desired outcomes, common milestones and project monitoring and problem solving. -Coordination between commercial funders, national governments and the European commission.	European Commission National and regional funding authorities supporting energy innovation European Commission SET Plan Working Group ETIP Ocean
Applying the requirement for grant deadlines and time limits to ocean energy deployment actions that are dependent on many different factors and actors	- When awarding grants and funding specific to wave and tidal projects, ensure an objective and clear discussion of timeline requirements, that incorporates a risk analysis of potential delays in the innovation action. -Regularly monitor and review projects to ensure appropriate progress and identify problems early. -Offer a forum for solutions to ensure that project delays do not lead to projects losing out on funding.	Private funding providers Technology developers European Commission National and regional funding authorities supporting energy innovation

	-Establish common project monitoring and problem solving strategies and miminise duplication of effort.	
Lack of corporate capability of smaller organisations	-Build corporate capability via assistance, advice and training	National and regional funding authorities especially authorities with responsibility for enterprise, and the promotion of small and medium-sized enterprises. European Commission – EASME ETIP Ocean Industry associations
Lack of route to market for developed technologies impacting on investment of early stage technologies	-Market pull mechanisms for developed solutions - Project finance mechanisms	National energy ministries/departments
Brexit impacting on collaborations between UK and EU partners	UK and EU27 stated desires for continued close cooperation on research, development and innovation should be translated into specific agreements – e.g. UK participated in Horizon Europe as an 'associated country'.	European Commission, EU27 national governments, UK government
Pre-commercial (pilot) projects and testing at TRL 5-7 is capital intensive	-Grant funding support for front-runner technologies to deployment in real-sea conditions remains priority number on for wave and tidal technologies -Coordinate amongst funding authorities and technology developers to fill funding gaps for specific TRL levels.	Technology developers at TRL 5-7 European Commission National and regional funding authorities with responsibility for energy transition, innovation.

Finance - Market pull – Revenue support for ocean energy

The "Market Pull – Revenue support for ocean energy" webinar was held on the 16th May 2018. Revenue support schemes have proven extremely successful at driving innovation, lowering costs and creating markets for renewable energy technologies. By incentivising production, revenue support provides the business case for the best performing technologies. It drives investment by reducing risk. It is a critical step for ocean energy on the road to industrialisation. During the webinar, Niamh Kenny from DP Energy explained the clear rationale for revenue supports for emerging technology such as marine renewables, based on historical trends and the requirements of current projects. Shelley MacDougall of Arcadia University presented Nova Scotia's support scheme.

Learnings and questions from the webinar

- Revenue support mechanisms and subsidies allow the delivery of public goods and services that would not otherwise be provided. Energy and electricity have been socialised for decades, since electrification began, and infrastructure continues to be supported at national level for all types of generation.
- Typical early stage supports include taxation, Feed in Tariffs (FiTs, which are most attractive for ocean energy sector), alternative offerings such as Renewable Energy Guarantee of origin (REGoOs), Renewable Obligation Certificates (ROCs), and Contracts for Difference (CfD). Finally, incentivisation can extend to ownership structure with the cooperative model or community ownership.

Workshop results

Challenge 1 – There is a lack of cohesion between Member States on decision making

There is irregularity between and within EU Member States when it comes to making decisions on critically important early project revenue support and grant aid. The first demonstration projects require a combination of revenue support, upfront grants and access to equity or debt on reasonable terms – which in practice requires public involvement. In addition, some jurisdictions require Member State central government specific decisions to zone areas for ocean energy projects.

All these 'pieces of the puzzle' need to be in place to allow the first demonstration projects to proceed. The absence of one 'piece' makes the transition from technology push to market pull a very difficult one.

Revenue support is particularly important as it determines whether a business case for a project exists or not. However, there is little consensus across member states both that the sector requires such revenue support and if it does, how to provide support.

Actions

-Encourage 100% project funding of the first demonstration projects. This establishes the viability of the technology and encourages private investors to enter the sector. Ultimately it helps break through the commercial valley of death, and sets technology on a 'virtuous cycle' of improved performance, greater investor confidence and lower costs.

-Encourage national and regional governments to provide ring-fenced revenue support for ocean energy projects. Policy must clarify what features and characteristics revenue support needs to have. Revenue support mechanisms must be set up to achieve a specific goal – to support young technologies while controlling costs. Revenue support can align to the cost reduction curve (i.e. the more technology deployed, the less support is provided).

Stakeholders

National and regional funding authorities with responsibility for energy (and energy transition), climate change. The European Commission. Industry associations such as Ocean Energy Europe.

Challenge 2 – High cost of energy

Ocean energy costs are currently too high for cost competitiveness with other forms of renewable generation. Other generation technologies have historically received and continue to receive significant subsidies that allowed them to deploy significant capacity and therefore reduce costs. Without similar support ocean energy cannot compete against these other forms of generation

Actions

Articulate real and practicable long-term cost-reduction pathways to justify initial revenue support requirements. In doing so, facilitate competition and allow new technology to be more independent from subsidies and other revenue support mechanisms as the technology advances. When seeking initial support, projects should aim for a level that is justified according to a future marker of success.

Stakeholders

The ocean energy sector in its entirety will play a role in the enactment of these actions. More specifically, industry associations, technology and project developers, and research providers will have the biggest impact.

Challenge 3 – A lack of unified messaging

There is no unified messaging surrounding the sector. Many aspects are unclear. It is not clear whether the technology's place in the market is niche or mainstream. It is yet to be said the impact the sector stands to have on jobs, or where and when they may be created. The sector is lacking an Industrial Strategy.

Actions

-

-Conduct a GVA study to establish the economic benefit to the wider society. Refer to the results, along with an Industrial Strategy, when setting messaging.
-Agree messaging: ocean energy technology co-exists with and complements incumbent generators – the relationship is not exclusively competitive.

Stakeholders
The European Commission, its Member States and their national governments stand to play a role in overcoming this challenge. The industry as a whole will also play a role – specifically industry associations, technology developers, project developers and research providers.

Summary table

Table 6 below summarises the results of the workshop on market pull – revenue support for ocean energy.

Table 6 - summary of workshop results on market pull - revenue support for ocean energy.

Challenge to ocean energy deployment	Actions	Responsible stakeholders
A lack of cohesion between Member States on decision making	- 100% public funding of first demonstration projects. - Encourage national and regional governments to provide ring-fenced revenue support for ocean energy projects	European Commission Member States National funding authorities responsible for energy (and energy transition) and climate change. Industry Associations.
High cost of energy	-Develop clear and comprehensive cost reduction pathways in the long term -Seek a justifiable level of subsidy based on a future marker of success.	Ocean Energy sector, including: Industry associations Technology Developers Project Developers Research providers ETIP Ocean 2 SET Plan OE Working Group
A lack of unified messaging	- Facilitate collaborations between ocean energy and the oil and gas sectors -Produce macroeconomic study to show the potential impact of the sector in terms of job creation -Agree messaging both on the state of the sector	Ocean Energy sector, including: Industry associations Technology Developers Project Developers Research Providers

4. Workshop Results – Environment and Socioeconomics Topics

Workshop results sections for the Environment and Socioeconomics topics are shown over the following pages. These give a general description of the topic and the webinar which took place regarding the topic, present the initial results from the webinar and the further workshop round table discussion results. The workshop results are also summarised in a table for each topic.

Environment and Socioeconomics – Environmental impacts and consenting

The webinar "Minimising negative environmental impacts" was held on 29 August 2017. The webinar addressed the Strategic Research Agenda priority category "Minimise environmental impacts" and attempted to build on Action 4 of the Ocean Energy Forum Strategic Roadmap "De-risking environmental consenting through an integrated programme of measures". Webinar presenters were François Batifoulier from Sabella and Caitlin Long from EMEC.

Learnings and questions from the webinar

- Even with the results of the environmental monitoring carried out so far around ocean energy devices, knowledge gaps remain significant.
- Findings around single devices can be modelled to calculate cumulative effects of future arrays, but only to a point. However, the effect of numerous devices close to each other will create additional impacts. There is not enough data to date to accurately model up-scaling effects.
- It is not possible to determine a single priority area requiring more urgent attention when looking at environmental impacts. Impacts are site specific.
- Moreover, environmental impacts are not limited to flora and fauna. The impact on navigational safety needs to be considered.
- Both studies presented during the webinar seem to indicate little impact of ocean energy devices on fish. However, impacts on fish-predators are less clear.
- Displacement of mammal populations around the sites monitored in Orkney seem to be linked to the entire deployment site (the sum of all berths) rather than the single devices.
- The biggest impact on displacement occurred during the construction phases due to increased vessel movements.
- Guidance is required in terms of where environmental focus needs to be. Clear methodologies for environmental monitoring and assessment need to be developed. These should be developed by academia in close cooperation with industry.
- Ocean energy developer should be encouraged to fit their devices with as many monitoring sensors as financially possible to increase data collection.

Workshop results

Participants in the discussion table follow-up on the results from the webinar and listed three main challenges to progress in ocean energy development linked to environmental impacts. Actions to overcome the challenges and responsible stakeholders were discussed and identified.

Challenge 1 – Excessive application of 'Precautionary Principle' Approach instead of 'Adaptive Management' Approach

Ocean energy is a relatively new sector with little environmental data available from full-scale deployed projects. Yet before allowing projects to go ahead, authorities often require that developers can prove a negligible or zero impact on a range of environmental fields. This can become a 'trap' that halts progress. Lack of experience and available empirical data means that a negligible or zero environmental impact can then only be proven through thorough extensive assessments and modelling that can significant increase the cost of the project.

It is important that consenting authorities adopt a risk-based consenting process that allows for appropriate assessment of impacts. The burden of absolute or very high levels of proof placed on developers is exacerbated by the lack of appropriate guidance to developers on what needs to be assessed to obtain environmental permits and the best practical measures for monitoring the project is deployed.

Actions

-Adopt a risk-based approach to consenting. The Ocean Energy Forum's Strategic Roadmap suggests adopting a risk-based approach to environmental analysis and monitoring in consenting procedures. A risk-based approach focuses on likely environmental impacts providing guidance for determining project baseline characterisation requirements and developing project environmental management plans that are proportionate to the level of risk posed by a proposed ocean energy project.

-To ensure that up-to-date information and data on potential impacts of ocean energy projects are available and considered in determining the likely significant impacts for future deployments, an on-going review of environmental impacts associated with the technology's increased deployment is required.

-The EU-funded RiCORE project developed a risk-based approach to ocean energy and offshore wind energy consenting. The project develops an approach to optimise management of uncertainties associated with environmental impacts in a cost-effective way. Member States should appropriately translate into national consenting processes the recommendations of the RiCORE project. The European Commission could facilitate this process by setting up a working group or platform for relevant national consenting authorities to exchange best practices and lessons learnt.

Stakeholders

The Risk Based Consenting of Offshore Renewable Energy Projects (RiCORE) and EU-funded consenting authorities of each Member State play the role of enforcing and managing each State's respective consenting process. Additionally, funding

authorities within Member States and of the EC will control and advise relevant funding elements.

Challenge 2 - Environmental monitoring is data heavy

Performing exhaustive Environmental Impact Assessments and conducting monitoring campaigns requires collecting and treating a very large amount of data. Moreover, it is not always clear what level of granularity of data is required for each aspect being analysed nor what sample size is required to detect a relevant effect with a given degree of certainty.

Collecting and treating this quantity of data is resource intensive. It is important that maximum benefits are extracted from the data. This requires coordinated approach to its collection, resulting in compatible/comparable data from separate projects.

Actions

-Develop an open-source software that collects data from existing databases to develop Direct Impact analysis. Environmental monitoring activities around ocean energy sites collect significant amount of data and feed them into various databases. There is, therefore, little need for more databases to be created but rather a requirement to ensure databases are synchronised and that data can easily be translated between databases. In addition, it is essential that project developers understand how the data can be used in a meaningful way.

-Develop a readily accessible, open source software, designed to carry out direct impact analyses based on a set of parameters. The software would be fed by existing databases and monitoring campaigns and help developers identify and assess the significance of environmental impacts associated with such a project. The software would help determine both direct and indirect impacts as well as determining suitable mitigation and monitoring techniques.

-Develop methodology for what data is needed for power analysis. To better inform authorities and stakeholders of what environmental data is needed to conduct an Environmental Impact Assessment and post-deployment monitoring activities, it is recommended that Power Analyses be run. Power Analyses allow a developer to estimate the number of observations of a given phenomenon needed to detect to any degree of certainty the impact they are looking for.

-The main issue that the methodology needs to address is the sample size of data required to positively determine the statistical significance of a potential impact pathway. Whereas Power Analyses are data-specific, a guidance document outlining the methodology for conducting them would facilitate the process. The latter should inform on the granularity of data required for each aspect that requires assessing or monitoring. Developing such a methodology would focus data collection and analysis and reduce the quantity of unnecessary data collected.

-Power Analyses allow a developer to estimate the number of observations of a given phenomenon needed to detect to any degree of certainty the impact they are looking for has the potential to occur. The development of such tools is typically an activity that should be facilitated by a Horizon2020 project, involving a consortium of several organisations in different European countries.

Stakeholders
Horizon2020-funded research providers and industry will play the most significant role in overcoming this challenge.

Challenge 3 - Challenges to awarded permits can have long lead-times

Obtaining all the permits required to build an ocean energy project can be time consuming. Many administrations have established processes with predetermined lead times which can be improved or made more fit-for-purpose. Once obtained, permits can be challenged, through both administrative appeals and/or legal appeal processes. In this latter case, beyond the cost and the resources that need to be allocated to the process, lead-times are uncertain. This uncertainty over the timing of the judgement and its consequences for a project come at a significant financial impact to the developer, reduce investors' appetite to support the project, jeopardise access to grants, and lead private investors to demand a higher return for higher risk. These factors all endanger projects and push up costs.

Actions
-Develop a common approach to scoping and guidance for developers. Environmental impacts of ocean energy projects are inherently site-specific. It is, therefore, not possible to develop one-size-fits-all guidance on what needs to be assessed or monitored. Nevertheless, ETIP Ocean suggests developing common guidance on scoping and assessment technique requirements. National consenting authorities should cooperate in the development of such a common framework, addressing common licensing issues and building on case studies and lessons learnt. The European Commission could use its central role to instigate and facilitate this activity.
-Develop guidance for developers. Based on this common scoping and assessment requirement framework, developers and national consenting authorities could work together to develop specific guidance for the ocean energy sector on appropriate assessment and monitoring requirements and the national permitting process. This would streamline permitting-related work for developers and provide a clear pathway to obtaining the necessary permits.
-The coherent roll-out of this integrated programme of measures will create a virtuous cycle where better-informed assessment and monitoring improves consenting policy allowing authorities to issue ever sounder guidance to ocean energy developers. Such a process should continually increase certainty in environmental assessments and increasingly facilitate the process of obtaining consent and permits for developers. Moreover, whereas permits can always be subject to legal challenges, clear procedures backed by ever-sounder science should also better inform legal proceedings.
-The results of the analyses within ETIP Ocean also highlight the importance of in-sea testing. Demonstration projects provide the sector with the opportunity to prove their technology in a real sea environment. The learning by doing allows industry and researchers to gather valuable insights to improve future policy and consenting processes. Consequently, public support for early demonstration projects through a deploy-and-monitor approach will facilitate the gathering of better evidence, reducing future risks for both the environment and developers.

Stakeholders
National consenting authorities, project developers and research organisations are all key stakeholders for this challenge.

Summary table
Table 7 below summarises the results of the workshop on environmental impacts.

Table 7 - summary of workshop results on environmental impacts

Challenge to ocean energy deployment	Action to overcome challenge	Responsible stakeholder
Excessive application of 'Precautionary Principle' Approach instead of 'Adaptive Management' Approach	Adopt risk based approach to consenting Common scoping framework and national guidance Support demonstration projects on a 'deploy and monitor' basis.	Member States – consenting authorities European Commission
Environmental monitoring is data-heavy	Develop Direct Impact Analysis and Power Analysis tools	Research organisations Project developers European Commission
Challenges to awarded permits can have long lead-times	National guidance, scoping framework, sound assessments	National consenting authorities Project developers

Environment and Socioeconomics - Adaptive Management Systems

The "Adaptive management systems – don't make the same mistakes twice!" webinar was held on the 13th December 2017. Adaptive management techniques can make ocean energy development vastly more efficient. Lessons learnt during previous project cycles are incorporated into the next stage of project development. It will ultimately lead to improve project performance, including reduced environmental impact and a better technical outcome. The lessons learnt during this process are also of value to regulators and funders. Finlay Bennet (Marine Scotland) and Frank Fortune (Royal HaskoningDHV) shared their knowledge of the details of Adaptive Management Systems, and answered questions from the participants.

Learnings and questions from the webinar
Workshop participants were presented with the main learnings and recommendations of the webinar:

- Adaptive management is an interactive process which progressively reduces uncertainty regarding environmental effects, by managed and science-led monitoring of agreed indicators. Adaptive management is

highly relevant for decision makers who are concerned about scientific uncertainty.

- In the face of uncertainty, regulators tend to favour a conservative approach, even when the objective of a project is broadly supported. Adaptive management establishes the process that enables decision makers to reduce uncertainty and to become progressively better informed and more confident in the decisions they make.
- The US is more advanced in implementing Adaptive Management. In 2009 the US Department of the Interior published technical guidelines - currently these are the best document that specifies Adaptive Management.
- EU law requires the application of the precautionary principal. Adaptive Management can be used in its context. If done properly, Adaptive Management will address concerns that assessments are overly precautionary.
- Adaptive Management system should be used in the consenting processes where there is a big scientific uncertainty. Adaptive Management gives comfort to the regulator that there is a mechanism in place to mitigate potential impact. Collect data on the impact on the key receptor. And over time reduce those mitigation measures if indicated, while continuing to monitor.
- The way in which data is collected at the environment assessment phase is critical – it is essential to reduce uncertainty. Uncertainties should be constructively discussed with the regulator early in the process.
- It is not reasonable to expect that developers alone will create a wider knowledge base line. To gather wider information (create wider basic knowledge) we need a help from other stakeholders, national or regional institutions, EU and national budget. There should be cooperation between academia and other institutions.
- We need to have demonstration projects (machines in the water) that will progress our understanding and deepen our understanding. There is a need to start collecting actual data about perceived impact.
- We should be careful when looking at standards and methodology, to ensure that they do not to become too dogmatic.

Workshop results

Challenge 1 – <u>Lack of evidence based attitudes</u>

Attitudes towards the wave and tidal sectors can have be negatively biased, without any supporting evidence. This leads to regulator paralysis and sub-optimal decision-making.

Actions

Develop processes for education of key groups whom lack access to firm information on ocean energy. These processes should contain strategies for dealing with actors that are willing to engage and those who are more reluctant. It is key that these engagement processes demonstrate that different views are heard and considered.

Stakeholders
Regulators can play a significant role in encouraging the engagement of key actors here. Engagement activities can be in the form of setting up interest groups, involving a range of different actors from ocean energy technology developers to fisheries, and from research institutions to marine spatial planners.

Challenge 2 – Perceived collision risk
There are great uncertainties in the collision risk for sea birds and marine mammals. There are no agreed standards for risk tolerance.

Actions
To be able to assess collision risk for sea birds and marine mammals, this risk needs to be quantified. To be able to develop standards, there needs to be agreement on the common questions and data collection at the different sites, to obtain a uniform result. This is required to inform standard monitoring procedure and reduce cost of these monitoring programmes. Part of this should be the production of evidence plans and the employment of adaptive management strategy, to learn and improve the processes.

Stakeholders
Standards should be developed by experts from different areas such as research institutions, environmental consultants and developers. Regulators should support the development of these standards.

Challenge 3 – Lack of focus in monitoring requirements
There is a lack of focus on monitoring requirements. This leads to different data sets, which sometimes results in information not being useful.

Actions
Develop a set of specific questions to determine standard monitoring requirements. These should be included in the monitoring programmes (see next challenge). 'Question-led' monitoring should be used and monitoring platforms should be included in technology development.

Stakeholders
Government support to set up guidelines in standard monitoring requirements, through engagement of, i.e. developers, research institutions and environmental consultants.

Challenge 4 - Risk of lack of sharing environmental monitoring results
There is a risk that knowledge obtained from environmental monitoring is not shared, resulting in the need for repeating projects and time delays, thus in increased costs.

Actions
Monitoring programmes need to be implemented to facilitate useful and safe knowledge sharing. Monitoring programmes will give insights in the real-world implementation and impact, they can therefore support the development of the

ocean energy sector. The type of data gathered of these monitoring programmes should be consistent for different sites, publicly available and peer-reviewed, to ensure independent results.
Advisory groups can ensure real-world and applicable insights in the requirements and content of these programmes.

Stakeholders
Regulatory experts and national environmental and permitting/licencing authorities should support the monitoring programmes, ensuring the correct data is collected and made available. Technology and project developers should take part in these monitoring programmes. Advisory groups, consisting of environmental consultants, research institutions and NGOs, can assist in setting up the programmes and with the analysis of the results.

Challenge 5 – Unclear impact on fisheries
The challenge concerning the impact on fisheries is based on lack of available information into this topic. The uncertainties of the economic impact can result in resistance. It is of importance to determine and indicate the economic impact on fishing from ocean energy implementation in a sustainable way, for example due to modification of environment; changes to currents, sedimentation and pollutants.

Actions
-To consider the impact of ocean energy deployment on the fisheries, a structured development – scaling up in phases – is recommended. This encourages learning by doing, and by means of an adaptive monitoring approach (e.g. noise impact – install, operate), the effects can be determined, and negative impacts can be minimized.

Stakeholders
It is of importance to engage the different stakeholders. Transparency at all different stages of the project facilitate the collaboration between developers, fisheries, marine spatial planners and research institutions.

Summary table
Table 8 below summarises the results of the workshop on Adaptive Management Systems.

Table 8 - summary of workshop results on Adaptive Management Systems

Challenge to ocean energy deployment	Actions	Responsible stakeholders
Lack of evidence based attitudes	-Develop relevant engagement processes	NGOs Interest groups Project and technology developers Marine Spatial Planners National environmental and licencing/consenting authorities Research Institutions

Perceived collision risk	-Quantify collision risk -Develop standard monitoring procedures -Produce evidence plans and employ adaptive management	NGOs Regulators Project and technology developers Research Institutions Environmental Consultants
Lack of focus in monitoring requirements	-Develop common questions/data collections -Develop monitoring platforms	Project and technology developers National environmental and licencing/consenting authorities Research Institutions (Environmental) Consultants
Risk of lack of sharing environmental monitoring results	-Support monitoring programmes -Publicise independent and peer-reviewed results -Advisory group consultations	Environmental Consultants National environmental and licencing/consenting authorities & experts Research Institutions NGOs Member States Advisory Groups
Unclear impact on fisheries	-Adopt a phased approach, involving graduated scaling of developments, learning by doing -Adopt adaptive monitoring (e.g. noise during installation and operation)	Project and technology developers Fisheries Marine Spatial Planners National environmental and licencing/consenting authorities Research Institutions

Environment and Socioeconomics – Socio-economic impact and acceptance

The webinar "Enhancing Social impact and acceptance" was held on 23 May 2017. The question addressed builds on Action 4 of the Ocean Energy Forum Strategic Roadmap "De-risking environmental consenting through an integrated programme of measures". Especially on the challenge – "need for the identification of socio-economic benefit potential for communities, regions and Member States hosting development, and the EU, to maintain political support and public backing". Presenters for this webinar were Sue Barr from OpenHydro and Bruce Buchanan from Marine Scotland

Learnings and questions from the webinar

- Consider the stakeholder engagement process as an important step in project delivery. Make stakeholder engagement plans part of the project. Bad stakeholder relations cost time, money and add risk to projects.
- Give a voice to the local community and make it a partner in the project.
- Identify key stakeholders (who should project developers be speaking with).
- Differentiate communication according to the different audiences and stakeholder groups being addressed. In certain cases, it may be useful to have a third party deliver certain messages.
- Communicate honestly about what is or isn't known. Adhere to social values and develop guidelines for developers on social work.
- Raise awareness of the specific benefits of ocean energy.
- Industry must work together and with the regulators to study impacts that are too big for a single project developer.
- Regulators and industry should prepare stakeholders' engagement guidelines.

Workshop results

Following up on the findings from the webinar, participants at the discussion table listed four main challenges to progress in ocean energy development linked to socio-economic impacts and acceptance. Actions to overcome the challenges and responsible stakeholders were discussed and identified.

Challenge 1 – Finding and identifying stakeholders

Identifying the right stakeholders at the early stage of project development is crucial for successful project delivery. Without common guidance, ocean energy project developers rely on their personal expertise and on the "trial and error" method. This leads to a lot of re-inventing the wheel. Guidelines on how to engage with stakeholders would streamline the process and help avoid costly mistakes.

Actions

-Develop good practise guidelines for ocean energy stakeholder engagement. Common stakeholder engagement guidance is useful for project developers, funders and for local communities. Project developers should be able to access a comprehensive checklist to follow during ocean energy project development.

-Demonstrating that a project developer is following established guidance, will help project funders and local communities to gain confidence in the process, guaranteeing that all relevant stakeholders are involved and that stakeholder engagement steps are followed. A facility for communities and for agencies developing support schemes to be introduced to one another and discuss projects and support mechanisms might also assist.

Stakeholders

The European Commission should take the lead in coordinating this process, with input from project developers, local authorities and consenting authorities.

Challenge 2 – Lack of definition of local content, benefits and community ownership

Because of the immaturity of the ocean energy industry compared with other renewable generation technologies, there is a lack of understanding over what positive (or negative) impacts ocean energy development could have on the local economy. Without this knowledge, public opinion is at risk of being influenced by misinterpreted facts and rumours.

Actions

-Regional governments and national or locally based economic developing agencies or cluster organisations should lead research into the benefits of ocean energy to the local economy. The European Commission could facilitate this process through Horizon2020 non-technological research projects or through Interreg.

-Due to the relative youth of the ocean energy industry, there is little precise data on the impact ocean energy development can have on regional economic growth. Research on this topic will increase the understanding of how increased deployment of ocean energy projects and the growth of the industry affects local economies. Demonstrated positive economic impacts will also increase local communities' acceptance of new ocean energy projects. Specialised media, ocean energy industry associations or/and ETIP Ocean could help disseminating results of such studies. An online repository of the studies should be available to industry and interested communities. ETIP Ocean could continue using this platform as a "knowledge hub".

-Ultimately, local communities and stakeholders will gain a thorough understanding of the benefits of ocean energy through the deployment of projects in their area. Consequently ocean energy demonstration projects should receive public support, ensuring that "real-life" impacts and benefits on local communities can be assessed and measured, paving the way for a harmonious integration of future commercial projects.

-Increased knowledge and engagement from local community (through consultations and co-ownership) would reduce the risk of misinterpretation of projects. This ultimately will lead to a reduction in costs. Improved dissemination of the results of such engagement would be beneficial.

-An additional recommended action focuses on the study of ocean energy community ownership. Increased participation of local communities through community ownership programmes would achieve a number of positive results – companies will reduce possible risks and costly delays, projects will attract additional source of financing. As financial partners, local communities will have more influence over the execution of the projects and a sense of ownership. The EU or national authorities can take a lead on coordinating such research. An appropriate starting point would be EU sponsored WISE Power project (http://wisepower-project.eu/) on community ownership in the wind energy sector.

Stakeholders
Studies on the benefits of ocean energy to local communities, and of community ownership will be coordinated by the EU, and carried out by national development agencies. Specialised media, industry associations, project developers and ETIP Ocean are responsible for the better dissemination of information, including from deployed demonstration projects.

Challenge 3 – A need for decentralised, regionally specific activity focused on aiding development

There are many regional growth support programmes. Unfortunately, in many of them ocean energy technologies are not specifically considered; nor are the potential benefits to local supply chains and the local economy well understood. The lack of alignment between different programmes and subsequent duplication is another problem that could be solved through better coordination. This lack of alignment can occur because different support programmes are developed in isolation.

Actions
-Access to support programmes for local and regional groups looking to implement create or amend support schemes to a forum on the web site might foster better alignment and engagement.
-Many EU regions have targeted support programmes for growth. It is important for national/regional governments and development agencies to align these programmes, to avoid duplication and improve synergies. Regional development programmes should consider what role ocean energy development can play in the future energy mix, and how it will affect local industry and supply chains.

Stakeholders
The EU and national authorities are in the best position to organise and coordinate such actions. These actions could be part of a broader project as discussed under point 2 above. Some form of centrally located register of such schemes sponsored by EU grant and operated by ETIP and/or Ocean Energy Europe might assist.

Challenge 4 - A lack of understanding of the value that ocean energy adds to other activities and infrastructure

While ocean energy stands to bring benefit to the wider economic context, there is minimal understanding of the extent of this benefit, and exactly how it will be brought about.

Actions
Studies on the added value of ocean energy installations on existing or planned infrastructure can provide a better understanding of the wider economic impact/costs of ocean energy development. A study about the "integration" of ocean energy with other activities/infrastructure would add value to existing activities (tidal bridges, etc.) For instance, tidal turbines can be integrated into bridges with a minimal extra financial cost. Similarly, near-shore wave power

devices can be integrated into seashore defences or port breakwaters. An analysis of how ocean energy development can bring added value to other planned infrastructure developments could pave the way smarter infrastructure development in the future.

Stakeholders

The industry could take the lead in carrying out such an analysis, supported by an appropriate funding. This would entail actively consulting of ocean energy developers, concerned marine construction industries and other appropriate stakeholders. The analysis should determine and quantify the benefits of combined development of infrastructure and ocean energy.

Summary table

Table 9 below summarises the results of the workshops on socio-economic impact and acceptance.

Table 9 - summary of workshop results on socio-economic impact and acceptance

Challenge to ocean energy deployment	Actions	Responsible stakeholder
Finding and identifying stakeholders	-Develop good practise guidelines	Project developers, local authorities and consenting authorities. Facilitated/coordinated by European Commission
Lack of definition of local content, benefits and community ownership	- Study the benefits of ocean energy to local economy -Study ocean energy community ownership -Encourage better dissemination of information, including from deployed demonstration projects.	Industry associations. Project developers ETIP Ocean
A need for decentralised, regionally specific activity focused on aiding development	-Review regional programmes for growth - Create centrally located register of regional support programmes	European Commission National Development Agencies, ETIP Ocean Industry associations.
A lack of understanding of the value that ocean energy adds to other activities and infrastructure	Study the "integration" of ocean energy with other existing/planned activities	Industry Marine construction industry

Environment and Socioeconomics - Knowledge sharing and collaboration

The "knowledge sharing and collaboration" webinar was held on the 29th June 2018. Knowledge sharing and collaboration helps avoid duplication and drives innovation in a more efficient manner, compared to working in silos. For ocean energy, this is true for collaboration within the sector itself, but also for collaboration with other industries, particularly those working offshore. These processes can however be challenging to stimulate. At the webinar speakers representing a technology developer (Petter Sund - AW Energy), a marine test site (Mathew Finn - EMEC) and free-to-use marine monitoring service (Laurence Crosnier - Mercator Ocean / Copernicus) presented their views on the advantages and challenges of knowledge sharing, and how it can best be facilitated.

Learnings and questions from the webinar

Workshop participants were presented with the main learnings and recommendations of the webinar:

- 80-90% of challenges in industry are common. Intellectual property (IP) rights are important, but we should not "hang-on" to the areas that could be done collaboratively.
- Patents are important, but new ideas to tackle common problems can be stimulated by sharing practical experiences.
- Governmental, both European and regional, support for demonstration projects is crucial for the further development of ocean energy. The EU and Member States should support sharing of information between the private sector/companies and all H2020 projects and Copernicus programs.

Workshop results

Challenge 1 – <u>Risk of lack of sharing environmental monitoring results</u>

There is a risk that knowledge obtained from environmental monitoring is not shared, resulting in the need for repeating projects and time delays, thus in increased costs.

Actions

-Through the implementation of governmental monitoring programmes and the requirement of making the results publicly available, both research on the environmental impact and industry-wide development is supported by making the results available to all. To ensure the results of the monitoring programmes are independent, peer reviews of the gathered data should be set up.

-Advisory group consultations can provide real-world insights, to ensure the relevant information is gathered and properly analysed.

-Collecting the work done in monitoring and environmental impact research, will increase awareness of the latest research and facilitate knowledge sharing, ETIP Ocean 2 will play a role in this. There will be close collaboration with the International Energy Agency (IEA) Ocean Energy Systems (OES).

Stakeholders

National and regional environment and consenting/licencing authorities should support the monitoring programmes, ensuring the correct data is collected and made available. Technology and project developers should take part in these monitoring programmes. Advisory groups, consisting of environmental consultants, research institutions and NGOs, can assist in setting up the programmes and with the analysis of the results. Projects such as ETIP Ocean 2 and RiCORE can engage with IEA Task 4 to collect and summarise research and new findings on environmental monitoring and disseminate as widely as possible.

Summary table

Table below summarises the results of the workshop on knowledge sharing and collaboration.

Table 10 - summary of workshop results on knowledge sharing and collaboration

Challenge to ocean energy deployment	Actions	Responsible stakeholders
Lack of sharing environmental monitoring results	-Monitoring programmes -Publication of monitoring results -Peer review for independent results -Consultation with advisory groups - Use ETIP Ocean 2 to publicise and disseminate accessible summaries of the latest findings on ocean energy's environmental impact	Environmental consultants Regulatory experts Research institutions NGOs Technology Developers Project developers National and regional environmental & consenting/licencing agencies European projects such as ETIP Ocean

5. Workshop Results – Technology Topics

Workshop results sections for the Technology topics are shown over the following pages. These give a general description of the topic and the webinar which took place regarding the topic, present the initial results from the webinar and the further workshop round table discussion results. The workshop results are also summarised in a table for each topic.

Technology - Metrics and stage-gate development programmes

The "Metrics and stage gate development programmes" webinar was held on the 6th of April 2017. Stage-gate procedures and the metrics that underpin them have proven their worth in a range of emerging technology sectors in recent years. Developing new technologies is inherently risky, with many failing to reach commercial viability.

Learnings and questions from the webinar

- Developers may choose to size devices according to the available funding, rather than what is best for the target environment/point in development.
- The Wave Energy Scotland (WES) programme is designed to assess technologies at both sub-system and whole-system (device) levels. The WES 'Novel Device' call is a good example of a whole-systems approach. Sub-systems are not assessed in isolation, but as part of a whole system.
- Stage-gate programmes are typically designed to consider what a full-scale device can achieve, even if a technology is initially only demonstrated at smaller scale. When moving through stage-gates it is important to consider aspirations for future development and deployment at greater scale. It is a challenge to develop a system of metrics and stage-gates that gives due consideration to the wide variety of environments and markets available to ocean energy technologies. There must be no built-in bias towards a particular form of technology.
- The designers of the WES programme recognise that the wave sector will likely see several successful technologies, rather than a single dominant technology. Details of all WES metrics currently defined can be found in WES competition guidance documents on the WES website.
- A WES knowledge-sharing platform is currently being developed to improve public availability of WES materials.
- Metrics and stage-gate programmes are not novel in the field of engineering. Although almost all engineering sectors employ similar techniques, the aerospace sector gives a good example. Aerospace technology development involves a process of moving from preliminary design reviews to, eventually, final design reviews. Each review stage involves a well-defined set of performance measures that must be met to progress.
- Metrics and stage-gate development programmes provide the next level of detail beyond the technology readiness level (TRL) system. The TRL system shows where a technology is in the development process while metrics and

stage-gates assess whether it is worth pursuing progression to the next TRL level.

Workshop results

Challenge 1 - Metrics need to be comprehensive and objective

From a technological perspective, metrics must fit the technology in several ways. As technologies cover a spectrum of TRL, characteristics and strengths, so must the metrics. Metrics should be developed to serve an internationally recognised set of topic areas such that they assess the right technology characteristics for all diverse wave and tidal energy devices and technology types. Similarly, metrics must reward the right strengths of a technology to avoid inappropriately steering its development. Metrics need to cover the entire system development pathway, across all TRLs. Therefore, they require the appropriate level of detail to incorporate all relevant TRLs. Metrics should be impartial, with subjectivity removed where appropriate. Some degree of subjectivity is always likely to remain, however, in more qualitative topic areas, and where flexibility is required to assess true novelty. Furthermore, an appreciation of the uncertainty of input data should be incorporated in the hierarchy of individual and combined metrics. Finally, the metrics must be monitored and refined at regular stages as time goes on.

Actions

-Develop a set of metrics and corresponding validation for ocean energy technology development. Development should incorporate learning and insight from various sources.

-To build sector trust and acceptance, a stakeholder consultation on the selection of metrics should be facilitated. Learning from previous due diligence activity in ocean energy and from other sectors should be included.

-Finally, uncertainty methods should be included, to better understand the range and probability of metric results.

Stakeholders

Stakeholders relevant to the enactment of these actions include: international bodies, such as IEA and IEC; international organisations, such as ETIP, OEE and EERA; technology/project developers, and private/public funders. International bodies such as the IEA and IEC can potentially become active driving forces behind international coordination and adoption of metrics.

Challenge 2 - There is a lack of tools and processes to support evaluation of metrics

With metrics being at such an early stage of development, they must be developed concurrently with the appropriate tools and processes required.

Actions

-Develop tools and processes to facilitate metric evaluations for sub-system, devices and arrays.

-Carry out validation activity to give confidence and confirm the appropriateness of the metrics to all ocean energy technology types and TRLs.

Stakeholders
Relevant stakeholders in this instance include: international organisations, such as OEE and EERA; technology/project developers; and private/public funders. International networks such as ETIP Ocean provide a sharing vehicle to support metric development and collaboration inside the European ocean energy industry.

Challenge 3 - Lack of investor confidence

Cross-sector approval of metrics is required to encourage investor confidence and allow cross-funder comparisons.

Actions

-Obtain cross-sector approval, appropriate standardisation and dissemination. Gain cross-sector approval and acceptance of the metrics including the method of integrating metrics into a prioritised hierarchy. Deliver appropriate standardisation and dissemination of the metrics to provide transparency of metric design and implementation, allowing investors to readily observe why and how technologies have been either successful or failed at that gate stage.
-Assess how standards bodies such as the IEA/IEC could drive standardisation of ocean energy metrics application.
-Showcase demonstration projects, which will provide the ocean energy sector with the opportunity to validate metrics through deployment and testing.

Stakeholders

Relevant stakeholders who might enact these changes include: international bodies, such as IEA and IEC; international organisations, such as OEE and EERA; technology/project developers; national funding authorities; and the European Commission. Also, technology developers, private/public funders, project developers and international coordination bodies should engage with metrics validation and acceptance.

Summary table

Table 9 below summarises the results of the workshop on Metrics and Stage-Gate Development Programmes.

Table 9 - summary of workshop results on Metrics and Stage-Gate Development Programmes

Challenge to ocean energy deployment	Actions	Responsible stakeholders
Metrics need to be comprehensive and objective	-Complete development of a set of metrics for ocean energy technology development, with validation. -Facilitate a stakeholder consultation on the selection of metrics. -Uncertainty methods should be included to	International bodies, such as IEA and IEC, International networks such as ETIP Ocean, Technology/Project Developers, Private/Public funders Member states standards agencies

	better understand the range and probability of metric results.	
Lack of tools and processes to support evaluation of metrics	-Develop tools and processes to facilitate metric evaluations for sub-system, devices and arrays. -Carry out validation activity to give confidence and confirm the appropriateness of the metrics	International organisations, such as OEE and EERA, Technology/Project Developers, Private/Public funders Member states standards agencies
Lack of investor confidence	-Gain cross-sector approval and acceptance of metrics. -Deliver appropriate standardisation and dissemination of the metrics. -Showcase demonstration projects	International bodies, such as IEA and IEC, International organisations, such as OEE and EERA, Technology/Project Developers National funding authorities and European Commission. Member states standards agencies

Technology - Control and Systems for improved yield, reliability and survivability

Control systems for wave and tidal energy converters act to optimise power production and reduce stress and fatigue on components, by allowing devices to adapt to changing ocean conditions. The webinar provided a brief introduction to the theory of control systems, including a look at their use in other sectors, before investigating how such systems can be applied to the ocean energy sector. The webinar was held on the 27th of June 2017. The speakers for this webinar were Ross Henderson from Quoceant and Jochen Bard from Fraunhofer IWES.

Learnings and questions from the webinar

Workshop participants were presented with the main learnings and recommendations of the webinar:

- Regarding the recent WES control systems landscaping study: what were the key report findings and lessons learned, and how do they apply to real world actions? The WES strategy is to take a whole system, modular approach to technology development by drawing in outside sector learnings with aim of filling technology 'gaps' between the 'State of the Art', and what is actually required. A common understanding is of key importance, with parallel and coordinated working groups focused on understanding the engineering drivers and resolving successfully a working, fully compatible final product. Communication is key. A landscaping study can provide a common technical foundation to avoid repetition, and give common starting point and proper model controls representation to find real world solutions.
- With respect to Hardware in Loop (HiL) testing – how are other systems like generators and pitch system controllers integrated? It is advised to use the real generator/pitch drive hardware and to connect them to controllers, with load machines to introduce real world parameters to excite realistic responses from subsystems. The use of filters are pre-determined in the systems design to limit degrees of freedom, and control interactions. Defining the real-world parameters (like absolute speed for example) that exceed system limits are an important prerequisite to HiL testing.
- With regards to dense device arrays: what is the value of defined control systems value, particularly with regards to cost of energy and reliability? From a wave perspective, since it is already considered important on an individual basis, it is even more important for an array. Arrays allow downside mitigation by taking advantage of far-field interactions in wave energy. Power absorption as an array's sum is greater than the sum if individual devices because phasing. With multiple devices, individual radiation patterns and power adsorption can be phased and focused to maximising energy extraction. This is a good example of useful insight from theoretical work done academically. From a tidal perspective: in a similar way to wind farm energy yields – having devices standing behind each other allows de-rating and a gain in array power. You must also ensure device wakes are considered, so downstream turbines are not operating in wake areas and subject to increased applied structural loads.

- Looking at other wave and tidal energy challenges – relative to other key challenge areas, what is the overall value of continued R&D into control systems? The biggest difference between wave and tidal is that tidal has converged on power stream conversion using single torque/speed control. Wave energy convertors (WECs) are still diverse, so the challenge is far more integrated to R&D compared to other sectors. Controls are considered as very important aspects for wave. Even if tidal does have commercial convergence however, control is still important since it allows system optimisation and cost reductions. So in the commercial world – controls are considered to have the largest impact on reducing the Levelised Cost of Energy (LCOE) for tidal today. Controls have traditionally been underestimated, since they are considered a marginal expense in relation to early stage CAPEX expenditures. Controls however can have a large impact for relatively little investment through continued R&D integration.

Workshop results

Challenge 1 – Common control systems guidelines

Common control systems specifications with realistic drivetrain examples need to be established to allow technical comparisons between different system control system approaches.

Actions
Advocate and construct blueprints for control system design best practices, like the detail level found in the European Ocean energy Centre (EMEC) ocean energy guidelines. These blueprints should not be too specific otherwise they will not be applicable, given the wide range of controls designs currently being developed.

Stakeholders
Creating a common set of control systems guidelines could originate as a product from the WES controls development landscaping and stage one project selection. Similarly, this could originate from industry, although commercial incentives and competitive market positions may limit the flow of technical input to a private sector developed guideline. Key stakeholders would be industry, research organisations and technology developers.

Challenge 2 – Lack of post-release maintenance of testing control simulation tools

There exists a diverse range of testing control simulation platforms and tools. There is a lack of post-release maintenance and upgrading of these open-source tools.

Actions
Further development of a limited number of advanced tools, such as WECSIM software and build similar software for tidal development. Funding needs to be made available to administer the maintenance and upgrading of developed tools.

Stakeholders
Research organizations maybe best placed to develop WECSIM software and to develop a similar tool for tidal energy arrays. Funding providers such as the European Commission are also a key stakeholder.

Challenge 3 - Lack of development of HIL testing equipment and procedures

Hardware in the Loop (HIL) 'real world dynamic/sensors/drivetrain' testing equipment and procedures are critical and over looked aspects of control system development. Such equipment and procedures are vital for calibrating, testing, validating and comparing solutions. In addition, control models are not properly tested, validated and optimised at each scale.

Actions
Develop HIL systems for industry use. HIL testing procedures could be fed into a common database for testing guidelines to be generated and applied.
Feedback loops and continual improvement of these guidelines would aid all developers in designing and testing controls systems to a common standard.
Including guidance on device upscaling effects needs to be considered.

Stakeholders
'Hardware in the Loop' rigs could be made available through programmes like MARINET. Other key stakeholders include Member States funding authorities and the European Commission.

Challenge 4 - Lack of transfer of lessons learned

There needs to be a clear transfer of lessons learned from the implementation of control solutions between groups working within the ocean energy sector and from other sectors.
Historically, groups will default to what they know to tackle problems. There is a need to combine the development efforts on different device components to tackle problems. The overlap of academic and private industry work on controls system research needs to be better coordinated, with feedback from both sides on their needs and progress. R&D academic researchers and private industry developers have overlapping controls requirements, which needs to be better, coordinated, with feedback from both sides on their needs and progress.

Actions
-Continued funding/project management of knowledge sharing webinars and open access workshop discussions. Although competitive secrecy will always exist, a knowledge exchange mechanism remains key to creating a more overt sharing environment.
-Technical specific control conferences/exhibitions between relevant R&D organizations and control system developers would enhance knowledge sharing and feedback loops.

Stakeholders

Key stakeholders include EU projects, such as ETIP Ocean for knowledge sharing webinars and workshops. Also R&D organisations, Project Developers and Technology Developers to share knowledge and key lessons learned.

Challenge 5 - Critical aspects are overlooked in control system development

Control systems often focus on optimizing power production instead of the other requirements of a control system, such as survivability, reliability, robustness, condition monitoring, etc. Optimisation does not include relevant cost functions. Further to this, control solutions are often not integrated into overall systems at an early stage as part of the design process.

Actions

More emphasis is required on investigating alternative benefits of control systems, such as survivability, reliability, improvements to cost of energy. Developers and funding bodies need to ensure that there is early integration of control systems into subsystems that might be otherwise developed in isolation. For example, if a project is developing a PTO for a larger system, the influence of the controller on the PTO and larger system should be considered from the outset.

Stakeholders

Industry association, Project funders such as the European Commission and Member States, technology developers, project developers and research organisations are all key stakeholders.

Challenge 6 - Control system development can seem to be reserved for experts

The area of control system development needs to be presented in a more accessible way, there is a risk that the area may seem reserved for expert mathematicians when it needs to be accepted by the whole industry.

Actions

Understandable knowledge sharing activities are required which keep control knowledge sharing events understandable to wider audiences by thinning down complicated mathematics.

Stakeholders

Increased involvement of trade associations, research organisations and developers of joint projects and improved knowledge sharing avenues could provide a better link between the developer's real-sea control needs and the R&D organisation's research subjects and topics.

Summary table

Table 10 below summarises the results of the workshop on Control and Systems for improved yield, reliability and survivability

Table 10 - summary of workshop results on Control and Systems for improved yield, reliability and survivability

Challenge to ocean energy deployment	Actions	Responsible stakeholders
Common control systems guidelines	Advocate and construct blueprints for control system design best practices.	Industry Research organisations Technology developers
Lack of post-release maintenance of testing control simulation tools	-Further development of advanced control simulation tools -Build similar software to WECSIM for tidal development. -Funding needs to be made available to administer the maintenance and upgrading of developed tools.	Research organisations Funding Providers European Commission
Lack of development of HIL testing equipment and procedures	-Develop HIL systems for industry use. -Develop a common database for testing guidelines to be generated and applied. -Provide guidance on device upscaling effects	Developers EU projects, such as MARINET National and regional funding authorities with responsibility for innovation, energy transition, renewables European Commission
Lack of clear transfer of lessons learned and coordination between academic and private industry work	-Continued funding of knowledge sharing webinars and open access workshops -Technical specific control conferences/exhibitions between relevant R&D organizations and control system developers	EU projects, such as ETIP Ocean, Research institutes Project Developers Technology Developers
Critical aspects are overlooked in control system development	-More emphasis on investigating alternative benefits of control systems, such as survivability, reliability, improvements to cost of energy. -Ensure that there is early integration of control systems into subsystems that might be otherwise developed in isolation.	Trade associations European Commission National and regional funding authorities with responsibility for innovation, energy transition, renewables Technology developers

		Research Organisations
Control system development can seem to be reserved for experts	Keep control systems knowledge sharing events understandable to wider audiences	Trade associations Wider networks such as ETIP Ocean Technology Developers Research Organisations

Technology - Power Take Off- have we cracked it?

The "Power Take Off – Have we cracked it?" webinar was held on the 25th of October 2017 and coordinated as a panel session at OEE2017 Conference and Exhibition. It consisted of a deep dive into the technical aspects of PTOs, aimed at answering: What progress has been made in the last 5 years? Which different concepts are available and how do they compare? Do we need to invest together to further one or two universal PTO solutions? The speakers at this event were: Patrik Moller from CorPower Ocean, Luca Castellini from Umbra Cuscinetti, Richard Linley from Aquanet Power, Kieran O'Brien from Carnegie Clean Energy and Alexander Martha from Nemos.

Learnings and questions from the webinar

Workshop participants were presented with the main learnings and recommendations of the webinar:

- Technology standards and verification are important to develop new technologies. However, their application can stifle early stage innovation. Presenters at the workshop consider quality control important. This should be incorporated into management processes and project timing. The outcomes of standards applications are key to long term investor confidence.
- A range of high standards for ocean energy technology are already available. Moreover, standards used in the offshore wind industry already being used where pertinent.
- If used internationally by all technology developers, investor technology appreciation and cross-comparison would be facilitated. In Carnegie's experience, however, the application of new technologies to recognised standards does not guarantee that technology is totally compliant. Internal testing on technologies brought into the company from elsewhere should still be carried out.
- A common approach to device testing among developers would allow the development of common infrastructure and specialists facilities for PTO testing at different scales. However, it should be highlighted that different technical PTO designs make it difficult to compare devices without the development and approval of a common metric. Potentially linear PTO's type test rigs could be standardised to avoid developers spending a large amount of their budgets on bespoke test rigs. It was noted, however, that facilities and industry consensus are currently lacking for a common PTO testing approach.
- The Dutch Energy Institute recently conducted an industry workshop on standards and certifications in ocean energy. A common conclusion is that all countries would benefit from a standard system of main device certifications. To create this device, developers need to be more forthcoming with potentially sensitive testing data to construct and feed such a system.
- A delicate balance exists among technology developers to knowledge sharing and maintaining competitive technology advantages. Hence the release of Intellectual Property (IP) to guide the design of standards is problematic.

- There are opportunities to take technologies from other sectors. It is necessary to identify "translational" technologies, which is not necessarily straight-forward. Knowledge transfer from the offshore wind industry is being explored, particularly regarding use of standards and electrical infrastructure. Other examples include hydraulic motors and offshore tethers from the oil and gas industry.

Workshop results

Participants at the discussion table followed up on the results from the webinar. At the beginning, they identified the PTO development progression challenges – divided in technical, infrastructure, technology/market, and qualification and standards challenges. Then they highlighted necessary actions to overcome the challenges, and finally stakeholders to take the main driving responsibility.

Challenge 1 - Challenging technical requirements and diverse range of WEC driving inputs

The PTO development is a technical challenge with a wide-ranging list of topics to consider and tackle, including the following:

- Peak to Mean wave height conversion
- Diverse range of Wave Energy Convertors driving inputs
- The reciprocal process of WEC to PTO feedback loop
- Unrealistic expectations being applied to the R&D process, i.e. no failures
- Low velocity but high forces wave type resources.

These also result in high percentage of OPEX compared to CAPEX spend for PTOs

Actions

-Requirements for the PTO sub-system design should be capable of high performance AND reliability during testing and operations.
-During PTO development scaling, there is a need to be iterative in design steps with the acceptance that it may fail due to optimisation towards a lower cost and higher energy output.
-An iterative R&D process provides vital learning for the development of a commercial product.

Stakeholders

To ensure PTO design and testing meets investor requirements, knowledgeable and conscientious equipment buyers will seek to ensure relevant and appropriate PTO design, testing steps, and performance. The European Commission could coordinate national and regional authorities to set up a framework to ensure that sub systems such as PTO's conform to minimum design standards, perhaps in a similar way to the US DoE Wave Energy Prize for innovative WEC designs, or via the support and construction of performance and reliability standards.

Challenge 2 - Lack of common, recognised and open access dry testing facilities

Technology agnostic, onshore, PTO input simulator testing facilities need to be recognised and available.

Actions
-Build open access, dry test facilities that are open to all Developers with PTO programmes. These should be designed to test performance levels, lifetime fatigue and efficiencies.
-FORESEA or MARINET2 projects allowing facility access across the EU could form a vehicle for common access permissions.

Stakeholders
The development of an EU-based test/lab facility by the European Commission, with similar FORESEA/MARINET2 open access agreements could be a solution. Development of cross-sector facilities and providers, e.g. oil and gas sector maybe willing through diversification to offer on a fee-paying basis PTO, and other testing facilities. Key stakeholders would include technology developers, research institutions and cross-sector facilities and providers.

Challenge 3 - Lack of technology transfer and engaged supply chain

There is a lack of technology transfer from established offshore industries into ocean energy. In addition, an undefined or not properly established supply chain with few "industries" and many SME or spin-off/start-ups.

Actions
-Increase technology transfer and engage supply chain. Wave Energy Scotland's example of Pre-Commercial Procurement funding of innovate PTO's using public funding is an efficient way to support high potential technology developments at the early and mid-stages of development.
-Diversification Outreach to other industry sectors to support development pathways, and create a competitive market for PTO design and testing.
-Policy change to introduce tax relief for R&D PTO or other sub system developments.
-At the R&D level, Utility Scale opportunities could be better forecast/defined and incorporated into commercialization pathways and roadmaps strategies to better inform early stage funders on potential outlooks and investor attractiveness.

Stakeholders
Key stakeholders would be at all levels of funding and support, from the EU level through focused diversification projects such as project NeSSIE, to national and regional diversification projects such as those supported by the ORE Catapult, Scottish Enterprise and Highlands & Islands Enterprise. Public funding calls, specifically, could include or be targeted at cross sector technology transfers. In addition, COSME and SME support through cluster to cluster collaboration should be made available.

Challenge 4 - Lack of recognised sub component validation and certification systems

The lack of recognized PTO (and other sub component) validation and certification systems to attract investors and create a common target for developers. In

addition, there is a poor utilization of certification processes by some Member States during R&D funding.

Actions
Create and support a system of appropriate target level metric criteria for PTO technologies to achieve, at various TRL development levels. Make these metric criteria a condition for future development funding calls. Agree upon a common terminology for testing and certification of different system components, perhaps using IEC defined efficiencies as an example.

Stakeholders
Funding and support for certification systems can come from any potential funders, public or private, EU or regional, intra or inter renewables or even from established cross sector standards bodies such as DNV-GL, Bureau Veritas, NORSOK, ISO or ICE.

Summary table

Table 11 below summarises the results of the workshop on Power Take Off

Table 11 - summary of workshop results on Power Take Off

Challenge to ocean energy deployment	Actions	Responsible stakeholders
Challenging technical requirements and diverse range of WEC driving inputs	-Suitable requirements for the PTO sub system design to be capable of high performance AND reliability during testing and operations. -Implement an iterative design process for PTO development scaling.	European Commission National and regional authorities responsible for innovation and energy transition Equipment buyers Technology Developers
Lack of common, recognised and open access dry testing facilities	-Build open access, dry test facilities open to all Developers with PTO programmes. -FORESEA or MARINET2 projects allowing facility access (funding) across the EU could form a vehicle for common access permissions.	European Commission European projects such as FORESEA and MARINET Cross sector facilities and providers Technology Developers Research Institutions
Lack of technology transfer and engaged supply chain	-Diversification Outreach -Policy change to introduce tax relief for R&D PTO or other sub system developments. -Forecasting and incorporate utility scale opportunities into commercialization pathways.	Cross sector industry European Commission National and regional authorities responsible for innovation and energy transition National and regional diversification projects Regional technology clusters

Lack of recognised sub component validation and certification systems	Create and support a system of appropriate target level metric criteria at various TRL development levels. -Agree upon a common terminology for testing and certification of different system components, perhaps using IEC defined efficiencies as an example.	Public/Private funders Cross sector standards bodies, such as DNV-GL, Bureau Veritas, NORSOK, ISO or ICE International organisations, such as OEE and EERA, Technology/Project Developers, Private/Public funders

Technology – Developing and implementing optimisation tools

The 'developing and implementing optimisation tools' webinar was held on the 29th January 2018. Optimisation tools can streamline ocean renewable energy project planning, with features ranging from optimal array designs to financial analyses. Projects using optimisation tools are more likely to be successful. They also gain a method for assessing and comparing performance which can be useful for future decisions and in stage-gate programmes.

This webinar discusses different optimisation tools and their role within ocean renewable energy projects. Speakers at the optimisation tool webinar were Dr. Ray Alcorn of Exceedece and Dr. Encarni Medina-Lopez of the University of Edinburgh.

Learnings and questions from the webinar

- Optimisation tools can have an important impact on the development of wave and tidal energy projects by proving reliability and availability, providing investor confidence, and LCOE reduction by for example the optimisation of the location (increasing power performance), cost per unit (device geometry) and reducing OPEX. The optimisation tools provide the possibility to make informed and robust decisions within the project. This will lead to cost reductions; this is of great importance to the sector.
- Developing and gathering a reliable and complete database with real (resource) data, for example an open source repository, can help with the optimisation results and validation.
- Standards are used where possible to validate the tools.
- Sensitivity analysis on a case-by-case basis can indicate what aspects in ocean energy projects will have the biggest impact on the project, from adjustment of location to structural integrity.

Workshop results

Challenge 1 – Use of optimisation tools for device/sub-system testing methodologies needs to be developed

A challenge to ocean energy deployment and commercialization has been identified as the development of sub-system testing methodologies. Optimisation tools representing the physical properties of ocean energy devices can be used in tandem with testing methodologies during the design process to understand the potential long term impacts (for example of the behavior of loads on such devices)

Actions

Actions for the development of fatigue testing methodologies include the use of optimization tools for the early scaling of devices and modelling of fatigue loads. It was suggested that the European Commission was in a good position to fund calls to develop optimization tools, with research and industry partners responsible

for their delivery. As such, cross-industry projects provide a wide range of experience and provides the opportunity for data and methodology sharing, resulting in risk mitigation due to more extensive knowledge sharing.

Stakeholders
Key stakeholders include the European Commission, Research Partners, Industry Partners, Supply chain, and testing centres.

Challenge 2 - Lack of comprehensive design process

A challenge to ocean energy deployment and commercialization has been identified as the lack of a comprehensive design process for large scale development. Optimisation tools play a key role in this design process in terms of early stage design calculations, scaling calculations, and site specific considerations such as array layout and infrastructure requirements.

Actions
Actions for the development of a comprehensive design process for large scale ocean energy devices and arrays include the use of optimization calculations and modelling tools in the early stage design process, ensuring that this process designs with specific site considerations in mind. Another action would be the early involvement of manufacturers in the design process so that the correct data can be input to these optimization calculations. Key responsible stakeholders include both manufacturers and developers as well as research organisations.

Stakeholders
Key stakeholders include Manufacturers, Technology/Project developers, Research organisations.

Challenge 3 - Research Limitations

Several challenges to ocean energy deployment and commercialization have been identified in terms of research limitations. These include gathering and distributing data and the limitations of prediction tools when modelling ocean energy systems.

Actions
Actions for the research limitations identified include better access to data measurements required as inputs to optimization tools and public sharing of testing and resource data. As well as being a key input to optimization tools, performance and testing data is useful for validation and verification of modelling methods, and so access to such data is very important. It was suggested that data sharing should be managed national authorities responsible for innovation actions, and that the European Commission, research organisations and testing centres all had useful roles to play.

Stakeholders
Key stakeholders include the European Commission, national authorities with responsibility for innovation actions, research institutions and testing centres.

Summary table

Table 12 below summarises the results of the workshop on Developing and Implementing Optimisation Tools.

Table 12 - summary of workshop results on Developing and Implementing Optimisation Tools

Challenge to ocean energy deployment	Actions	Responsible stakeholders
Use of optimisation tools within device/sub-system testing methodologies needs to be developed	-Develop cross-industry projects -Create a database information of localised testing -Develop standardised methodologies for Optimisation/Early scaling tools -Sharing risk and data	European Commission Technology Developers Research Organisations Supply chain Testing centres
Lack of comprehensive design process	-Include appropriate optimisation calculations in early stage design process, ensure this process designs with site in mind -Early involvement of manufacturers in design process	Manufacturers Technology Developers Project Developers Research organisations
Research limitations (gathering and distributing data, limitations associated with optimisation tools)	-Data library – better access to data measurements required -Data sharing management at a member state level -Funding for cross-industry projects on data sharing and data management	European Commission, DG RTD National authorities responsible for innovation actions Research Organisations Testing Centres

Technology – Investigating novel devices before moving towards convergence of design

The 'Investigating novel devices before moving towards convergence of design' webinar was held on the 23rd March 2018. The argument around the optimal concept for wave energy has yet to be settled and further research is needed to reach a consensus. This webinar explored the goals of funding organisations such as Wave Energy Scotland, and how these goals correspond with the needs of developers working on novel wave energy devices, such as PolyWEC. At the novel devices webinar, Matthew Holland of Wave Energy Scotland and Marco Fontana of the University of Trento gave presentations on WES and PolyWEC respectively

Learnings and questions from the webinar

- Convergence in the wave energy sector could take several forms. Different markets, locations and sites will have specific needs and it is likely that a single device type will not meet them all.
- Research into new novel WEC concepts is still ongoing and still very important for the sector. Technology push funding programmes such as WES are vital for their development, and for obtaining a greater understanding of their attractiveness and risks.
- Applying technologies and learnings which are more conventional in other sectors could lead to new concepts for wave energy converters which are only possible by this transfer of knowledge.
- A key issue in terms of researching novel WEC devices is bringing results from the laboratory to industry. The research at many European universities is isolated from larger projects, and this hinders the development of their research and the confidence in their conclusions in terms of progressing performance and technical readiness.
- Through programmes such as WES, funding for wave energy projects is becoming more structured and focused than in the past. This focus should be to deliver projects that really work. This is being enabled by WES who structure their programmes to deliver quantifiable outputs through thoroughly planned, sustainable, testing programmes that address the project's key development objectives and technical risks.

Workshop results

Challenge 1 - Device convergence is hindered by a lack of knowledge sharing and IP restrictions

Knowledge and experience of (previous) device developers is not always captured and used to the advantage of the sector, leading to 'reinvention of the wheel'. The difficulty of sharing information and IP raises the question of 'what is worth protecting'. What is the balance between protecting technologies and sharing

experience? How can sharing experience be encouraged? Innovative funding programmes such as the WES programme are a good way to collaborate and move the sector forward – in the provision of an overarching knowledge centre - however this does not solve the 'IP problem'. While there are many European funded projects, not all information is publicly available.

Actions
-All information deriving from European-funded projects should be made available, gathered in a database, and catalogued. In addition, guidelines on storing the data should be written to ensure uniform input, support potential analysis, and improve data security. The United States Department of Energy currently logs all measurements in a database: a positive example of this action in practice.
-A distinction should be made between data and information. Gathered data must be translated into understandable information before distribution.
-Publicly-funded benchmarking programs should be set up to encourage knowledge-sharing in a safe environment.

Stakeholders
Relevant stakeholders who might enact these changes include: the overall industry; technology/project developers; the European Commission; and the EC's Member States.

Challenge 2 - Lack of manufacturer engagement in development, particularly in the supply of small-scale device components

The economic risk involved in manufacturing components for small-scale, novel devices discourages prototype manufacturers. In developing early-TRL, possibly niche components that may not achieve economies of scale, manufacturers lack the incentive to produce such parts/devices.

Actions
-Encourage cross-industry projects. Mitigate the risk posed to manufacturers by procuring a more widely-applicable technology. Further maximise cross-sectoral knowledge sharing by facilitating events aimed at presenting and acquiring lessons learned.
-Establish market commitment to the development of novel devices. Include the manufacturer in the dialogue around long-term intentions.
-Engage the existing supply chain in sourcing and designing components.

Stakeholders
Stakeholders relevant to these actions include: technology/project developers; manufacturers; funding bodies (e.g. European Commission); supply chain; industry associations.

Challenge 3 - Research is limited by a lack of data

There are gaps in research data for a variety of reasons. The need for tank testing was indicated as a reason for the gaps in the gathering and distribution of data. Gaps in resources data indicate the need for investment into real-world data capture (such as via databuoys). Prediction tools also have limitations in this arena.

Actions
Invest in and implement databuoys – in other words, in-water device data capture - for data collection. Member States should make data measurements publicly available. Look to examples from the UK and Dutch government for wind energy tenders, where data on specific sites is gathered and made available by the government. This eliminates the need for expensive testing by the ocean energy developers and encourages the release of data to the public. One possible channel of information to the public could be via data libraries.

Stakeholders
Stakeholders relevant to these actions include: the European Commission; Member States; research providers; and testing centres

Challenge 4 –*Device and* Sub-system testing methodologies need to be developed

Device and sub-system testing methodologies need to be developed for both wave and tidal technologies. For example – for tidal technologies there is a need for a full-scale blade testing environment; there is currently no tangible fatigue testing facility for tidal technology, specifically. Similarly, for wave there is a requirement for Power Take Off testing methodologies. There is only limited guidance in place for testing devices in general.

Actions
-Design test set-ups and testing guidelines, including design-loading tests. If testing follows guidelines, the results can be compared and used throughout the sector.
-A database of information pertaining to localised testing can allow results – and the risk associated in their acquisition - to be shared beyond sector boundaries (for example, with regard to optimisation and early scaling tools, or site-agnostic foundations and moorings). Cross-industry involvement in the development of these guidelines is therefore imperative.

Stakeholders
Stakeholders relevant to these actions include: EC's funding elements; academic partners; industry partners; supply and design chain; testing centres.

Challenge 5 - Lack of full-scale pilots and testing in relevant environment

To reduce cost and move towards commercialisation, there is a need to scale up, however a strategy to do this is yet to be defined. Getting devices into the water is essential to gathering information, de-risking and proving the reliability of a

technology. There are, however, several challenges associated with real environment testing: site-specific considerations hold back scaling; non-standard foundations (like offshore wind); and site-specific turbulence (e.g. Metocean).

Actions
-Develop a scaling-up strategy. Take manufacturing and location into account at an early design stage, along with the role of early stage optimisation calculations. Insight into the relevant environment must be sought and gained.
-It is essential to design with the site/location in mind, specifically for wave energy where larger devices do not necessarily result in higher energy output.
-Develop a strategy for getting projects with TRL > 6 into the water, including how to acquire the large quantity of investment required. This will support the funding gap, additionally, as it can reduce uncertainty.
-Seek political stability and clear signs to market.

Stakeholders

Stakeholders relevant to these actions include: Funding bodies such as the European Commission; National and regional authorities with responsibility for innovation, energy transition; technology and project developers; and manufacturers.

Challenge 6 - Limitations of standards and verification

With the progression of the ocean energy sector, common standards and certification are important to ensure quality and to reduce risk and costs. A lack of adequate standards and verification means technology is more expensive to develop, with reduced performance and reliability. Their presence would lead to a reduction in risk, and an increase in confidence, market access, financing availability and insurability.

*Action*s
Facilitate communication and engagement across industries. Within this, build projects that span the sector and industry.

Stakeholders
Relevant stakeholders include: EC funded project developers; research providers; technology developers; and manufacturers

Summary table

Table 13 below summarises the results of the workshop on investigating novel devices before moving towards convergence of design.

Table 13 - summary of workshop results on investigating novel devices before moving towards convergence of design

Challenge to ocean energy deployment	Actions	Responsible stakeholders
Device convergence is hindered by a lack of knowledge sharing and IP restrictions	-Set up benchmarking programs/innovation -Write and publish guidance for data/information storage, dissemination and protection -Look to successful examples of data mining and sharing (e.g. US DoE)	Technology Developers Project Developers European Commission National and regional authorities with responsibility for innovation, energy transition
Lack of manufacturer engagement in development, particularly in the supply of small-scale device components	-Develop cross-industry projects -Cross-sector knowledge sharing events -Cultivate market commitment -Engage the existing supply chain in component procurement	Technology Developers Project Developers Manufacturers Funding bodies European Commission Supply chain Industry associations.
Research is limited by revenue constraints	-Channel investment into real-world data capture -Prioritise data collection from in-water devices -Build and host a public data library	European Commission National and regional authorities with responsibility for innovation, energy transition Research organisations Testing Centres
Device/Sub-system testing methodologies need to be developed	-Encourage cross-industry projects and knowledge sharing -Create and make public a database of information on localised testing -Develop site agnostic foundations/moorings -Create a safe environment in which to share risk and data	European Commission Research Organisations Industry partners Supply chain Testing centres
Lack of full-scale pilots and testing in relevant environment	-Develop a scaling-up strategy -Design with the site in mind -Involve manufacturers early in design process -Ensure funding and route to market for higher TRL technologies	European Commission National and regional authorities with responsibility for innovation, energy transition Manufacturers Project Developers Technology Developers Research Organisations
Limitations of standards and verification	-Communication and engagement across industries	EC funded projects Research Organisations Technology Developers

	-Encourage cross-sector/industry projects	Project Developers Manufacturers

Technology - Alternative materials and manufacturing processes

The 'Alternative materials and manufacturing processes' webinar was held on the 8th June 2018. Alternatives to traditional structural materials such as steel could perform better in offshore environments, and offer cost and survivability improvements. This webinar discussed the development and use of alternative materials in the ocean energy sector, including composites and concrete. Manufacturing processes, and their optimisation, will also come under focus as a crucial part of the commercialisation process. Presentations were given by Ricardo Neta of Composite Solutions, Aneel Gill from Balmoral Offshore Engineering and Jacob Ahlqvist of ARUP.

Learnings and questions from the webinar

Composites:

- Composites are proven materials within a marine environment, but rarely used in high load and fatigue environments
- Composite Solutions and Balmoral Offshore Engineering have both developed composite solutions for CPO devices using appropriate analysis techniques and design experience

Concrete:

- Reinforced concrete is a well understood technology in the offshore environment, with a range of applications in oil and gas and offshore renewables. It has the potential to offer a low-cost solution taking advantage of a mature supply chain.
- A cost, manufacturing and supply chain assessment has confirmed the advantage of low cost and access to a mature supply chain for a concrete point absorbed and submerged pressure differential WEC, with potential fabrication sites identified in Scotland.
- Further work into loads assessment and the manufacturing of complex geometries would address current challenges

General:

- Developers need to make sure that they have a partner that well understands the manufacturing techniques. Including their inputs from a very early stage will maximise the effectiveness of the development process
- In terms of commercialisation of the ocean energy sector, it's important to take lessons from the offshore wind sector and their experiences with materials like steel and concrete, and take advantage of the supply chain opening for the offshore wind sector. This could be a good way to de-risk ocean energy technologies.
- Innovation is still required in developing offshore sectors. Collaboration with other sectors such as aeronautics can often give cost effective, well developed solutions.

Workshop results

Challenge 1 - Lack of manufacturer engagement in development

A Lack of engagement from manufacturers was highlighted as a key challenge in project development. This could be due to a lack of familiarity and perception of risk regarding the ocean energy sector.

Actions

Cross-industry projects and cross-sector knowledge sharing events can address the challenge of a lack of engagement by reaching a wide range of stakeholders. Events provide networking opportunities to set up connections and collaborative projects with different stakeholders can support development of the sector through knowledge and experience transfer.

Stakeholders

Key stakeholders include the European Commission, Member States, Technology Developers, Project Developers and Manufacturers.

Challenge 2 - Research limitations – lack of resource data

Gaps in gathering and distributing data was highlighted, where the need for tank testing was indicated. Gaps in resource data was another point raised, indicating the need for investment into data capture (real world)/ databuoys. Limitations of prediction tools was also expressed.

Actions

Databuoys for data collection is required. Data measurements and made available by Member States was suggested. Examples from the UK and Dutch government for wind energy tenders were mentioned, where data on specific sites was gathered and provided by the government. This eliminates the need for expensive testing by the ocean energy developers and encourages public data.

Stakeholders

Key stakeholders include the European Commission, Member states, Research organisations and Testing Centres.

Challenge 3 – Device and Subsystem testing methodologies need to be developed

Testing of devices is essential to de-risk a technology. For tidal turbines, the need for full-scale blade testing is a suitable example. Fatigue testing methodologies need to be developed for ocean energy technologies. Limited guidance on testing devices is a key part of this challenge.

Actions

-Designing test set-ups and testing guidelines including design-loading tests. If testing follows standardised guidelines, the results can be compared and used throughout the sector.

-Cross-industry involvement in the development of these guidelines is required.

Stakeholders
Key stakeholders include the European Commission, Research organisations, Technology Developers, Project Developers, Supply chain and Testing centres.

Challenge 4 - Lack of comprehensive design process for large-scale development

To reduce cost and move towards commercialisation, there is a need to scale up in terms of device size and in terms of deployment of arrays of multiple devices, however due to the early stage of ocean energy technologies (particularly wave energy converters) a strategy to do this is yet to be defined. Material selection and manufacturing processes are key elements to the design process when moving towards large scale deployment, in terms of manufacturability, operability, survivability, operability and affordability. Getting devices in the water is essential to gather information, to be able to de-risk and prove reliability of a technology. Challenges mentioned with real environment testing:

- Site-specific considerations hold back scaling
- Non-standard foundations (similar to offshore wind)
- Site-specific turbulence – Metocean

Actions
Key actions include designing larger scale devices and deployments using optimisation calculations and tools at an early stage in the process. Early involvement of manufacturers in design process ensures that expensive redesign processes are not required. Designing with site in mind is also very important in terms of conditions, accessibility and local supply chain. Insights in relevant environment are needed.

Stakeholders
Key stakeholders include manufacturers, technology developers, project developers and Research organisations.

Challenge 5 - Difficult to source/supply small-scale manufacturing of device components

At demonstration stages, only small numbers of devices are developed and deployed, often relying on bespoke, small number of components. This is difficult and costly for manufacturers to produce.

Actions
By indicating the potential market development and long term goals, the value of involvement can be provided to manufacturers. By engaging the existing supply chain in the product development, the expertise of manufacturers can be applied in the design of the devices.

Stakeholders
Key stakeholders include funding providers, supply chain and industry associations.

Challenge 6 - (Novel) Material selection

Building a prototype in the material is often not possible due to the cost of the material. The following factors must be considered when conducting material selection:

- Commercial risk and supply chain, rather than optimum material
- Composite price and supply chain
- Material recyclability
- Long term performance of new materials (Polymers/composite guidance)

Actions
Engagement with the supply chain and sharing of material data and lessons learnt. Funding bodies should make all information from funded projects available. Developers should engage with supply chain to incorporate material selection at an early stage of design

Stakeholders
Funding providers, Technology Developers, Project Developers, Supply chain.

Summary table

Table 14 below summarises the results of the workshop on alternative materials and manufacturing processes.

Table 14 - summary of workshop results on alternative materials and manufacturing processes

Challenge to ocean energy deployment	Actions	Responsible stakeholders
Lack of Manufacturer Engagement in development	-Cross-industry projects -Cross-sector knowledge sharing events	European Commission National authorities responsible for innovation, enterprise and industrial strategy Industry organisations. European Projects (E.g. ETIP Ocean, NeSSIE) Technology developers Project developers Manufacturers
Research Limitations – lack of resource data	-Strategic investment into data collection for design and manufacturing processes -Creation of a data library	European Commission, DG RTD National authorities responsible for innovation, enterprise

		and industrial strategy Research Organisations Testing Centres
Device and Sub-system testing methodologies need to be developed	-Designing test set-ups and testing guidelines including design-loading tests. -Testing following standardised guidelines -Cross-industry involvement in the development of these guidelines	European Commission Research Organisations Technology developers Project developers Supply chain Testing centres
Lack of comprehensive design process of large-scale development	-Development of early stage optimisation calculations and processes -Development of site specific design processes -Early involvement of manufacturers in design process	Manufacturers Technology developers Project developers Research organisations
Difficult to source/supply small scale manufacturing of device components	-Market commitment/ development is required -Product development -Engagement of existing supply chain	Funding providers Supply chain Industry associations.
Material selection	-Supply chain engagement -Sharing of material data and lessons learnt	Technology developers Project developers Supply chain Funding providers ETIP Ocean

Appendices

Annex I – Workshop Agendas

Workshop agenda 26/10/17

ETIP Ocean Workshop: 26th October, Nantes, France

1.30pm Introduction (’10)
Kasparas Kemeklis: ETIP Project Manager

1.40pm Scene setting: Recap of findings in each work-stream

1) Socio-economic & Environment (5”)
   - Enhancing social impact and acceptance
   - Minimizing negative environmental impacts

   Presenter: Jacopo Moccia (OEE & ETIP Secretariat)

2) Technology (15”)
   - Metrics and stage-gate development programmes
   - Control systems for improved yield, reliability and survivability
   - Wave Power Take Off – Have we cracked it?

   Presenter: Henry Jeffrey (University of Edinburgh & ETIP Secretariat)

(1.45pm Coffee for 50 people available in the room)

2pm Attendants choose a discussion table
Table 1: Socio-economic & Environment
Table 2: Metrics and stage-gate development programmes
Table 3: Control systems for improved yield, reliability and survivability
Table 4: Wave Power Take Off – Have we cracked it?

3pm Reports from roundtable leaders (4x 5”)

3.20pm Feedback from European Commission (10”)
Matthijs Soede (’10)

3.30pm Session close

Workshop agenda 29/10/18

ETIP Ocean Workshop: 29th October, Edinburgh, UK

10.00am Registration, Coffee, Networking

10.30am Introduction (10”)

Donagh Cagney, Ocean Energy Europe

10.40am Scene setting: Recap of findings in each work-stream

3) Socio-economic & Environment (10")
   - Enhancing social impact and acceptance
   - Minimizing negative environmental impacts

   Presenter: Kasparas Kemeklis, Ocean Energy Europe

4) Technology (5")
   - Metrics and stage-gate development programmes
   - Control systems for improved yield, reliability and survivability
   - Wave Power Take Off – Have we cracked it?

   Presenter: Shona Pennock, University of Edinburgh

10.55am Explanation of roundtables and discussion points (5")

Shona Pennock, University of Edinburgh

11.00am Attendants choose a discussion table

Table 1: Technology – materials, novel devices, optimization tools

Table 2: Finance – maintaining grant funding for early TRL technologies

Table 3: Finance – funding ocean energy technology development using PCP and stage gates

12.00 Reports from roundtable leaders (3x 3")

12.10pm Lunch, networking

1.00pm Attendants choose a discussion table

Table 1: Technology – materials, novel devices, optimization tools

Table 2: Env&Socio – Adapative management systems, knowledge sharing and collaboration

Table 3: Finance – Warranties, guarantees and insurance

Table 4: Finance – Market pull: revenue support for ocean energy

2.00pm Coffee break

2.10pm Reports from roundtable leaders (4x3")

2.25pm Discussion about Integrated Strategy and ETIP2

3.00pm Wrap up, session close

Annex II - Table Leaders list

Workshop 1 26/10/17

- Table 1: Enhancing social impact and acceptance/Minimizing negative env. impacts.
  Social;
    - Phil Gilmour (Marine Scotland)

  Environment;
    - Caitlin Long (EMEC)
    - Diane Dhomé (Sabella)

- Table 2: Metrics and stage-gate development programmes
    - Jonathan Hodges (WES) – Confirmed

- Table 3: Control systems for improved yield, reliability and survivability
    - Richard Yemm (Quoceant)

- Table 4: Wave Power Take Off – Have we cracked it?
    - Patrick Moller (CorPower)
    - Luca Castellini (UMBRA)

Workshop 2 29/10/18

- Table 1: Technology – Materials, Novel Devices, Optimisation Tools
    - Aneel Gill (Balmoral Offshore Engineering)
    - George Walker (ARUP)

- Table 2: Finance – Maintaining grant funding for early TRL technologies
    - Andrew Smith (Deja Blue consulting)

- Table 3: Finance – finding ocean energy technology development using PCP and stage gates
    - Tim Hurst (Wave Energy Scotland)

- Table 4: Env&Socio – Adaptive management systems, knowledge sharing and collaboration
    - Finlay Bennet (Marine Scotland)
    - Frank Fortune (Royal HaskoningDHV)

- Table 5: Finance – Warranties, guarantees and insurance
    - Michael Bullock (Renewable Risk Advisors)

- Table 6: Finance – Market Pull – revenue support for ocean energy
    - Niamh Kenny (DP Energy)

Annex III – Registered Attendees

Workshop 1 26/10/17

Thirty-two people signed the attendance list, from the following organisations:

#	Organisation
1	ETIP Secretariat / OEE
2	Scottish Development International / Ocean ERA Net
3	OpenHydro
4	Marine
5	Quoceant
6	Umbra Group
7	EMEC
8	Marine Scotland
9	Highlands and Islands / WES
10	Quoceant
11	Hann Ocean
12	Highlands and Islands / WES
13	D-ICE Engineering
14	France Energies Marines
15	University of Plymouth
16	Aquatera
17	Highlands and Islands / WES
18	Deja Blue Consulting
19	CorPower
20	University of Ghent
21	Sabella
22	GEPS Techno
23	Tecnalia
24	European Commission JRC
25	ORE Catapult
26	SEAI
27	ETIP Secretariat / OEE
28	Aquanet Power
29	University of Edinburgh
30	The Crown Estate
31	University of Edinburgh
32	ETIP Secretariat / University of Edinburgh

Workshop 2 29/10/18

Twenty-eight people signed the attendance list, from the following organisations:

#	Organisation
1	Deja Blue
2	TU Delft
3	University of Edinburgh
4	Ocean Energy Europe
5	University of Edinburgh
6	UCC Cork

7	Liepajas University
8	Wave Energy Scotland
9	Renewable Risk Associates
10	DP Energy
11	Marine Scotland
12	University of Edinburgh
13	University of Edinburgh
14	Sabella
15	Sabella
16	Engie
17	ARUP
18	Andritz
19	Uaine Gorm
20	RHDHV
21	Balmoral offshore engineering
22	Aquanet power
23	EMEC
24	Wave Energy Scotland
25	MRIA
26	ORE Catapult
27	Ocean Energy Europe
28	University of Edinburgh

Annex IV – Format

Workshop 1 26/10/17

The workshop was introduced by the secretariat that presented the main findings and results of the webinars under the two classifications on the agenda: Technology and Environment & Socio-economics. Questions were posed to take discussions under each topic forward during the workshop.

Participants were split into five different tables, each addressing a specific webinar topic. The experts that presented during the webinars were invited to moderate the discussions at their respective tables. Participants were tasked with suggesting actions to address identified challenges in their topic and determine which stakeholder category should be responsible to carry out the actions.

The secretariat distributed printed copies of the presentations made during the webinars and reports on the main findings at each discussion table.

At the end of the discussion, a spokesperson from each table presented the challenges, actions and identified responsible stakeholders to all participants.

Workshop 2 29/10/18

The workshop was introduced by the ETIP secretariat, who presented the main findings and results of the webinars under the classifications on the agenda: Technology, Finance and Environment & Socio-economics. Questions were posed to take discussions under each topic forward during the workshop.

Participants were split into three different tables in the morning and four in the afternoon, each addressing a specific webinar topic. The experts which presented during the webinars were invited to moderate the discussions at their respective tables. Participants were tasked with suggesting actions to address identified challenges in their topic and determine which stakeholder category should be responsible to carry out the actions.

At the end of the discussion, a spokesperson from each table presented the challenges, actions and identified responsible stakeholders to all participants.