Wave and Tidal Energy Market Deployment Strategy for Europe

June 2014

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Wave and Tidal Energy
Market Deployment Strategy
for Europe

June 2014
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Glossary

AEP Annual Energy Production
CAPEX Capital Expenditure
CCS Carbon Capture and Storage
DG ENER Directorate-General for Energy
DG MARE Directorate-General for Maritime Affairs and Fisheries
DG RTD Directorate-General for Research and Innovation
DNO Distribution Network Operator
DSO Distribution Systems Operator
EC European Commission
EERA Ocean Energy JP European Energy Research Alliance Joint programme for Ocean Energy
EIA Environmental Impact Assessment
EMEC European Marine Energy Centre
EMP Environmental Monitoring Programme
ENTSO-E European Network of Transmission Systems Operators for Electricity
ESBI Electricity Supply Board (Irish Utility)
ETS Emissions Trading Scheme
EU European Union
FIT Feed-in Tariff
GIS Geographic Information Systems
GWhs Gigawatt Hours
IRR Internal Rate of Return
JRC European Union Joint Research Centre
kW Kilowatt
LCOE Levelised Cost of Energy
MCT Marine Current Turbines
MW Megawatt
O&M Operations and Maintenance
OEM Original Equipment Manufacturers
OPEX Operational Expenditure
ORECCA Off-shore Renewable Energy Conversion platforms Coordination Plan
PTO Power Take Off
R&D Research and Development
RD&I Research, Development and Innovation
ROCs Renewables Obligation Certificates
RTE Réseau de Transport d’Électricité (Electricity Transmission Network)
SEA Strategic Environmental Assessment
SHEPD Scottish Hydro Electric Power Distribution
SOWFIA Streamlining of Ocean Wave Farms Impact Assessment
TP Ocean Technology and Innovation Platform
TRLs Technology Readiness Levels
TSO Transmission Systems Operator
TWh Terawatt hours
WEC Wave Energy Converter
Despite an investment crisis brought on by the biggest economic recession Europe has seen since the Second World War, the EU is on track to fulfil its ambitious 2020 renewable energy targets. In 2012, Europe’s renewable energy industry employed 1.2 million people and generated €130 billion of economic activity\(^1\), the vast majority of which did not exist just one decade ago.

The reasons for this are straightforward. Targets at the EU level have provided long-term regulatory stability, matched with EU funding, which reduces risk by advancing technologies along readiness levels. National-level targets in every Member State have resulted in governments putting in place capital and revenue support mechanisms, creating a vibrant market for renewable energy and generating volume production which has driven remarkable cost reduction across the most mature renewable energy technologies.

Although it has now taken the first generation of renewable energy technologies to competitive levels, Europe still needs to diversify its electricity supply further if it is to meet its 2050 policy objective of reducing greenhouse gas emissions to 80 – 95% below 1990 levels\(^2\). Increased energy generation from renewable sources has been identified by the European Commission as a ‘no-regrets option’ for meeting these objectives\(^3\). Wave and tidal energy are the next generation of renewable energy technologies, and they will be needed if Europe is to meet its decarbonisation targets. These technologies can also support better grid integration for all renewables. Wave and tidal projects can, for example, be developed in areas of low solar or wind resource. Electricity generation from wave and tidal is also out of sync with other renewable technologies, and will provide further balancing effects for European transmission systems.

However, binding renewable energy targets for the post-2020 period are necessary in order to provide clarity for investors. In a tough economic climate, and without binding targets, the incentive to shift from the status quo will be significantly weakened. Wave and tidal energy technologies must now find a route to market in more uncertain times than their predecessors.

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2. European Commission Communication: Energy Roadmap 2050* COM/2011/0885 final */
3. European Commission: A Roadmap for moving to a competitive low-carbon economy in 2050
At present, the appetite amongst Member States for long-term renewables support has decreased. Uncertainty surrounding revenue support for renewables has meant that today’s utilities have become more risk-averse and less inclined to fund demonstration projects for new technologies from their balance sheets.

Some tidal energy technologies have reached the stage where Original Equipment Manufacturers (OEMs) and utilities are trying to secure finance for the first pilot array demonstration projects. Wave energy technology development is a little less advanced. For all developers in these sectors, however, the challenge of raising capital to invest in technology innovation and demonstration has slowed progress, and in many cases the learning curve has been far steeper and longer than originally anticipated. In the medium-term, the industry faces other barriers, in the form of infrastructure. Across Europe, the wave and tidal energy resource is often strongest in areas where grid, port and harbour infrastructures are weakest. However, this physical challenge is not unique to wave and tidal renewable energy, and the solutions developed in the build-out of more mature renewable energy technologies over the last two decades should be adapted for wave and tidal energy.

Despite all these challenges, wave and tidal energy provides excellent long-term potential for economic growth, energy security and job creation, and policy makers at EU and Member State level are seeking innovative ways to accelerate commercialisation. Agreeing a common plan and putting in place appropriate support will be essential steps towards industrialising these sectors and putting Europe on track to secure 100GW of installed capacity by 2050.

Funded by the Intelligent Energy Europe programme, the SI Ocean project’s Market Deployment Strategy makes several high-level recommendations for commercialising the emerging wave and tidal energy sectors. The industry looks forward to taking these recommendations forward through the Ocean Energy Forum and working with decision-makers to produce a Strategic Roadmap, which we hope will lead to a European Industrial Initiative for wave and tidal energy.

Sian George
CEO
Ocean Energy Europe
EXECUTIVE SUMMARY
Executive Summary

The potential for economic growth, energy security, job creation and global export inherent in wave and tidal energy technologies is considerable. Even in their pre-commercial state, wave and tidal technologies already draw on supply chain companies from almost all European Member States. In addition to Europe’s competitive global position in the offshore wind, oil and gas sectors, it is also the global leader when it comes to technology innovation and invention in this new industry. If managed correctly, this advantage will ensure Europe’s front-runner position abroad and will result in the production of significant amounts of renewable energy at home, along with the security, growth and employment benefits that this will bring.

Furthermore, wave and tidal energy technologies have certain advantages over other energy sources. For example, they provide an opportunity to generate energy at a wide range of locations throughout Europe. Additionally, wave and tidal power produce energy at different times, and more consistently, than other renewable energy sources, such as wind and solar. This will add to the overall stability of Europe’s energy networks. These new technologies also offer an attractive alternative in areas where the visual impact of electricity generation sources is a concern. Lastly, they can leverage extra value by exploiting synergies with sectors such as offshore oil, gas and offshore wind. Opportunities include using common components and sharing expertise on project development challenges.

However, significant risk on four main fronts is currently impeding development.

1. **Financial risk** – there is a shortfall in upfront capital investment for technology development and pilot array demonstration, which is compounded by the current lack of long-term clarity on revenue supports.

2. **Technology risk** – uncertainties relating to survivability, reliability and cost reduction potential are inherent in all new energy generation technologies, but particularly in those designed for offshore operations in harsh conditions.

3. **Project consenting risk** – unknown interactions between devices and marine environments make it challenging for regulators and developers to assess and mitigate potential impacts.

4. **Grid-related risk** – the best and most economical resources are frequently not located near accessible grid infrastructure, creating grave uncertainty over connection dates in key areas.

Over the coming decade, Europe’s ability to reduce these risks will be the deciding factor when it comes to commercialising the wave and tidal energy sectors. For these sectors, it is clear that installing the first pilot tidal arrays will be a critical milestone. The EU, its Member States and industry will need to act in a coordinated manner to ensure that a shortfall of capital and revenue support does not stall the industry’s progress by delaying financial close on these first-of-a-kind demonstrations.

These first pilot arrays – consisting of three or more devices with a maximum installed capacity of 10MW – will be the cornerstones of a successful market deployment strategy for Europe. They will, for the first time, prove the viability of generating electricity from more than one device, and in doing so they will generate vital lessons which will help developers target future innovations in array performance, reliability and cost reduction. Successful demonstrations will not only pinpoint where further improvements are required; they will also build investor confidence. This will stimulate investment into all stages of technology development, and will help to engage the supply chain. Successful electricity generation from the first arrays will also galvanise planning for future grid connection and the development of efficient regulatory regimes.

Agreeing a common plan to de-risk wave and tidal technology development will be an essential step towards creating a new industrial sector in Europe. This plan – or road map – should give a clear account of the exact nature and level of support that will be required for the wave and tidal energy sectors to
fulfil its potential of hitting an installed capacity of up to 100GW by 2050. Such a road map should set out clear and specific milestones for 2020, 2030 and 2050. As well as indicating the level of market push and market pull that will be needed to hit key milestones, it should set clear priorities for technology innovation aimed at delivering cost-effective, high-yield and reliable devices to the marketplace as quickly as possible.

The SI Ocean project’s Market Deployment Strategy provides recommendations to tackle risk head on.

**De-Risking Finance**

Financing innovation and technology development at all technology readiness levels (TRL) is a key priority, with the goal of advancing several of the most promising early-stage technologies. This will deliver the next pilot arrays for demonstration and ensure that the industry has no shortage of game-changers and second-generation solutions.

Wave and tidal energy companies need a suitably large and consistent pipeline of future projects to justify continued investment. They must see sustained commitment from the EU and Member States to long-term stable mechanisms to support wave and tidal energy technologies, including technology push (capital grants) and market pull (market incentives, such as revenue support).

Current experience of trying to get the first tidal pilot arrays in the UK to financial close demonstrates that available support packages fall short of leveraging the upfront capital needed to build these projects. These pilot arrays should not be viewed as commercial projects, as they are a necessary R&D step following on from the demonstration of full-scale prototypes. Therefore, large capital grants, project equity loan guarantees or soft loans will need to be combined with available revenue support mechanisms to get these pilot arrays over the line.

Deployment of the first pilot arrays will provide a clear view of wave and tidal energy’s route to market. With practical experience and performance data under its belt, the industry can start to understand, quantify and manage risk. These pilot arrays will stimulate appetite for investment in the whole sector, and will provide utilities with clear evidence that there is a market for wave and tidal energy.

While revenue support mechanisms should be guaranteed for the lifetime of individual projects, they will need to be capped and time-bound to give Member States a clear view on the duration and likely cost of the overall schemes.

Increasing the volume of R&D capital available is one part of the solution, but these sectors also need to make smarter use of the available funding by setting out a clear agenda for technology and innovation. Coordination between stakeholders seeking R&D funding needs to be improved. Competition for funding is important, but so is collective learning through collaborative research projects.

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**Summary of Industry Priorities and Goals – SI Ocean Market Deployment Strategy Priorities and Goals**

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Priorities</th>
<th>Goals</th>
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</table>
| By 2020   | • Innovation – TRL progress  
• Demonstration and testing | • Financial close on up to ten pilot arrays  
• Technology innovation: reduce costs, increase reliability, increase yields |
| By 2030   | • Continued innovation  
• Supply chain engagement  
• Accelerating cost reduction: standardisation and scaling up | • Commercial array installations (30MW+) |
| By 2050   | • Rapid cost reduction – volume production  
• Mass market roll-out | • Supply up to 100GW of clean energy |
De-Risking Technology

Significant technology innovation is still required to deliver cost-effective, reliable and high-performance solutions for wave and tidal energy generation. The SI Ocean Strategic Technology Agenda identifies key challenges and priorities technology development topics for the short term.

Technology risk can be minimised by improving reliability and by reducing the Levelised Cost of Energy (LCOE). LCOE can be reduced via a combination of cutting capital costs and improving yield, firstly at the level of the single device, then in array formation. The Strategic Technology Agenda identifies that this will require technology push, in the form of grants and capital investment in technology development, and market pull, in the form of revenue support for scaling up deployments.

Capital support is required for continued technology development at the research and design stage and for onshore and offshore testing and real-sea deployment of prototypes and pilot arrays. This twin-track ‘develop-and-deploy’ approach will drive both innovation and early economies of scale.

Continued public sector support for research, innovation and demonstration coupled with commitment from industry will create a virtuous circle, in which increased reliability and cost reductions trigger further investment. This will ensure that Europe retains its current position as the global scientific and engineering hub for wave and tidal energy technology development.

In the medium term, cost reduction will mean moving to standardised devices and components, integrating the supply chain and mass-producing devices at volume. However, this depends on a market being created. While the first pilot arrays will need large capital grants combined with revenue support, the industry will require clear and stable revenue support schemes to help it achieve significant economies of scale.

Overall, closer cooperation between the public and private sectors will foster a common understanding of the most promising technologies and the highest priorities for innovation. This will automatically reduce risk and improve the strategic impact of public and private investments in wave and tidal energy technology innovation. The Technology and Innovation Platform for Ocean Energy (TP Ocean), which has just been set up by Ocean Energy Europe, is expected to provide good support in this area.

De-Risking Project Consenting

Wave and tidal energy’s first-of-a-kind nature makes it challenging to evaluate the potential impacts that devices – and arrays of devices – could have on the marine environment. As a result, the planning and consenting process can be excessively expensive and time consuming, adding new layers of risk and uncertainty to wave and tidal energy projects. Disseminating best practice is the best way to mitigate this risk in the short term. Applying processes that have worked in one country to other areas seems an obvious win–win, but can be difficult to implement without the necessary political will.

Scotland and the UK have taken the lead in tackling consenting barriers for the nascent wave and tidal sectors by adopting a series of pragmatic actions: simplifying their procedures, such as Marine Planning, conducting a Strategic Environmental Assessment (SEA) and developing a ‘one-stop-shop’ for consenting. Ireland is also now putting appropriate measures in place to support the sector’s development.

Sharing and disseminating experiences will ensure that regulators across Europe can learn from each other. Agencies in Ireland, France, Portugal or Spain can benefit from the programmes developed in Scotland and the rest of the UK by applying best practices to their own programmes in terms of simplifying consenting and environmental monitoring processes while still taking into account local concerns.

Streamlining planning and consenting processes will work best in a context of high-quality interactions between the regulator and wave and tidal energy developers. Regulators need to thoroughly examine the evidence base regarding consenting issues, including relevant evidence from other industries (e.g. the impacts from the laying and operation of power export cables from offshore wind farms), and revise
consenting advice accordingly. Developers need to provide feedback to regulators on the impacts of the planned processes and procedures.

The newly formed Ocean Energy Forum is ideally placed to help disseminate Europe-wide guidance between regulators and project developers.

**De-Risking Grid**

The crux of the sector’s grid issue is that Europe’s high wave and tidal energy resource areas are in locations where the grid infrastructure is severely lacking. Regulators are hesitant to facilitate sizable grid connections until it is certain that projects will connect and fully exploit them. While some companies are pursuing small-scale off-grid solutions, for several others grid connection is causing substantial uncertainty, and will become an increasing concern as the industry moves past pilot arrays.

Grid planning and investment will require commitment and support from policy makers to ensure that key milestones for commercialising the entire sector are not held up by grid-connection problems. Options such as combining Horizon 2020 funding for demonstration projects with structural funding for grid connection upgrades, which is currently being explored by the Commission’s DG ENER, could present a novel solution to pilot array barriers. Further financial assistance for national grid developments and reinforcements could also be made available from funding sources such as the EIB (the Connecting Europe Facility and the Structured Finance Facility), where the strategic benefit to the industry – and to Europe – is clear.

Policy makers can also support these sectors by ensuring that regulators incorporate wave and tidal energy projects into future grid development plans, such as ENTSO-E’s 10-year plan. Coordinated offshore grid planning between wave and tidal energy projects and offshore wind projects could also help alleviate the costs of major sub-sea interconnections in areas where both resources are strong.

The following chapters set out the key barriers to market deployment for wave and tidal energy technologies, focusing on the major risk areas of finance; technology development; consents and regulations; and grid. Each chapter concludes with a list of goals, with detailed recommendations that industry and policy makers can take forward in order to achieve them.

**Summary of Goals**

<table>
<thead>
<tr>
<th>Markets &amp; Finance Goals</th>
<th>Introduce market push and pull support to ensure that up to ten pilot arrays – of three devices or more – can reach financial close by 2020 across Europe</th>
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<tbody>
<tr>
<td></td>
<td>Develop clear and flexible European Commission State Aid checks for financing up to ten pilot arrays in Europe by 2020</td>
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<td></td>
<td>Continue to push game-changers, challengers and frontrunners up the Technology Readiness Levels (TRL1–8)</td>
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<td></td>
<td>Encourage early investment in innovation for materials, supply chain components and services, enabling innovation, standardisation and cost reduction along the supply chain</td>
</tr>
<tr>
<td>Technology Innovation &amp; Development Goals</td>
<td>Accelerate technology innovation aimed at reducing costs, improving reliability and increasing yield, via research and design as well as deployment</td>
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<tr>
<td></td>
<td>Deliver medium-term cost reduction through economies of scale, by investing in development, innovation and demonstration of pilot arrays today</td>
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<td></td>
<td>Involve the supply chain and incentivise its innovation potential</td>
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<tr>
<td>Consents &amp; Regulations Goals</td>
<td>Allow for integration of wave and tidal energy into long-term planning and with existing ocean users</td>
</tr>
<tr>
<td></td>
<td>Streamline and accelerate the consenting processes by removing excessive administrative and cost burdens</td>
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<tr>
<td>Grid Goals</td>
<td>Explore innovative ways to reduce prohibitive costs and delays for connecting early-stage projects</td>
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<td>Extend the grid to reach the wave and tidal energy resource rather than constraining ocean projects to grid-connected areas</td>
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The Strategic Initiative for Ocean Energy (SI Ocean)

The SI Ocean project’s goal is to deliver a common strategy for ensuring maximal wave and tidal installed capacity by 2020, paving the way for exponential market growth in the 2030 and 2050 timeframes.

The project consortium has seven members: Ocean Energy Europe (Belgium); European Commission Joint Research Centre (JRC); RenewableUK, Carbon Trust, and University of Edinburgh (UK); WavEC (Portugal); and DHI (Denmark).

The consortium has held four workshops and four webinars reaching 455 participants over the last two years, and has communicated with a network of 800+ contacts. Each workshop focused on one of the key project deliverables:

1. Resource assessment;
2. Policy analysis;
3. Technology gaps and barriers; and
4. The market deployment strategy.

Extensive industry engagement included interviews, panel discussions, and webinars which provided feedback on foundation documents, recommendations and industry data. The project benefited from strategic validation provided by an Advisory Board consisting of 26 industry experts and three European Commission observers. The Market Deployment Strategy engaged with three advisory sub-groups on finance, consenting and infrastructure.

SI Ocean focused geographically on the Atlantic Arc: Denmark, France, Ireland, Portugal, Spain and the United Kingdom. Although SI Ocean focuses on six EU Member States, the environmental and economic benefits of accelerating wave and tidal energy deployment will benefit the whole of Europe.
**SI Ocean Project Deliverables**

**Resource assessment modelling:** The main objective was to fully understand the potential contribution of wave and tidal energy to EU energy needs.

**Technology Assessment:** The main objective was to assess current technology development priorities and develop a Strategic Technology Agenda as the basis for justifying the inclusion of ocean energy in the SET Plan. The recommendations developed here will be used as a basis for a technology road map by the newly formed TP Ocean.

**Market Deployment Strategy:** To identify current policy and market barriers to the deployment and commercialisation of wave and tidal energy. The main objective was to engage with key stakeholders and develop a robust consensus on the swiftest route to commercialisation.

For copies of the SI Ocean reports, visit: [www.si-ocean.eu](http://www.si-ocean.eu)

*Figure 1 - The SI Ocean work packages and deliverables*
CHAPTER I
Europe’s Wave & Tidal Market Deployment Strategy
CHAPTER I – Europe’s Wave & Tidal Market Deployment Strategy

1.1. Realising Europe’s 2050 Wave & Tidal Energy Potential

By 2050, Europe could have up to 100GW\(^6\) of wave and tidal energy installed capacity delivering 260 terawatt hours (TWh) of clean, affordable and reliable electricity – enough to power 66 million European homes. With up to 337GW\(^7\) installed around the world, wave and tidal energy could be a multi-billion-euro international industry with significant exports to markets in Asia and across South and North America.

Ocean Energy Europe, 2014

European companies currently hold a global lead in developing wave and tidal technologies, supported by cutting-edge academic research and testing facilities. If this advantage is preserved through innovation, it will enable Europe to dominate the world market. As the wave and tidal energy supply chain is pan-European, economic returns will flow to several EU Member States, and not only to those with ports, wave and tidal energy resources or a traditional maritime industrial base.

This Market Deployment Strategy identifies the major milestones the industry will need to reach in order to fulfil its potential of delivering 100GW by 2050. This report draws on the previous work of the SI Ocean consortium, and identifies recommendations for policy makers which will help to create a European market for wave and tidal energy.

These recommendations are intended to be taken forward by the Ocean Energy Forum, a stakeholder platform which was first announced in the European Commission’s Communication on Ocean Energy\(^8\)

The Forum will build on the recommendations for wave and tidal energy support in the course of its work to deliver a road map for accelerating commercial development across the whole wave and tidal energy industry.

This report provides high-level recommendations and approaches for stakeholders to take forward in order to deliver a road map for accelerating development. These recommendations are based on extensive consultation with industry, the research community, Member States and European Commission Directorates General.

This report presents their vision of success for the wave and tidal energy sectors, and sets out the next steps the industry should take.

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\(^7\) Ocean Energy Systems: Annual Report 2013

\(^8\) European Commission: Blue Energy: Action needed to deliver on the potential of ocean energy in European seas and oceans by 2020 and beyond, January 2014
CHAPTER II - Finance and Markets

2.1. Today’s Finance Challenges

Wave and tidal energy, like established generation sources, has traditionally relied on government support, with some involvement from venture capital and private equity investors. The frontrunners in these sectors have started to emerge from the R&D phase, and private financing activity has picked up in response. In the last decade, a number of OEMs, utilities and privately owned developers have acquired or invested in the leading SME technology developers.

In total, over €700m in private investment has flowed into the industry in the last eight to ten years. This has yielded good results, and market leaders are now close to securing finance for the first small pilot arrays of tidal turbines. Other, predominantly wave power, companies have chosen to minimise early technology risk by focusing on developing smaller-scale demonstrations for niche and/or intermediate markets, such as providing off-grid power to military installations, met masts and navigational buoys.

As a result of this progress, machines deployed in the last five years have generated over 10GWh of electricity to the grid, and several other technologies have completed proof-of-concept with scale models in test tanks and ocean test sites across Europe. Assuming a good balance of capital grants and revenue support is made available, this industry could feasibly achieve financial close and approval for construction on up to ten pilot arrays by 2020. At present, it is likely these will be predominantly tidal arrays, and that there will be between three and five located in the UK and France, as well as one pilot array in Ireland.

Demonstrating technologies in pilot arrays will be a critical milestone for the whole industry. Regardless of technology type, array demonstration will maintain momentum and trigger further investment across all stages of development. However, securing that investment is proving to be a major barrier to reaching financial close for the first pilot arrays.

The reasons for this are manifold. Early R&D activity in the wave and tidal energy sectors ten or twelve years ago relied on significant private investment, with some grant support from EU institutions and Member States. The expectation was that as test devices eventually emerged out of R&D and built up a track record for reliability, traditional sources of project finance would play a more prominent role, attracted by enhanced revenue support programmes and driven by long-term EU decarbonisation commitments. To a certain extent, this has happened, in the form of acquisitions and investments in leading SME technologies by ABB, Siemens, Andritz, Alstom and DCNS.

However, the 2008 economic crisis changed the funding landscape. With the diminished availability of private capital and bank credit, finance has become more difficult to secure, particularly for high-risk ventures such as wave and tidal energy. In parallel, decreased energy consumption and lower profit margins have meant that some of Europe’s biggest utilities are now trading at up to 50% below their 2007 value. In addition, since the economic crisis, Member State governments have focused closely on the ‘value for money’ and ‘needs case’ for renewable technologies.

The general thrust of EU-level policy today is still towards decarbonising the power sector and mitigating climate change. Policy makers have recognised that the wave and tidal energy sectors can be a major player in meeting EU decarbonisation targets and delivering energy security and jobs.

“Ocean energy has a significant potential to enhance the security of supply. Developing a wide portfolio of renewable energy sources including ocean energy also facilitates their integration in the European energy system.”

European Commissioner for Energy – Gunther Oettinger

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2030 Climate and Energy Goals for a Competitive, Secure and Low-carbon EU Economy

- 40% reduction in domestic greenhouse gas emissions below 1990 levels
- Increase renewable energy market share to at least 27%
- Continued improvements in energy efficiency
- Reform EU Emissions Trading Scheme (ETS)

In a sense, the wave and tidal energy sectors are caught in a ‘perfect storm’: the aftershocks of the economic crisis have focused attention on other maturing renewable technologies, such as offshore wind, which are competing in the same space for policy and financial support.

The wave and tidal energy industry has delivered a number of viable solutions for generating energy from waves and tides. Today’s challenge is financing the next step on the road to market, and getting the first pilot arrays in the water.

2.2. Mission Critical: De-risk Early Array Finance

“Deploying the first pilot arrays will show that ocean energy technology has a route to market. The priority is to get the first arrays in the water as soon as possible. With more practical experience and further performance data under its belt, the industry can start to better understand, quantify and manage risk. These pilot arrays, together with a reliable regulatory and support regime, will stimulate appetite for investment in the entire industry, and will give utilities clear evidence that there is a market for ocean energy.”

Kai Kölmel, Vice President of Hydro & Ocean Power, Siemens AG

Accessing finance for any emerging energy technology project is challenging. The LCOE of first-of-a-kind prototypes is inevitably high. High capital costs, lower revenue projections and high scores on project risk audits make it difficult to underwrite risk or to attract private equity. Banks will typically not consider lending money to such projects due to high technology risks and a lack of certainty over revenues. Likewise, traditional venture capital or private equity investors are not attracted to high-risk demonstration projects, whose primary benefit lies in learning and experience rather than financial returns.
For the first wave and tidal energy arrays, the finance challenge is compounded by the higher initial capital costs associated with new offshore technologies, combined with lower revenues predicted for pilot technologies. The SI Ocean project calculated that the LCOE for a 10MW array to be installed after the first pilot 10MW array will range from €0.35/kWh to €0.52/kWh, depending on final costs and resource levels. This is a promising starting point for an early technology which can credibly assume a 12% learning rate, based on the SI Ocean cost reduction calculations. However, the industry lacks the scale of capital needed to finance demonstration projects – approximately €70–100 million for each of the first 10MW arrays.

When it comes to performing due diligence on wave and tidal energy investments, a lack of operational experience drives up insurance premiums, limits the coverage available, and makes it difficult for potential backers to assess technology risk. Developers can provide design certifications for equipment and processes, but the prohibitive cost of extensive seabed surveys and rock core sampling, to verify seabed conditions for foundations for example, makes the ‘unknown unknowns’ even harder to insure.

Figure 2 – LCOE Predictions for 10MW arrays, after 10MW has already been installed (Source: SI Ocean Cost of Energy Report, 2013)

Figure 3 – Early array costs (Source: SI Ocean Cost of Energy Report, 2013)
Despite this situation, several developers are currently very close to securing the finance they need to demonstrate viable tidal technologies in small arrays. While these projects will generate negligible revenues, and revenue predictions are less stable for new technologies, a select group of utilities and OEMs are considering investing equity off balance sheet in these first projects. However, their boards are unable to justify 100% of the upfront capital costs, and they are understandably cautious about doing so without some EU or Member State-led commitment to sharing this upfront risk with them.

2.3. Market Push and Pull: Capital and Revenue Support

The UK has so far led the way in delivering financial support for technology push (public grants and private equity) and market pull mechanisms (feed-in tariff, renewable obligations) (Figure 4). This has already paid dividends, attracting significant inward investment in UK companies, skills and test centres from across Europe and overseas.

Ireland and France have now put capital and revenue support mechanisms in place to drive development, which is stimulating market activity in these countries. This new Irish and French support, together with the opportunity to secure grants from the European Commission’s Horizon 2020 programme, is stimulating serious market interest outside of the UK.

In May 2014, the French government received no less than seven competitive bids after it opened a call for tenders, offering capital and revenue support for up to four tidal pilot arrays in French waters. It remains to be seen whether the French equation for balancing market push and market pull will make it easier to get these projects to completion, but the high volume of bids clearly demonstrates that combining large upfront capital grants with enhanced revenue support is the key to stimulating significant interest in deploying pilot arrays.

Current experience with the first tidal pilot arrays planned for construction in the UK shows that while enhanced revenue support is essential, the capital support packages currently available are not sufficient to get these projects approved for construction. Large capital grants, loan guarantees or soft loans\textsuperscript{15} will also be needed to provide the level of market push required to get pilot arrays over the line.

\textit{Figure 4 – Ocean energy market pull and technology push programmes to date across the Atlantic Arc}

<table>
<thead>
<tr>
<th>Member State</th>
<th>Market pull</th>
<th>Technology push</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.K.</td>
<td>• 20yr ROCs replaced by 15 yr CfD in 2017 CfD = €375/MWh until 2019</td>
<td>• MEAD, ETI, TSB, Crown Estate Scottish Government Grants and Equity investment (total c. €120m)</td>
</tr>
<tr>
<td>FRANCE</td>
<td>• Approx. € 173/MWh</td>
<td>• Estb. FEM (€133m for 10yrs)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• De-risk technology upfront to ensure successful projects</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• ADEME (€40m Investing for the Future)</td>
</tr>
<tr>
<td></td>
<td>• €200m Capital support for pilot projects</td>
<td></td>
</tr>
<tr>
<td>IRELAND</td>
<td>• €260/MWh up to 30MW from 2016</td>
<td>• SEAI Prototype Dev. Fund (€10m)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• RE RD&amp;D prgm (€3.5m)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ocean Energy Development Budget (€26.3m)</td>
</tr>
<tr>
<td>SPAIN</td>
<td>• Moratorium suspending FIT for all renewables</td>
<td>• BIMEP (€20m invested 2007-2014)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PLOCAN (€20m for construction 2007-2014; €16m for O&amp;M between 2015 and 2021)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ocean Lider (€15m for R&amp;D support, 2009-2013)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• EVE (€3m Demonstration support, 2014-2015)</td>
</tr>
<tr>
<td>DENMARK</td>
<td>• Approx. € 80/MWh</td>
<td>• Energinet.dk manages funds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Energy Agreement (€2.9m)</td>
</tr>
<tr>
<td>PORTUGAL</td>
<td>• Scheme halted</td>
<td>• FAI, QREN (not specific for W&amp;T)</td>
</tr>
<tr>
<td></td>
<td>• Previously €260/MWh decreasing with capacity</td>
<td></td>
</tr>
</tbody>
</table>

\textsuperscript{15} A loan with below market-rate interest, typically provided by an agency with a vested interest such as a Member State seeking to fulfill policy objectives or stimulate market investment (e.g. Chinese Investment Bank).
CASE STUDY: FINANCE AND TECHNOLOGY RISK

The Balancing Act for NER 300 Projects

The European Commission’s NER300 scheme has been an extremely welcome development for the industry. It is the world’s largest support scheme for the demonstration of Carbon Capture and Storage systems (CCS) and has served as a catalyst for innovative renewable energy technologies.

In practice, developers have encountered challenges. NER300 revenue funding drawdown is tied to meeting pre-agreed operational milestones and power output. This requires project developers to accurately forecast technology progress and deployment dates some years in advance. With any pilot project, it is inevitable that there will be technical delays, outage, under-performance and weather delays. It is, by definition, difficult to give accurate power projections for innovative projects. This level of risk and uncertainty is a fact of life when demonstrating new technologies, as technical delays and challenges actually represent the true value of these pilots in terms of learning and experience. By only offering a reward for performance post-construction, the NER300 does not mitigate the significant upfront capital risk of building innovative pilot arrays.

While NER 300 Phase 1 funding was awarded to the WestWave project in Ireland, ESB was not in a position to progress with the award under the scheme, as technology had not progressed in line with original expectations and would not be sufficiently proven to meet the specified operational dates required of the scheme. While this type of delay is not unusual for new product development; the scheme is compatible with the technology’s TRL. ESB has applied for the funding again under Phase 2 of the scheme (with later deployment dates) in order to better reflect the current view of wave power technology progress and expected operational dates. This has added an additional level of uncertainty and risk to this proposed pilot project.

The European Commission has been flexible in permitting some up-front funding during the capital-intensive build-out phase of these projects. However, securing a guarantee for this up-front capital from Member States is proving to be an extremely complex process. It may be simpler to accept an appropriate Parent Company Guarantee (PCG) from the project sponsor.

While the Irish WestWave project has been delayed by slower progress in wave power technology development, the leading tidal project developers in the UK (ScottishPower Renewables, Atlantis Resources Ltd and Siemens) have so far secured at least one source of capital or revenue support from the public sector, but are finding it difficult to leverage the private equity required. Out of necessity, developers have put together complex funding packages drawing on a variety of sources. This complexity creates an additional hurdle when it comes to understanding the State Aid position of each project. Given the highly innovative and risky profile of these projects, they are not competitive. This indicates scope for developing a more flexible approach to applying State Aid rules to the first ten or so pilot projects.

While revenue support mechanisms should be guaranteed for the lifetime of individual projects, they will need to be capped and time-bound to give Member States a clear view on the duration and likely cost of the overall schemes. Going forward, it will be important that Member States have access to up-to-date and rigorous assessments of technology costs. This will help them in consultation with developers, to set the appropriate tariff to suit domestic goals, market conditions and progress on cost reduction for each technology (wave and tidal). It will also help to set fair incentives, bringing subsidies down in stages to match progress down the cost curve without penalising progress or creating excessive or ‘windfall’ profits.
2.4. De-risking Technology: Stimulating Investment in Innovation and Development

“The overall goal for this industry is to build cost-effective, high-performance ocean energy farms. Installation and maintenance must be quick and safe, and they must generate power reliably in sub-sea conditions for over 20 years. To do this, Member States, industry and the Commission will have to work together to de-risk the first pre-commercial pilot farms.”

John McSweeney, Head Of Innovation, ESB

Beyond demonstrating wave and tidal technologies in arrays for the first time, a significant level of technical innovation will be required on all fronts to successfully industrialise these sectors. Current R&D investment in wave and tidal is only 10% of that spent on offshore wind innovation. To propel the industry forward, the current level of investment will need to increase significantly. Chapter 4 outlines the logic and key priorities for targeting investment in research and demonstration. However, beyond spending the right amount of money on the correct priorities, there are a number of other challenges facing earlier-stage technology developers.

Some early-stage wave and tidal energy technology developers have secured grants, but have not been able to leverage match funding to draw down their grants. Others, meanwhile, have successfully drawn down full grants, but have not delivered the performance required to progress to array deployment. This creates a funding hiatus as developers rethink their development pathway and try to secure interim funding to ‘stay alive’. Several start-ups have not made it past this stage and have been forced to close. On the one hand, failures diminish investor confidence. On the other hand, any emerging technology sector requires the “freedom to fail without policy-makers losing their nerve”. Exits allow consolidation of available finance, expertise, enabling technologies and techniques in the remaining players.

16 European Commission – JRC Report on marine energy innovation, April 2013
17 Renewys, Global Marine Report 2014
2.4.1. Improving Coordination and Cooperation

There is also strong scope to improve levels of coordination and cooperation between the stakeholders seeking funding for technical innovation and research in these sectors. Competition for grants is essential and should be encouraged. However, stakeholders do need to make a collective effort to improve the quality and reduce the volume of competing and/or duplicate applications for similar projects being submitted to the European Commission and to Member States when they open calls.

Additionally there is scope to improve selection procedures by encouraging the European Commission and Member States to evaluate the performance of past R&D investments with a view to learning lessons and identifying best practice. Recommendations from the workshops held for the SI Ocean project included increasing the level of due diligence carried out on large grant applications for device demonstration. This could be done by including expert assessments of the technical, commercial and financial prospects of the technologies involved.

2.4.2. Stimulating New Investment: Co-investment and Risk-Sharing

Increasing the volume of R&D capital spend is part of the solution, but this industry also needs to focus its efforts on making smarter use of the funding available by setting out a clear agenda for technology innovation.

Closer cooperation between the public and private sectors will foster a common understanding of the most promising technologies and the highest priorities for innovation. This will reduce risk and improve the impact of public and private investments in wave and tidal energy technology innovation.

New private investors must be brought into these sectors. The challenge of finding new sources of private equity is common at all stages of development, from the earliest concept to pilot array deployment. One approach to this challenge could be to set up risk-sharing funds.

Input from SMEs and project developers indicates that several large companies and investment funds have looked closely at these sectors with a view to investing in early-stage technology development or backing a project, but have so far decided not to invest. In general, they are put off by the scale of investment and risk involved in backing a single technology or project. It will be important to take an innovative approach to channelling investment, not just into just pilot arrays but also into the most equity-starved TRL stages.

One option could include exploring ways in which Member States or European investment vehicles could potentially bring in these tentative investors by enabling them to share risk, learning and returns across more than one technology or project. If Member State and EU capital could be used as the corner stone of an investment fund, it may be possible to attract a range of potential investors, from angels looking to invest in early-stage disruptive technologies, to venture capitalists, OEMs and utilities looking at the first array projects.

Finally, it will not be enough to set up risk-sharing funds and other co-financing strategies. While these will help leverage more public and private finance investment, there is no single, stand-alone solution to the funding challenge faced by these sectors. Stakeholders need to work together to create a suite of financial instruments designed to do two things:

- help project developers reach financial close on pilot arrays; and
- create a stable supply of investment into research, demonstration and innovation at all TRL. The key lies in bringing all potential backers to the table to establish their willingness to work together with the goal of backing the industry as a whole.

The recent launch of the Ocean Energy Forum, which will be supported by the newly created Technology Innovation Platform for Ocean Energy (TP Ocean), as well as two further Steering Committees on Finance and Environment/Consenting, aims to deliver a strategic plan to guide public and private investments. The following recommendations are intended for uptake by the Ocean Energy Forum, to use as a basis for a road map for commercialising these sectors.
## 2.5. Key Finance Recommendations

<table>
<thead>
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<th>Goal</th>
<th>Recommendation</th>
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| **Financial close on up to ten pilot arrays by 2020, starting this year** | 1. Deliver financial models and estimates of the scale of revenue support, public and private capital, loans and guarantees required to get up to ten pilot arrays to financial close before or during 2020  
2. Identify options for co-investment and risk-sharing, including ‘super funds’ and government-backed guarantees to underwrite risk, based on expert advice from the finance community and prospective investors  
3. Discuss options for financing the first ten arrays with as many potential investors as possible, to stimulate investment from new sources  
4. Map post-2020 requirements and identify milestones required to bring in traditional sources of finance (private equity, State-backed investment banks, EIB) to deliver the first medium-sized arrays (30MW+) |
| **Remove financial and market-based blocks to grid-connecting up to ten pilot arrays, and develop a strategy for connecting a pipeline of projects in the 2020–30 timeframe** | 1. Identify, through the Ocean Energy Forum, any financial and/or regulatory barriers to grid-connecting any of the first pilot arrays aiming for financial close before or during 2020  
2. If this study demonstrates that projects are blocked by grid-related barriers, then the Forum should work with relevant actors (e.g. Member States’ regulators, DSOs, TSOs, DG ENER, ENTSO-E, etc.) to evaluate alternative options, such as delivering off-grid solutions or compensating developers for delayed connections  
3. The Ocean Energy Forum should set the terms of reference for a strategic study of the short-, medium- and long-term barriers to connecting wave and tidal projects. This study should involve DG ENER and key Member States’ organisations, and should be linked to a robust assessment of the pace and location of developments for 2030 and 2050 |
| **Develop clear and flexible European Commission State Aid checks for financing up to ten pilot arrays in Europe** | 1. Bring together actors with State Aid experience to identify common characteristics and recommend a standardised approach for early projects up to 2020. Investigate possibility of fast-tracking State Aid approval  
2. Deliver recommendations for future European Commission State Aid checks, and provide guidelines for all Member States on progressively reducing support for wave and tidal energy projects as they become more competitive to 2030 and beyond |
| **Supporting Innovation – continue to push game-changers, challengers and frontrunners up the Technology Readiness Levels TRL1–8** | 1. TP Ocean should provide detailed recommendations on how many technologies should be funded at each TRL stage to ensure a viable pipeline of innovation and R&D investment  
2. TP Ocean should then validate innovation targets and recommendations from SI Ocean. A set of more detailed pathways outlining industry-wide targets for innovation, such as cost reduction, reliability improvement and yield increase, could also be published  
3. Ocean Energy Europe and TP Ocean should foster a more strategic approach to submitting and assessing funding applications from industry and research institutions  
4. Ocean Energy Europe and Member States’ trade associations should improve coordination services at the European level with consortium brokerage, workshops and information exchange, between potential applicants for Horizon 2020 and Member States’ calls  
5. Member States, Ocean Energy Forum and relevant European Commission bodies should identify workable options for co-investment and risk-sharing to encourage more private equity investment in innovation from TRL1–8, including ‘super funds’, based on expert professional advice from the finance community and prospective investors  
6. Member States and the European Commission should share lessons and develop best practice processes for conducting thorough due diligence on grant applications based on expert evaluations of the commercial, financial, technical and operational prospects of each project |
| **Trigger early investment in materials, supply chain components and services, enabling innovation, standardisation and cost reduction** | 1. TP Ocean to identify common standards for supply chain components to focus investment in a single component suitable for multiple developers  
2. Member States and the European Commission to include supply chain innovations on their R&D funding agendas |
CHAPTER III
Delivering Reliable and Affordable Technology
CHAPTER III – Delivering Reliable and Affordable Technology

This chapter builds on the following previously published SI Ocean reports: The Technology Status Report\(^{18}\) (December 2012), The Cost of Energy Assessment Report\(^{19}\) (May 2013) the Technology Gaps and Barriers Report\(^{20}\) (November 2013) and the Strategic Technology Agenda\(^{21}\) (February 2014). These reports assessed the wave and tidal industry’s potential to overcome the technology innovation challenges it faces, focusing on reliability improvement, yield increase and cost reductions both at the design and deployment stages.

3.1. The Status of Ocean Energy Technology

The SI Ocean Strategic Technology Agenda, published in February this year, confirmed that wave and tidal technology developers have made significant progress in recent years. The most advanced devices have undergone multiple design improvements and have sustained full-scale testing in operational conditions as stand-alone demonstration projects, which have generated over 10GWh of electricity\(^{22}\).

Tidal technologies are expected to commercialise earlier than wave technologies, as evidenced by the number of tidal concepts that have managed to generate electricity during full-scale demonstration with devices of 1MW or more. Tidal energy concepts present a greater convergence in design, with the majority of developers opting for horizontal-axis turbine concepts.

Wave energy devices have not yet reached the same stage of development. Fewer concepts have undergone large-scale testing, and the sector presents a vast number of different concepts, with no clear convergence in design. This is partly due to the different characteristics of the wave resources available at various water depths, which will ultimately require different technical solutions for power capture.

At this stage, significant innovation and further technology development will be crucial to delivering reliable and cost-effective wave and tidal technologies and to positioning these sectors as a major source of electricity supply for the future. The SI Ocean Strategic Technology Agenda has proposed a series of approaches and priority topics to progress these technologies in the short and medium term.

3.1.1 Cost Reductions via Technology Development and Deployment

Delivering reliable and cost-effective technologies will be paramount to the ultimate commercial success of Europe’s wave and tidal industry in the medium term.

Commercial arrays will not reach the water without significant cost reductions through innovation, and increasing the performance and reliability of successive iterations of prototypes and demonstrators. In the short-term, demonstrating strong potential for cost reduction will send the right signals for further market support and investment. In the medium-term, as the roll-out of larger-scale tidal and wave energy arrays across multiple markets starts to happen, policy makers will need to see real and continued cost reductions to justify continued financial support.

Reducing the LCOE (see Figure 5) of wave and tidal energy technologies will hinge on progress on two fronts: a) technology development at the research and design stage; and b) full-scale deployment of arrays to demonstrate the first cost reduction from initial volume production. This second stage will be essential to proving that these technologies can work their way down the cost curve and achieve similar cost reduction profiles to other, more mature renewable energy technologies.

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\(^{22}\) Marine Current Turbines, a Siemens Company, has produced 9 GWh in Stranford Lough alone.
Cost reduction will be driven by:

- **Increased Performance**: increasing energy yield and economic return by improving power capture, reliability and survivability.
- **Innovation**: step changes – new devices or concepts, alongside new and improved components, sub-components, and materials for proven concepts.
- **Experience**: optimising production, installation and operations through learning by doing.
- **Economies of Scale**: volume manufacture, fixed maintenance costs spread over a larger number of devices (lower CAPEX and OPEX per device) and increasing the scale of converters (lower cost/capacity).

### 3.2. Cost Reduction: Focusing on Survivability, Availability and Moving Towards Pilot Arrays

The importance of improving the yield from wave and tidal energy devices as a factor in reducing cost cannot be overstated. To get there, the industry must specifically focus on improving survivability, reliability and availability.

- **Survivability**: wave and tidal energy converters must be able to survive both their expected operational loading, and also the extreme loading seen during storm conditions. The ratio of extreme loads to operational loads is greater for wave energy than it is for tidal energy, so the challenge is steeper for wave energy converters.
- **Reliability and Availability**: increased reliability and minimising downtime will improve yield production and reduce the frequency of unplanned maintenance requirements. This can be achieved by improving the design, component selection and better testing of the ‘mean time between failure’ and operational life expectancy of devices.

It should also be noted that prioritising onshore testing of survivability, component life expectancy, etc., can offer early wins in cost reduction – by helping to cut the very considerable cost of sea trials while also improving results.

#### 3.2.1. Innovation in Wave and Tidal Energy Devices: Improving Existing Devices, Identifying Game-Changers

Validating the performance and reliability of devices in real sea conditions is essential. The Strategic Technology Agenda concludes that in the short term, technology should operate with a capacity factor >25% and an availability factor of at least 75–85%. This will help to mitigate risk for potential investors. These figures should then be revised upwards, in line with technology development and operational experience.

Currently there are many competing Wave Energy Converter (WEC) designs. Improvements to power output, reliability and survivability will be necessary before a consensus on the most promising design concepts can emerge. Innovation should encourage solutions optimised for two main locations – near-shore and offshore wave resources – and improving their efficiency and cost profile.
3.2.2. **Innovation in Components and Sub-components**

Failure of components and sub-components can have a huge impact on the LCOE of projects. Unscheduled maintenance can stop operations until a repair crew is sent out, sea conditions permitting. Optimising the design of critical sub-systems will help minimise the impact of unplanned maintenance events. These sub-systems include:

- Foundations and moorings
- Support structures
- Power take-off systems (PTOs)
- Power electronics
- Control systems
- Sensors

3.2.3. **Test and Demonstration Facilities: Setting Testing Standards, Facilitating Access, Enhancing EU Coordination**

Developing standards and guidelines for testing and demonstrating components, scale devices, full-scale devices and the first arrays will accelerate technology progress for the entire industry. Clear standards and guidelines for testing protocols and evaluating results will also encourage investment from the supply chain.

Access to offshore and onshore testing facilities could also be improved across Europe. Options include: subsidising costs; providing infrastructure; and/or improving facilities. Integrating facilities for trialling electrical infrastructure into existing and new test centres will also be important. Channeling financial assistance from the European Commission and from Member States towards building a stronger, more accessible network of European testing facilities will provide much-needed support for developers at all TRLs.

Improving coordination between European facilities should also be a priority. This would promote knowledge sharing and avoid unnecessary replication of testing in different countries and/or test centres. Programmes such as the successful MARI-NET Programme\(^{23}\) have helped in this regard, and future programmes aimed at facilitating testing should be prioritised.

3.2.4. **Enabling Wave and Tidal Energy Grid Integration**

Without action, grid integration issues are likely to hinder the development of wave and tidal pilots and early arrays. Technical guidelines and standards for grid integration and connection need to be developed in coordination with other onshore and offshore energy sectors.

In the short term the industry requires marinised electrical systems for devices which are ready for pilot array, including:

- Array electrical systems
  - Sub-sea electrical systems allowing the interconnection of multiple devices to reduce cost
  - Sub-sea umbilicals and wet-mate MV connectors
- Array interaction analysis /modelling

3.2.5. **Improving Technology through Collaborative R&D Programmes, Demonstration and Testing**

Technology development and innovation can be best delivered via a strong collaboration between industry, research institutions, Member State governments and European Commission organisations. This type of coordination will help guarantee that ongoing R&D programmes can be tailored, year after year, to the needs of the industry, and focused on “live” issues.

There is also scope for better coordination within the industry. Decision-makers require certainty that the support on offer fits into a wider, strategic plan for advancing the whole industry. There is a strong role for TP Ocean\(^{24}\) and the Ocean Energy Forum in facilitating better coordination and recommending strategic priorities for policy and financial support.

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\(^{23}\) The Marine Renewables Infrastructure Network is a network of research centres and test facilities offering free-of-charge access to facilities for wave, tidal stream and offshore wind, funded by the European Commission’s FP7 programme. http://www.fp7-marinet.eu/

\(^{24}\) Details about TP Ocean are available here: http://www.oceanenergy-europe.eu/index.php?tpocean/tpocean
3.3. Reducing Costs for Commercial Arrays through Increased Deployment and Improved O&M

3.3.1. Cost Reduction Potential to 2030

Technology innovation and learning by doing must be translated into a comprehensive cost-reduction pathway\(^25\) if wave and tidal energy technologies are to achieve cost competitiveness on commercial markets.

Long-term cost reduction will be achieved by pure innovation; by standardising processes and components during the design phase; and by increasing competition. SI Ocean has found that learning rates could deliver a 12% cost reduction for every doubling of a repetitive activity\(^26\).

Increased deployment will increase experience and decrease risk. This will also have a positive impact on key elements of the LCOE, such as the cost of capital and insurance premiums, both of which are significant costs for CAPEX-intensive new technologies.

Cost reduction can also be delivered by developing common R&D actions with offshore wind. Both industries share offshore synergies with regards to grid infrastructure, equipment, operations and maintenance procedures, as well as project development and permitting processes.

Recent research carried out by the SI Ocean consortium partner JRC indicates that offshore wind and wave and tidal projects could have component and project synergies of up to 40%. This represents another avenue for future cost reduction, and indicates the value of investigating opportunities for shared R&D into key components and processes with potential for application in both sectors (see Figure 6).

By 2030, further R&D programmes, joint research and industrial initiatives could deliver significant cost reductions. Collective efforts will need to focus on:

- Design consensus on off-the-shelf technologies
- Installation, operations and maintenance procedures (e.g. specialised station-keeping/cable-handling capability)
- Optimisation and standardisation of serial manufacturing of converters and materials

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3.2.2. Installation, Operations and Maintenance Innovation

Current installation costs for wave and tidal energy prototype projects are prohibitively high. Installation presently makes up 18% of lifetime costs for a wave array and 27% of lifetime costs for a tidal array, considering both floating wave and bottom-mounted tidal arrays.

Developing best practice procedures for installation, operations and maintenance will share knowledge and experience across the industry and drive cost reductions. This can only be done by deploying the first pilot arrays as soon as possible to generate cross-sector experience of installation, maintenance and retrieval of devices, thereby pinpointing opportunities for reducing CAPEX and OPEX.

In some circumstances, wave and tidal energy installations use offshore vessels from the oil and gas industry, at costs of between €120,000 and €180,000 per day. These vessels are neither cost-effective nor optimised for wave and tidal operating conditions, especially in the case of aggressive tidal flows. Optimised vessels will offer another potential source of cost reduction.

3.2.3. Tools to Support Array Deployment

Specific tools need to be developed to accelerate array deployment and improve their cost profile. These include:

- Resource analysis tools
- Array design and modelling tools
- Predictive maintenance systems
- Tools for linking met-ocean conditions to maintenance schedules
- Standardised procedures for installation, maintenance and retrieval of devices
- Knowledge transfer and dissemination

An influx of co-financed technology grants for inter-array R&D will be needed to drive cost reduction and streamline array operations.

3.4. Supply Chain Innovation Providing Reliability and Affordability

3.4.1. Standardisation of Devices and Components

Significant cost reductions can be achieved from supply chain sub-component innovation (in the PTOs, control, structure and prime mover, foundations and moorings) as well as in the electrical cabling (cables, connectors and switchgear). Identifying common components will help reduce costs by driving down CAPEX and ramping up volume manufacturing.

Examples from the wind industry show that standard blades and electrical equipment have enabled OEMs to reduce costs by developing products incorporating off-the-shelf components. In the wave and tidal energy sectors, industry collaboration will be needed to identify common device components and sub-components, and to reach consensus standard specifications.

Standard off-the-shelf components will significantly reduce costs by avoiding the need for customised solutions developed for individual devices and enabling initial economies of scale. This would also help the supply chain to focus innovation on key products for which there will be an early market. For this to happen, a robust understanding of the requirements and potential issues for each component will be required.

3.4.2. Industrial Leadership: Mass Manufacturing to Deploy Large-Scale Arrays

In the long term, significant cost reduction will only be achieved by unlocking economies of scale via mass production. Europe can achieve its full wave and tidal energy deployment potential by 2050 by supporting the development of a cost-efficient manufacturing capacity, which will enable it to take full advantage of a large home market.

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This critical step can only begin when significant numbers of pilot arrays have demonstrated viability, which will stimulate cooperation with the supply chain as the industry starts to move towards standardised manufacturing and the mass production of converters and infrastructure.

### 3.5. Key Technology Recommendations

The ultimate goal for wave and tidal energy is to deliver reliable and efficient technology at a reasonable cost. This will require a twin-track support framework aimed at providing capital support for ongoing development and innovation alongside deployment and demonstration of technologies in pilot arrays. This will require a combination of capital and revenue support in the short term, but ultimately unlock cost reduction via innovation and economies of scale. Providing capital support for novel approaches should also ensure step-change breakthroughs make their contribution.

Achieving the necessary medium-term cost reduction will require a balance of design consensus, standardisation of devices and components, and integration of the supply chain to facilitate economies of scale via mass production.

Delivering reliable and affordable wave and tidal energy technology will require commitment and coordinated activity from stakeholders across Europe. The newly formed TP Ocean and the European Energy Research Alliance Joint programme for Ocean Energy (EERA Ocean Energy JP) are both key to facilitating joint industry and academic R&D programmes, in collaboration with EU and government institutions.

### Goal | Recommendation
--- | ---
**Accelerate technology innovation aimed at reducing costs, improving reliability and increasing yield, via research and design as well as deployment**

1. TP Ocean and the European Research Alliance to identify industry-wide targets for innovation and deliver a set of detailed pathways for key targets such as cost-reduction
2. Focus European Commission and Member State calls for collaborative projects (covering research, innovation and deployment) aimed at decreasing LCOE by improving:
   - Yield, reliability, availability and survivability of devices
   - Cost and performance of components, sub-components and materials
   - Technical grid integration solutions
3. Facilitate access to onshore and offshore testing facilities; devise testing standards, and prioritise testing of components, materials and subcomponents, as well as full-scale devices

**Deliver medium-term cost reductions through economies of scale by investing in development, innovation and demonstration of pilot arrays today**

1. Develop tools to support array deployment
2. Focus on standardisation to reduce costs by developing ‘off-the-shelf’ devices, components and sub-components
3. Focus on processes and systems for mass manufacturing
4. Share best practice from installation and O&M experience across the industry

**Involve the supply chain and incentivise its innovation potential**

1. Promote knowledge and technology transfer from other offshore industries such as oil & gas or offshore wind
2. Identify and develop common specifications for standard components that will be required by several developers
CHAPTER IV
Regulations and Consent Regimes for Project Development
CHAPTER IV - Regulations and Consenting Regimes for Project Development

Streamlining consenting processes and developing focused environmental monitoring protocols will ensure that early project developers receive consent in a timely fashion, thereby reducing costs and delays. Deploying the first wave and tidal energy arrays is important, but it will be equally important to invest in understanding the potential impact that devices, and arrays of devices, could have on the marine environment. Understanding potential impacts will not only reduce costs and delays; it will also ensure that future arrays are located sensitively with regard to environmental impacts and key maritime stakeholder interests.

Reducing uncertainty over the potential impacts of wave and tidal energy projects will take sustained coordination and collaboration between regulators, environmental advisors, stakeholders, developers and researchers.

4.1. Current Member State Consenting Practices

Implementing strategic plans, simplifying processes and sharing environmental data across the Atlantic Arc will help reduce some of the initial burden on the industry. Coordination of research and information sharing on practical experiences between regulators, marine stakeholders and wave and tidal energy project developers will be integral to delivering a robust and streamlined consenting process.

Real progress has already been made to overcome some of the consenting challenges, but that progress varies widely between Member States, as Figure 7 demonstrates.

**Figure 7 – Consenting processes across the Atlantic Arc (Source: Adapted from ORECCA and SOWFIA project)**

<table>
<thead>
<tr>
<th>Country</th>
<th>Strategic Environmental Assessment for ocean energy</th>
<th>Maritime Spatial Plan in place</th>
<th>‘One-stop-shop’ for consenting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wave</td>
<td>Tidal</td>
<td></td>
</tr>
<tr>
<td>Denmark</td>
<td>No</td>
<td>No resource</td>
<td>Under development</td>
</tr>
<tr>
<td>France</td>
<td>No</td>
<td>No</td>
<td>Under development</td>
</tr>
<tr>
<td>Ireland</td>
<td>Yes</td>
<td>Near completion</td>
<td>No</td>
</tr>
<tr>
<td>Portugal</td>
<td>No</td>
<td>No resource</td>
<td>Yes</td>
</tr>
<tr>
<td>Spain</td>
<td>No</td>
<td>No resource</td>
<td>Yes**</td>
</tr>
<tr>
<td>UK – Scotland</td>
<td>Yes</td>
<td>Yes</td>
<td>Near completion***</td>
</tr>
<tr>
<td>UK – England</td>
<td>Yes</td>
<td>Yes</td>
<td>Under development</td>
</tr>
<tr>
<td>UK – Wales</td>
<td>Yes</td>
<td>Yes</td>
<td>Under development</td>
</tr>
<tr>
<td>UK – Northern Ireland</td>
<td>Yes</td>
<td>Yes</td>
<td>Under development</td>
</tr>
</tbody>
</table>

* Dedicated consenting but not fully streamlined yet (encompasses 4 different authorities)
** Adopted under the Marine Strategy Framework Directive
*** Draft National Marine Plan for Scotland has been through public consultation, but final plan is yet to be published.
Across Europe, three key areas for improvement have been suggested for Member States and the European Commission to help encourage positive changes in the consenting and environmental monitoring process.

1. Improving environmental planning
2. Simplifying consenting and environmental processes
3. Promoting best practices

### 4.2. Strategic and Environmental Planning Programme

Member States hold the responsibility for shaping the regulatory framework for wave and tidal energy developers and stakeholders. EU conservation legislation, especially the Habitats Directive\(^{29}\), the Birds Directive\(^{30}\), and the establishment of marine Natura 2000 sites, places the onus on Member States to protect the marine environment.

Direction on Maritime Spatial Planning (MSP), stakeholder consultations and Strategic Environmental Assessments (SEA) from the Member States and the European Commission can help overcome potential conflicts of interest.

Existing regulatory regimes and institutions within Member States are more familiar with interpreting European Commission guidelines for traditional maritime uses (e.g. Oil & Gas, shipping, fishing). However, Member States are already working closely with new project developers planning wave and tidal energy installations.

#### 4.2.1. Maritime Spatial Planning: Integrated Planning for all Stakeholders

Spatial planning is needed to maximise the benefits derived from Europe’s seas without compromising their ability to continue to provide benefits for generations to come.

Member States and maritime users will both benefit from the full implementation of Maritime Spatial Planning (MSP) programmes. Factoring in wave and tidal energy installations should be considered as a short- to medium-term priority. Member States should prioritise the introduction of comprehensive spatial planning, with clear guidelines on selecting appropriate areas for wave and tidal energy projects based on a consideration of environmental impacts, other stakeholder interests and economic production potential. With this backing, developers can maintain and build upon the current high levels of public support.

To date, Scotland has developed the most advanced marine planning system in Europe. Scottish regulators have completed extensive public consultation with a wide range of stakeholders on proposed spatial plans for marine renewables (including offshore wind). Once they have been formally adopted, these plans will indicate potential areas for development, which will accompany national and regional marine plans. The other Atlantic Arc countries included in this study have partially developed programmes, with different levels of marine management in place.

#### 4.2.2. Stakeholder Engagement and Consultation Processes

Consultation is an integral part of the project development process. It is best started early and carried out frequently, with enough time to allow concerns to be resolved. Public exhibitions, meetings and documentation are key parts of this process.

Early indications show that wave and tidal power projects enjoy relatively high levels of public support. However, research carried out by the EU SOWFIA project\(^{31}\) found that France is currently facing challenges to improve its consultation process. In contrast, the 2013 full consent of the Aquamarine 40MW wave project – with zero public objections – in Scotland attributed its success to the close consultation with the local community on the Isle of Lewis\(^{32}\).

Good stakeholder engagement should consult and gather stakeholders’ views in a meaningful way so that these views can be incorporated into the project proposal. Successful stakeholder engagement will be essential to delivering early projects and increasing public acceptance of wave and tidal power projects.

4.2.3. **Strategic Environmental Assessments**

Under the SEA EU Directive, all Member States are required to carry out Strategic Environmental Assessments (SEAs). By conducting SEAs, Member States’ regulators will be better informed about suitable locations for, and potential impacts of, wave and tidal power deployment. An SEA does not mitigate the need for site-specific impact investigations to be carried out under the terms of the Environmental Impact Assessment (EIA) Directive. However, conducting a SEA will enable Member States and regions to support the strategic development of wave and/or tidal energy in their jurisdictions.

Several Member States have already realised the strategic merits of conducting a SEA; however, not all have conducted one yet. Scotland was the first country to implement an SEA to evaluate the potential impact of wave and tidal energy, closely followed by the remaining UK regions and Ireland. Concerns have been raised about the broad-brush nature of SEAs, which means that developers are still required to undertake extensive survey work at the project level. However, SEAs can help inform strategic decision-making and eventually guide the location of future wave and tidal energy plans. The development of more detailed SEAs should be explored by all Member States.

4.3. **Streamlining Consenting and Environmental Procedures**

Proactive Member States with a clear commitment to these sectors have already introduced many simplifications to consenting and environmental procedures to support wave and tidal energy deployments, including:

- Tailored and ‘fit-for-purpose’ licensing processes
- ‘One-stop shops’ to streamline and accelerate consenting
- Flexible consenting
- Data gathering proportional to the size of the project and the relative environmental impact
- Data sharing between sites and technologies where applicable

4.3.1. **‘One-stop shops’ for Licences**

A ‘one-stop shop’ for consenting provides developers with a single point of contact, which then coordinates all relevant assessments across several regulatory agencies. Due to the disparate nature of maritime agencies involved in issuing wave and tidal energy licenses, some regimes are still extremely time-consuming and onerous. For example, developing a wave energy project in Spain requires developers to work individually with 16 different agencies, a process which places a significant burden on the developer and does not encourage easy communication and interaction between the relevant parties.

So far, Marine Scotland has provided a one-stop shop for Scottish projects, and the Marine Management Organisation has done the same in England. This system enables developers to focus on gathering necessary data and preparing the information required to inform the consenting process, while the central coordinating authority is well placed to communicate between the relevant agencies and other stakeholders. Developers also benefit from smoother communications on the status of their applications which they can then relay to project stakeholders and potential investors.

Introducing a one-stop shop requires restructuring regulatory agencies, which can take several years. In the interim, increased coordination and communication between agencies is a very useful first step. Parallel processing of consenting stages can also help speed up processes.

4.3.2. **Ensuring Flexibility in the Consenting Process**

Creating flexibility in the consenting process will help more projects to obtain consent. Success will depend on taking the most pragmatic approach possible when it comes to processing individual project applications. Some approaches offer greater flexibility and can potentially be replicated throughout Europe:

1. The ‘Rochdale Envelope’
2. Adaptive Management Approach
3. Phased Deployment
4.3.2.1. The ‘Rochdale Envelope’ Approach

Experience from the offshore wind industry shows that due to long lead times between the first project application and actual construction, some UK projects had to re-apply for consenting as the technology had changed significantly, thereby invalidating the original permit.

The Rochdale Envelope is derived from UK planning law and aims to enable consenting flexibility when reviewing environmental impacts. Developers can apply for consent based on a defined project design envelope, allowing for some details to be confirmed at a later stage. This information can be provided in a Construction Method Statement prior to final sign-off by the regulator, to ensure that the proposals fall within the original design envelope.

However, while the ‘Rochdale Envelope’ approach can be useful when realistic scenarios are used, the use of overly broad project envelopes can cause challenges for regulators and developers alike, resulting in worst-case scenarios which are unrealistic and cause particular challenges when it comes to cumulative impact assessments.

4.3.2.2. New Approaches: Survey, Deploy, Monitor

As a general rule, EIAs require the compilation of at least two years’ data on marine wildlife habitats and migration at a particular site. For many marine energy developments, this can be an overly onerous burden, and one which is disproportionate to the level of environmental risk presented.

In response, the Scottish Government has developed a ‘survey, deploy and monitor’ policy. The intention of the policy is to provide regulators and developers with a ‘risk-based’ approach for taking forward wave and tidal energy proposals. It assesses the ‘risk’ of a development based on the environmental sensitivity of the location, the scale of the development and the type of device being deployed. For those developments deemed to be low-risk, consent determination may be sought using one year of wildlife survey effort and analysis. For higher-risk projects, further survey efforts will still be required.

Rather than a one-size-fits-all approach, Scotland has introduced a risk management process which applies an appropriate and proportionate approach to licensing based on the unique circumstances of individual development proposals. Ultimately, this approach can reduce the cost and time of monitoring and data collection for lower-risk proposals, and should facilitate earlier consenting decisions and more rapid build-out of early projects, as long as they can be defined as lower-risk.

Post-construction impact monitoring is highly likely to be a condition for most consents. The aim is to generate data which will support subsequent applications for either new phases, or new sites. The nature and duration of these conditions will be project-specific and will only be determined and agreed once consent has been secured.

4.3.2.3. Adaptive Management

An Adaptive Management Approach focuses on monitoring devices once they have been deployed, and can be used in conjunction with a ‘survey, deploy and monitor’ policy. Under the adaptive management approach, the regulator stipulates a threshold for acceptable impacts, beyond which a mitigation process is put in place, including device retrieval if necessary. The devices are closely monitored over a long period of time, using a ‘before and after gradient’ approach, to determine whether the threshold has been breached and mitigation is required.

This approach places a high monitoring burden on the developer, which can be very expensive. The possibility of mitigation being required, including device retrieval, adds a further risk of delays and/or additional costs. However, as with the survey, deploy and monitor policy, taking a risk-based approach facilitates the deployment of novel technologies and can provide valuable evidence which can be transferred to a larger number of devices or a different site.

ADAPTIVE MANAGEMENT CASE STUDY

SeaGen 1.2MW Strangford Lough Installation, Northern Ireland

Managing Uncertainty with Appropriate Mitigation Measures

MCT carried out an agreed Adaptive Management Approach for the deployment of its 1.2MW SeaGen device in Strangford Lough, Northern Ireland. The deployment was in a Natura 2000 site, and required monitoring and mitigation in relation to marine mammals, particularly protected Harbour seal species.

There were concerns about the potential for marine mammals to collide with the rotors. Therefore an ongoing Environmental Monitoring Programme (EMP) was created to monitor their interaction. Agreed mitigation procedures were implemented as part of the EMP, including shutting down an operational turbine if a marine mammal was observed within 30 metres of it. No collisions have occurred. The SeaGen deployment is a safe and well monitored deployment, supervised by an independent science group which advises the regulator on the design of the EMP.

Though adaptive management, the EMP will move to a phase where monitoring continues, but the rotors are left running. This will provide information on how marine mammals behave around an operational turbine. The project has had no major impact on the Lough’s marine life.

© Wildlife observers undergoing environmental monitoring of Pelamis at EMEC
PHASED DEPLOYMENT CASE STUDY

**MeyGen 86MW Tidal Farm Consent, Inner Sound, Pentland Firth, Scotland**

*Implementing Incremental Phases to Understand Turbine Interactions*

In September 2013, Meygen was awarded the section 36 consent for 86MW (Phase 1 of the MeyGen Project) at its Inner Sound site in the Pentland Firth in Scotland. The consent is conditional upon the company deploying the turbines in stages.

Condition 2 of the consent limits the first stage of development to an initial demonstration array of up to six turbines\(^{35}\). This stage is due to be commissioned in 2015. This initial phase helps both the regulators and the developer understand the operational impacts and how to mitigate any risks to the environment. This demonstrates a proactive approach to compiling real marine interaction evidence.

4.3.2.4. Phased Deployment Approach

Adopting a ‘phased deployment approach’ can help give regulators and developers more confidence that wave or tidal arrays will have a low impact on the marine environment. Taking a phased approach, regulators can consent an initial phase of a project, which will be a small proportion of the overall development. The deployed devices will then be monitored to assess environmental impacts and interactions. Regulators will only consent future phases of the project if the monitoring outputs of the initial phase show that the environmental impacts are within agreed limits. This approach can be used in conjunction with the survey, deploy and monitor policy.

This approach also places an onerous monitoring burden on developers, and gives the regulator a high degree of discretion as to whether future phases of a project can be built, creating a new risk for the consent of future phases. However, in the face of uncertainty, it makes sense to build a small part of a larger project first. This will generate good evidence about the interactions between marine wildlife and devices at a particular site before the developer moves ahead with expansion. Taking a phased approach will also deliver valuable information about device performance, power production and financial returns of a project.

A phased deployment approach has helped to consent the largest tidal stream project in the world to date.

4.3.3. Ensuring Appropriate Levels of Data and Cost

The level of required environmental data needs to be proportionate to the size of the project and the potential risks associated with the device at a particular location. For smaller projects which carry less environmental concerns, for example, a developer should be able to do one year’s baseline survey work before moving to deployment\(^{36}\). First-mover technology and project developers have so far borne the significant cost of the first EIAs and environmental monitoring programmes. The initial environmental monitoring of Marine Current Turbines’ SeaGen installation cost €1.5 million\(^ {37}\), a huge financial burden for an SME technology developer.

Proportionate baseline and post-consent monitoring are particularly needed for prototypes and single devices, with a focus on defining what data is actually necessary. Striking the right balance will help to simplify the process and get more devices in the water.

Furthermore, research on common environmental questions relating to wave and tidal projects should be undertaken to create a shared knowledge base. This will reduce uncertainty and inform future, larger-scale developments, and should be undertaken in parallel with the deployment of the first arrays. This strategic research should be planned in coordination with regulators, stakeholders, industry and researchers to reduce practical costs that Siemens has incurred since acquiring MCT.

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\(^{35}\) The section 36 consent conditions are listed on the Scottish government website. Condition 2 is on p65 of the Decision Letter Consent and Conditions http://www.scotland.gov.uk/Topics/marine/Licensing/marine/scoping/MeyGen.

\(^{36}\) Similar conclusions have been made for offshore wind. See http://www.marinemanagement.org.uk/evidence/1031.htm, Marine Management Organisation 2014

\(^{37}\) The cumulative cost to date for the SeaGen Environmental Monitoring Programme is in the region of €3 million, including the additional costs that Siemens has incurred since acquiring MCT.
and cost burdens on project developers. Collaborative research in this area will also ensure that the necessary information is available to all stakeholders to inform the development of consenting processes across Europe.

4.3.4. Transferring Relevant Data between Sites and Technologies

Some consenting applications require site-specific baseline and monitoring data. Regulators should consider allowing the use of relevant data from previous monitoring programmes, carried out either at the same site with different technologies, or with the same technology in comparable habitats. The inclusion of this data as supplementary evidence could reduce the amount of time needed to monitor interactions at the project location (for baseline and post-construction monitoring). Implementation of this practice across Europe would help share data and reduce the monitoring process for wave and tidal energy projects.

4.4. Key Consenting Recommendations

Making consenting less burdensome, in terms of both time and costs, while keeping a high standard for environmental integrity, is the main objective of work around consenting and environmental issues.

Planning is the first step to efficient consenting procedures. Making best use of all existing strategic planning tools such as MSP, Stakeholder Consultations and SEAs should help overcome potential conflicts, including with other maritime users, at an early stage.

Consenting procedures should be streamlined. One-stop shops should be generalised across wave and tidal energy countries, as they facilitate the consenting process and remove inefficiencies by providing developers with a single point of contact. Sharing best practices is equally integral to accelerating wave and tidal energy deployment in the short term; transferring processes that enabled successful deployment in one country to other countries is an obvious win-win. Adopting a flexible approach to consenting will help get more projects to construction stage.

Keeping consenting costs in check to avoid overburdening projects is paramount, especially at the early stage. To this end, the level of environmental data required needs to be proportionate to the size of the project and the potential environmental risks associated with the device and its proposed location.

Scotland and the UK have overcome consenting barriers by adopting a series of simplified procedures, such as MSP, SEA and a ‘one-stop shop’ for consenting. Agencies in Ireland, France, Spain, Portugal and Denmark could all benefit from the programmes developed in Scotland and the UK.

The newly formed Ocean Energy Forum is well placed to help disseminate Europe-wide guidance and share best practices, and to help these sectors achieve the following goals:

<table>
<thead>
<tr>
<th>Goal</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allow for integration of wave and tidal energy in long-term planning and with existing ocean users</td>
<td>1. Finalise implementation of Maritime Spatial Planning and Strategic Environmental Assessments directives across the Atlantic Arc 2. Disseminate best practices for successful stakeholder engagement, including regulators, project developers and other industries</td>
</tr>
<tr>
<td>Streamline and accelerate the consenting processes by removing excessive administrative and cost burdens</td>
<td>1. Generalise the use of ‘one-stop shops’ for project consenting in all EU countries 2. Ensure reasonable requirements for data collection to keep costs and delays in check 3. Allow for flexibility in project consenting – survey, deploy, monitor 4. Ensure environmental monitoring data can be used as evidence for other projects and technologies</td>
</tr>
</tbody>
</table>
CHAPTER V
Removing Grid Barriers to Wave and Tidal Energy Projects
CHAPTER V - Removing Grid Barriers to Wave and Tidal Energy Projects

5.1. Grid Issues affecting the Wave and Tidal Energy Industry

Grid poses a costly and difficult infrastructure challenge for wave and tidal energy projects today. Relatively few sites in Europe have the right mix of resource, reasonably sheltered waters nearby, infrastructure to support deployment and O&M, and grid access.

SI Ocean resource work has shown that the best wave energy resources are on the western fringes of northern Europe, while tidal energy resources are concentrated in a relatively small number of sites with high flow velocities. These areas are often far from significant grid connections and are unable to integrate wave and tidal energy electricity into the grid.

The cost of grid upgrades is high. In some cases, upgrade costs can be equivalent to the total capital costs of the early arrays to be connected (for hundreds of MW capacity). The burden of underwriting grid upgrades in some countries falls directly upon the projects wishing to connect. Further to this, high connection charges and use-of-system charges are making early wave and tidal energy deployments unfeasible in many of the best sites.

The up-front costs for developing and grid-connecting wave and tidal energy projects pose significant risk, as projects may not have received consent or have finalised the site design before they are required to spend significant amounts on development and even larger amounts to secure grid connections. These costs can potentially cripple wave and tidal energy projects.

On the other side, regulators are hesitant to facilitate grid connections and upgrades until it is certain that the industry can connect to them on time and fully utilise them at scale. This is causing substantial investor uncertainty in the industry. The grid situation varies across Member States in the Atlantic Arc, as shown in Figure 8.

GRID CONSTRAINT CASE STUDY

Argyll Tidal Limited (ATL) & Nautricity, Mull of Kintyre Project, Scotland

Grid Constraints Impacting on the Development of 3MW Tidal Project

In October 2011, Argyll Tidal Limited entered into an Agreement for Lease from The Crown Estate for a 3MW demonstration array off the western coast of the Mull of Kintyre, Argyll and Bute, Scotland.

The original plan was to deploy up to six of Nautricity’s 500kW CoRMaT devices at the site\(^\text{38}\). During the feasibility and design stages of the project, ATL sought a grid connection offer from the local Distribution Network Operator, Scottish Hydro Electric Power Distribution (SHEPD).

Due to transmission network constraints in the wider region, it became clear that without construction of extensive and costly new grid infrastructure, it would not be possible to connect more than a single 500kW CoRMaT device to the existing electricity network.

This constraint has considerably hampered the ability for ATL and Nautricity to develop plans to deliver their demonstrator array and make full use of their Agreement for Lease from The Crown Estate.

\(^{38}\) Details of ATL and Nautricity’s Mull of Kintyre project grid issues can be found here: [http://www.nautricity.com/docs/014_036__argylltidal_environmentalappraisal_dec13_lores3_1392661149.pdf](http://www.nautricity.com/docs/014_036__argylltidal_environmentalappraisal_dec13_lores3_1392661149.pdf)
**Figure 8 – Grid issue comparison between Atlantic Arc countries**

<table>
<thead>
<tr>
<th>Country</th>
<th>Priority Time Frames*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>Wave resources are far from shore based grid infrastructure. Grid connectivity challenges will be likely in the future</td>
</tr>
<tr>
<td></td>
<td>Grid companies required to upgrade grid for renewables when requested</td>
</tr>
<tr>
<td></td>
<td>Under development: Smart Grid Network to integrate electricity from small producers</td>
</tr>
<tr>
<td>France</td>
<td>Good grid capacity near coastal tidal resources</td>
</tr>
<tr>
<td></td>
<td>RTE commissioned to study grid requirements for tidal energy projects in Cotentin Peninsula and Brittany</td>
</tr>
<tr>
<td></td>
<td>Modifications to the grid are expected for future array installations</td>
</tr>
<tr>
<td>Ireland</td>
<td>Grid challenges: wave resources are located off the west coast, while most of the grid is in the east of Ireland</td>
</tr>
<tr>
<td></td>
<td>Good options are in place for connecting the first planned projects</td>
</tr>
<tr>
<td></td>
<td>‘2008 All Island Grid Study’ led to an upgrade program</td>
</tr>
<tr>
<td></td>
<td>EirGrid progressing €4bn Grid25 and DS3 grid upgrade programs</td>
</tr>
<tr>
<td>Portugal</td>
<td>Strong grid: 600km infrastructure along the coast. Connection costs not insignificant</td>
</tr>
<tr>
<td>Spain</td>
<td>Strong mainland grid. Northern Spain – 2GW capacity for renewables already along the coastline</td>
</tr>
<tr>
<td></td>
<td>Future connectivity between 7 islands in Canary Islands is required</td>
</tr>
<tr>
<td>UK</td>
<td>Poor grid infrastructure in areas of high resource, particularly on the Scottish islands</td>
</tr>
<tr>
<td></td>
<td>Island transmission charging in Scotland is under review, but will continue to be expensive without additional government support</td>
</tr>
</tbody>
</table>

* Priorities within the short, medium and long-term time scales. Colours (Green/Amber/Red) refer to how critical the issue is.
5.2. Short-term Interim Solutions for Small/Early Wave and Tidal Demonstration Projects

For some early demonstration projects, grid issues are delaying financial close and/or deployment. This calls for interim solutions, though these have serious limitations.

Resorting to ‘off-grid’ or ‘near-off-grid’ solutions for pilot arrays (where the electricity is used close-to-source rather than connecting and transmitting into the national grid) is one option, though it is difficult to implement. Ice factories and data-centres could potentially be used to absorb ocean electricity; and electric heating or electric transport technologies are also being investigated. However, it is likely that the variability of stand-alone wave and tidal energy production will require some kind of backup which prohibits full ‘off-grid’ operations.

Distributed electricity storage might also be considered, enabling a smaller grid connection (or continuous load) to accept fluctuating power from the earliest tidal or wave arrays. In order to benefit pilot array projects, energy storage could be included as a ‘small grid’ solution. That said, storage technologies remain at an early stage, limiting the usefulness of this solution.

While staying close to existing grid connections might seem a short-term solution, going for the best resource can make the difference between earning revenue and losing money on a project. Transmission costs have a strong impact on a project’s LCOE, and energy resource is at the core of internal rate of return (IRR) calculations. Additionally, early demonstration arrays are often funded because of the potential to build out larger arrays of the same technology at a later stage, which is only practical in areas with a good resource.

Medium and long-term solutions to grid availability have to be developed in addition to considering the interim solutions outlined above, especially given these solutions’ limitations (see also 5.4.1 and 5.4.2).

5.3. Reducing Project Grid Costs – Collaboration and Public Support

Grid access has historically been a State responsibility. In the past, grid infrastructure was strategically planned and supported by the State to facilitate connections for new generation sources such as nuclear power. Today, this responsibility is shared between different actors (regulators, grid owners, the State, and electricity generators).
However, new entrants developing novel and already expensive technologies cannot be expected to bear the full cost of grid connection.

Grid connection costs and transmission charges are significant and vary greatly between different sites and countries (see Figure 8). Costs depend on the distance to the main grid system, and also on the policy mechanisms which are used to calculate charges and how they are allocated. There is a large variance in costs between connecting an array off the Outer Hebrides (Scotland) and an array at the Raz Blanchard (West Normandy), close to high voltage lines on the French grid 39.

SI Ocean respondents have stated that there is some uncertainty from regulators and transmission companies about who will be responsible for paying for grid costs, and how liabilities for these costs will be distributed. Project developers could, in theory, share the costs of mutually beneficial grid assets to help de-risk project applications and reduce the total financial burden. Such collaboration could provide better access to significant structural funding for grid reinforcements due to the cumulative size of grid extensions. In practice, this is very difficult to achieve, as projects have different financing, permitting and installation timelines, and project developers can be in direct competition.

Furthermore, transmission and distribution network operators in all Member States have a role to play in alleviating the financial burden that project developers face. A first step towards this would be to help network operators to understand the finance and technology-risk challenges associated with marine energy deployment.

5.4. Overcoming Longer-term Grid Limitations

In some cases, pilot projects are not being built in the best array test sites because they cannot connect to the local distribution network. Longer-term solutions are needed to address these issues and enable Europe to exploit its significant wave and tidal resource potential.

Not developing Europe’s sizeable wave and tidal energy resources because they are not located close enough to current transmission systems is not an option. Mechanisms must be found to ensure that projects in some of the most promising locations in the world are not penalised or blocked altogether because of the absence of a grid connection. More overt European-level support would certainly be beneficial here.

5.4.1. Expanding and Reinforcing the Existing Grid and Interconnectors Will Benefit the EU

In the medium and long term, new transmission and distribution infrastructure will need to be built to transfer power from Europe’s fringes to its cities and demand centres. But funding the extension of grid capacity outside of population centres is often a challenge.

The European Commission can assist with interconnector grid plans and coordination of grid development across multiple Member States, including trans-regional interconnection (e.g. Wales–Ireland, England–Belgium–Netherlands, etc.). Member States have a role to play in allowing investments in grid capacity for new and existing renewables, which will be essential to guaranteeing both the security and sustainability of electricity supply in the future.

The level of medium-term investment is extensive 40, and requires cooperation between the industry, other offshore renewable generation (offshore wind), and grid operators to mitigate grid-related risks for stakeholders.

5.4.2. Connecting Projects in High Rather than Low Resource Areas

Beyond general grid strengthening, connecting distant areas to accommodate wave and tidal energy generation can quickly come down to a ‘chicken and egg’ situation: a project cannot be built because there is no grid, and the grid cannot be upgraded because there are no projects.

Any action by the European Commission, even just signalling that grid upgrades will be necessary for the strategic development of the entire industry in many countries, would help in some way to reduce this uncertainty. Both the Europe-

40 DG ENER predicts that €30 billion is needed for northern seas offshore grid development by 2030: http://ec.europa.eu/beps/pdf/cef_brochure.pdf
an Commission and EIB can play a role in financing grid upgrades in the medium term. Several options are available:

1. Wave and tidal energy grid extensions and connections could benefit from EU structural funding. The European Commission has recently started to explore the possibility of combining funding for research and demonstration projects and structural funds. Grid connection has specifically been outlined as a logical component for structural funding, while the wave or tidal project itself could draw funding from Horizon 2020.

2. The EIB can also financially support grid extension projects that are difficult to fund, under its Structured Finance Facility. These initiatives could provide some support for immediate priorities, as well as introducing options for medium- to long-term financing as the industry scales up.

3. Remote island communities could be connected through the Connecting Europe Facility. This instrument is currently reserved for inter-state interconnection, but it could ultimately help reduce connection costs for areas with large untapped resources which are sizeable enough to offer strategic benefits at the EU level.

5.4.3. Integrating Wave and Tidal Energy in Grid Planning

Developing an interconnected offshore grid between countries will enable electricity generated from domestic wave and tidal resources to benefit countries far beyond the Atlantic Arc where the resources are located. Strategic planning should prioritise interconnections and reinforcements that offer the best opportunities to maximise electricity production from sustainable resources within the EU.

Wave and tidal energy should be considered as part of pan-European plans for smart-grid and Member State High Voltage Direct Current (HVDC) interconnectors. Future wave and tidal energy grid requirements should also be incorporated into European strategic plans, including in ENTSO-E’s ten-year plan.

Regulators, policy makers and industry need to collaborate to resolve short- and long-term issues to ensure grid-related issues do not block progress in the wave and tidal sectors. A Europe-wide study assessing Member State grid connection policies for connecting wave and tidal energy projects in the short, medium and long term would be a very useful tool to aid regulators, Member States and project developers in planning future pipelines.

5.5. Key Grid Recommendations

Securing grid investments will require commitment and support from policy makers relative to the strategic significance they hold for the deployment of a major new offshore energy source for Europe. Combining Horizon 2020 funding for demonstration projects with structural funding for grid connection upgrades – as is being explored by the DG ENER – may present a novel solution for removing grid barriers from pilot arrays. Further financial assistance for national grid developments and reinforcements could also be made available from funding sources such as the EIB (Connecting Europe Facility and the Structured Finance Facility).

Policy makers need to ensure that regulators incorporate wave and tidal energy projects into future grid development plans, such as ENTSO-E’s ten-year plan. Coordinated offshore grid planning between wave and tidal energy projects and offshore wind projects could also help alleviate costs in areas where both resources are strong.

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| Explore innovative ways to reduce prohibitive costs and delays for connecting early-stage projects | 1. Use public funding to reduce the weight of grid connection costs for small and early projects  
2. The Ocean Energy Forum to identify ways to provide European network operators with challenges and potential solutions in connecting successive stages of wave and tidal projects |
| Extend the grid to reach the wave and tidal energy resource rather than constraining ocean projects to grid-connected areas | 1. Promote EU grid extensions and interconnections between countries/regions  
2. Integrate wave and tidal energy into short- and long-term grid planning at EU and Member States level  
3. Decentralise EU electricity systems |
SI OCEAN
strategic initiative for ocean energy

SI OCEAN
IEE co-funded project 2012–2014
Areas: Resource assessment, Technology assessment, Market assessment

Wave and Tidal Energy Market Deployment Strategy
conducted by RenewableUK and Ocean Energy Europe

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