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Blue power:
how to get ocean energy working

A Science|Business Special Report
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About this report:

On 19 November 2020, Science|Business organised a private expert roundtable to debate the evolution of the offshore renewable energy sector, in line with the launch of a new European Commission strategy and other policy developments. This report is based broadly on those discussions, but is ultimately a product of Science|Business. As such, the views expressed herein do not necessarily reflect those of individual members of its Network.

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The challenge of ocean energy – in brief

In November 2020, the European Commission published an ambitious new strategy for offshore renewable energy, as part of its bold plans to make Europe the first climate-neutral continent by 2050. The strategy outlines 28 actions to boost a sector and market which could be worth a potential €53 billion annually by the middle of the century. It also seeks to secure Europe's leadership and industrial competitiveness at a global level, at a time when the US, Canada, China and other nations are similarly ramping up their investments and policy commitments.

However, experts say, there are crucial issues still to be addressed. While offshore wind and solar technologies have proven their reliability and performance, other sources like tidal and wave lag behind, for various reasons. One reason is that there are wide differences in technology readiness levels in the offshore renewable sector, most of it due to the rough conditions in which it operates. This leads to increased production costs, which makes investors sceptical. Moreover, there is no political consensus on how to help or support the sector. The Commission suggests that €800 billion of (mostly private) funding will be needed to achieve its long-term goals for the sector, but a compelling investment case remains elusive.

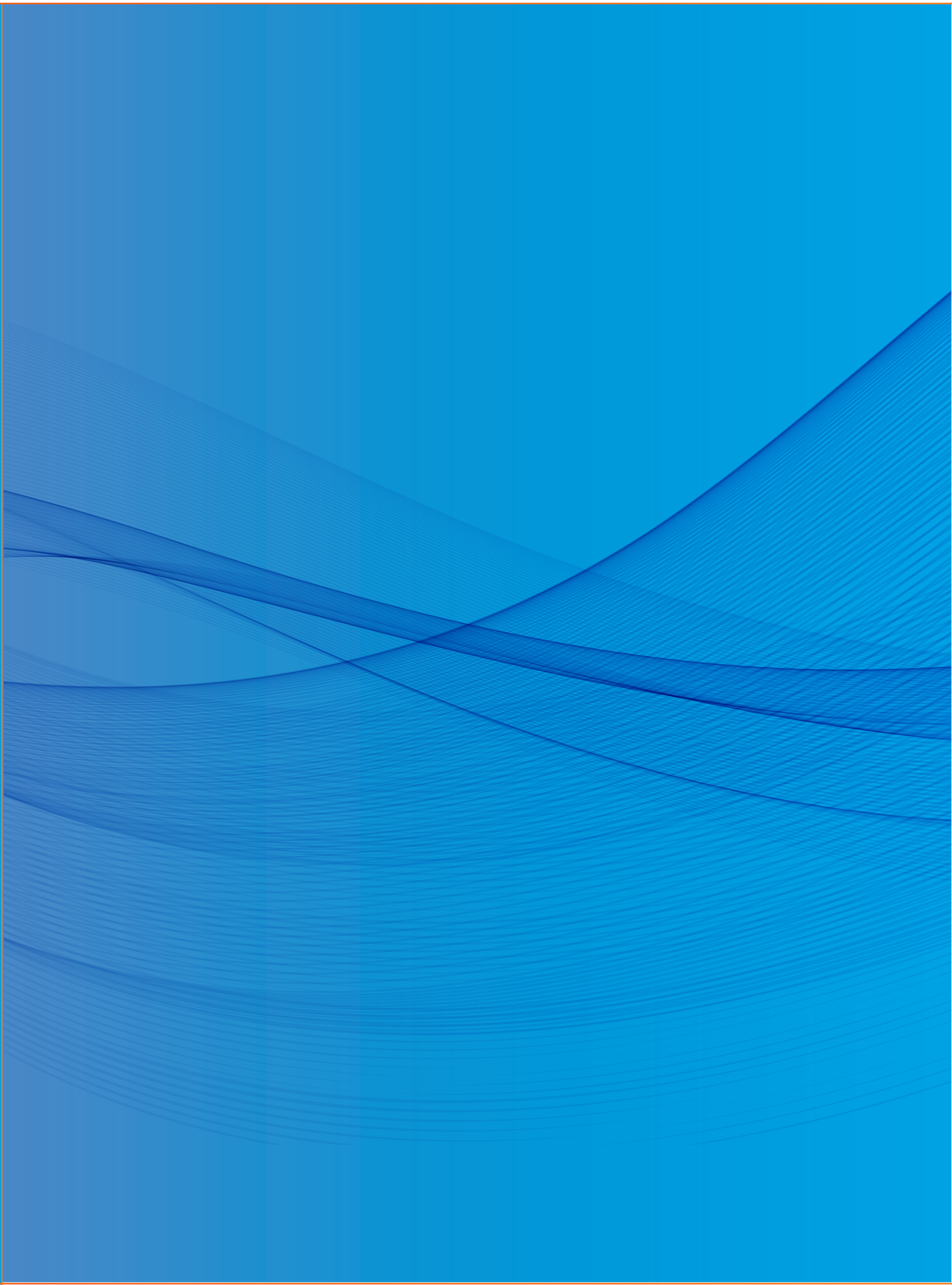
Even so, the race is on. Globally, there are around 40 test and demonstration centres in ocean energy. Australia recently launched a A$330 million (€205 million) research project to boost its ocean energy sector. Canada ranks fourth globally in terms of total installed tidal power capacity. China recently approved its first temporary feed-in tariff policy. India is pushing forward with ocean energy investments, and the US is allocating several millions to different R&D projects focusing on next generation marine energy devices. Meanwhile, Europe is currently taking a lead in wave and tidal patents globally.

The purpose of this Science|Business special report is to shine a light on some of the key challenges and opportunities facing ocean energy leaders today, in an increasingly important domain for R&D, energy, industrial and climate policy. In addition, the report lists a range of options, suggested by experts at a 19 November 2020 Science|Business online event, which could help national governments, agencies and other stakeholders accelerate progress.

In short, we need to develop better metrics to assess and increase technological competitiveness, such as standardisation on technology testing or methodologies. We need to share more data among researchers and companies in the sector. More subsidies and other form of public support are needed to entice private investors. Public agencies also have vital roles to play in encouraging synergies with other energy sources and the shared use of grid infrastructures. And we need far more international cooperation.

Rémi Gruet,
Chief Executive Officer,
Ocean Energy Europe.

Roland Roesch,
Director-General,
Innovation and
Technology Center,
International
Renewable Energy
Agency.



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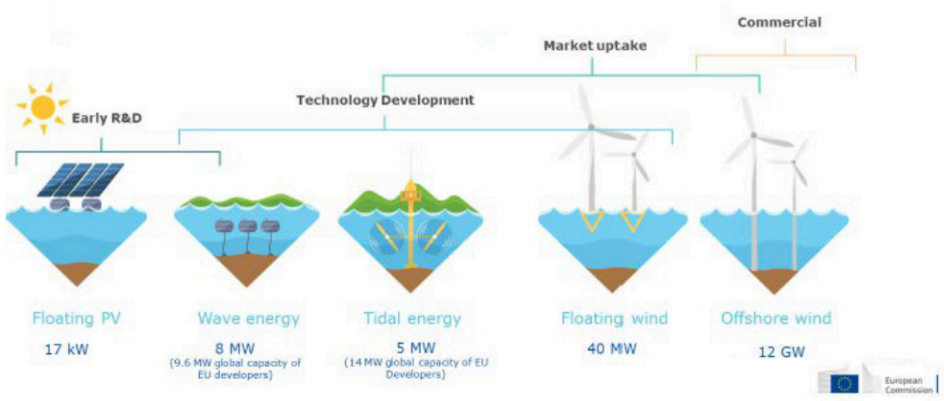
I. The context

As the United Nations launches its “Decade of Ocean Science for Sustainable Development (2021 – 2030)”, the prospect of sourcing clean energy at scale from the marine environment is starting to attract serious attention from policy makers, industry and leading research and innovation agencies alike.

Covering two-thirds of the earth’s surface, the ocean holds tremendous energy resource potential. The European Green Deal emphasises a key role for marine renewable energy in the transition to a climate-neutral economy; and in November 2020 the European Commission published an ambitious new strategy for offshore renewables. Meanwhile, other countries such as Canada, Australia, China, the UK, and a handful of EU member states (notably France, Ireland, Portugal and Denmark) are already investing significantly in solar, wind, tidal and wave power projects.

According to the industry association Ocean Energy Europe (OEE), the global ocean energy market could be worth up to €53 billion annually by 2050 – large enough to merit a strategic approach to securing technology leadership and first-mover advantages.

Offshore renewable energy technologies



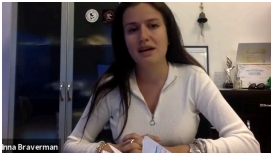
Cumulative installed capacity of five offshore renewable energy technologies in Europe 2019, highlighting different technology readiness levels. Offshore wind is at commercial stage, while wave (TRL 5-6) and tidal (TRL 7-9) energy are still in development.

Source: Joint Research Centre (2019)

Today, Europe is well positioned to be a leader in this technology, holding around 23% of all ocean energy patents globally, including by far the largest shares in tidal and wave. What is more, the EU27 and UK offshore wind market combined represents over 75% of installed capacity worldwide. The current level of floating wind and offshore wind capacity is about 12,04 GW, while tidal and wave accounts for 13 MW.

According to the Commission’s SET-Plan Ocean Energy Implementation Plan, this technological base – coupled with the need to stay close to the resource to reduce costs – will ensure that manufacturing remains in the region, helping to establish a powerful new industrial sector in Europe. Nonetheless, a concern persists that growing competition from countries like Canada and China could leave Europe behind if a range of critical steps are not taken, both in terms of policy leadership and investment.

Stephen Wyatt, Research and Innovation Director, Offshore Renewable Energy Catapult.



Inna Braverman, Board Member, Founder and CEO, Eco Wave Power Ltd.

That said, there are two more positive ways of looking at the situation. The first is that increased visibility for, and competition within, the sector could lead to more international collaboration opportunities. Currently, a series of pilot projects involve both European and Canadian companies in the Bay of Fundy. A strengthening of cross-border, even transatlantic, cooperation could help to mature the scientific research and innovative technologies needed to advance the sector. The second positive view is that all this activity may lead to a growth in global market size, and thereby in its appeal to a broad spectrum of investors – both, vital factors in accelerating the transition to more sustainable energy sources in the years ahead.

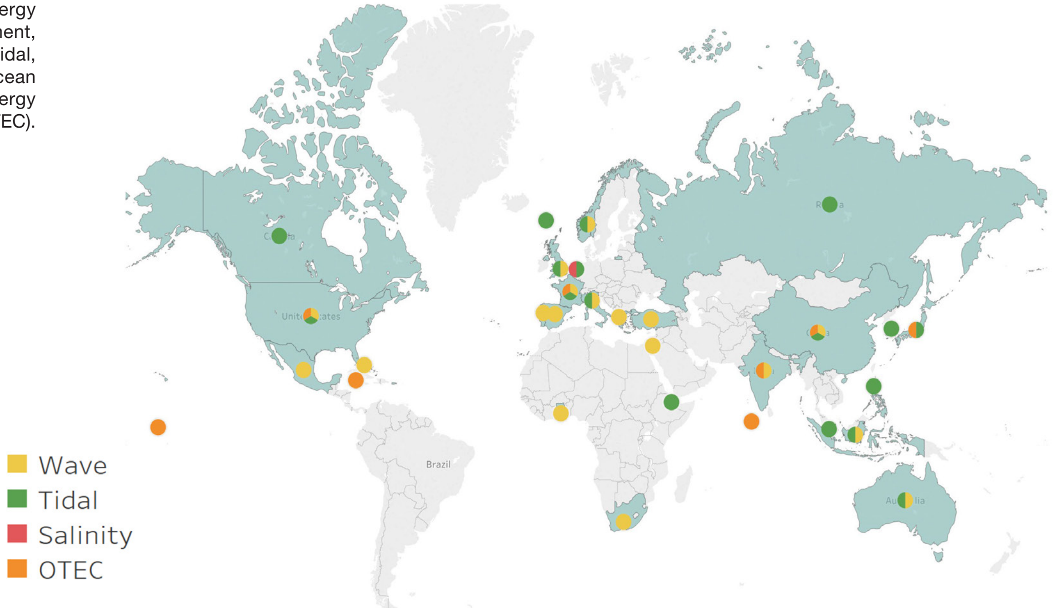
On 19 November 2020, the same day that the Commission launched its new offshore renewables strategy, Science|Business convened a private expert roundtable with leaders from the public and private sectors, plus senior representatives from academia and research and innovation organisations. The discussion paid particular attention to the growth prospects for tidal and ocean wind energy, given their relative immaturity compared to onshore wind and solar. The overall objective, however, was to identify current challenges facing the marine renewable energy sector, and in parallel to explore growth and scaling opportunities.

II. The state of ocean energy

Global ocean energy electricity continues to rise annually – by 19% in 2019 alone, according to the International Energy Agency (IEA). However, to be aligned with the IEA's Sustainable Development Scenario, a further boost of 23% annually to 2030 is needed. The challenges facing the sector as it seeks to expand are broadly similar across the globe. These include deficiencies in finance, global supply chains, infrastructure in some places, knowledge, technology standardisation, and market size. These problems are particularly pressing for tidal and wave energy, which are currently at pilot farm and prototype stage, respectively. Today, there are around 40 test and demonstration centres in ocean energy globally. Herewith, an overview of some of the most advanced countries in the world.

Countries active in the ocean energy sector (deployed and / or pipeline projects)

Global ocean energy deployment, in wave, tidal, salinity and ocean thermal energy conversion (OTEC).



Source: International Renewable Energy Agency (2020)

Australia has a long and largely deep-water coastline, and has advanced quickly in ocean energy. In April 2019, the government launched a A$330 million (€205 million) research project called the Blue Economy Cooperative Research Centre, a cross-sector effort to boost the country's ocean sector and reduce greenhouse emissions. Another initiative seeking to increase national and international cooperation is an industry-led cluster, the Australian Ocean Energy Group.

Canada has for years implemented a number of policies and initiatives to drive the development of ocean energy. It is one of the few countries that has set a basic price per kilowatt-hour for tidal energy – so-called feed-in tariffs – that aim to fund development. Most of its ocean energy activity is found in the Bay of Fundy, where more than 330 businesses of varying size are now operating. As in Europe, the most advanced technology is tidal; and with a total installed tidal power capacity of 40 MW, Canada ranks fourth (behind South Korea, France and the UK). In September 2020, the Canadian government announced a C$9.4 million (€6 million) investment in four tidal energy projects to accelerate development. Progress is also being made in other ocean energy areas, such as wave and river currents, with a focus on providing clean energy to remote places and islands.

China recently approved its first temporary feed-in tariff, of €0.33/kilowatt perhour for a major tidal project near Xiushan island. China is ramping up its efforts to extract and harness ocean energy; and with 17,700 km of coastline, the scope is massive. Most of the country's tidal energy projects are found in Fujian and Zhejiang. A Scottish-Chinese partnership between the companies SIMEC Atlantis Energy and Three Gorges launched a giant 500 KW wave energy turbine near Wuhan in March 2020 (despite COVID-19). And overall, the Chinese government has invested around $160 million (€131 million) in tidal and wave energy projects since 2010.

India in 2019 declared oceans a priority source of renewable energy. With an untapped 7,500 km of coastline, the country has an estimated tidal energy capacity of 12,455 MW, plus 40,000 MW in wave energy and 180,000 MW in ocean thermal energy conversion (OTEC). The government has already pushed forward with investments in the latter technology, approving the construction of a new OTEC-powered desalination plant of 100 m3/day capacity in Kavaratti, Lakshadweep Island.

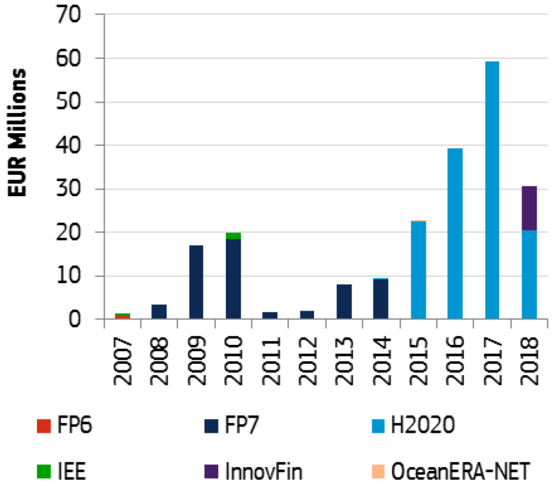
US: According to the US Energy Information Administration, the country has an estimated ocean energy potential of 2.64 trillion kilowatt-hours, which if exploited would have accounted for 64% of the country's total electricity production in 2019 alone. The Department of Energy's Water Power Technologies Office has recently allocated $25 million to a series of R&D projects focused on next generation marine energy devices. Another initiative, titled "Powering the Blue Economy", aims to understand how to relieve power constraints and promote economic growth in the offshore energy sector. There are a number of open sea test sites in the US. One of them is PacWave, a first-of-its-kind full-scale test facility for wave energy converters that will be grid-connected. The government-funded site is being developed in Newport, Oregon, and can house up to 20 converters that will demonstrate the viability of wave energy.

Europe: As mentioned earlier, the EU is strengthening its efforts to remain a leading developer of ocean energy technology through several channels. Its starting point is a strong one: European companies hold 66% of patents in tidal and 44% of patents in wave energy. And 70% of global ocean energy capacity has been developed by EU27-based companies.

The EU has been ramping up its funding of marine renewables since 2007. So far, EU institutions have invested around €493 million in ocean energy research and development. Of that sum, €140 million has been allocated to 47 projects through the Horizon 2020 R&D programme, from basic research to larger-scale demonstrations – up from €60 million in the prior R&D programme. Europe also provides different types of financial instruments to boost ocean energy capacity and infrastructure, such as the European Investment Bank's InnovFin Energy Demo Projects, which provide between €7.5 and €75 million in loans, loan guarantees or equity-type financing.

EU (financial) support for Ocean Energy

Breakdown of EU support for ocean energy R&D, in Framework Programmes 6 and 7, Horizon 2020, the Intelligent Energy Europe programme, InnovFin and the Ocean European Research Area network.



Source: Joint Research Centre (2019)

Of equal importance, these financial commitments have been mirrored in formal policy frameworks, such as the Energy Union, the SET-Plan, the Blue Growth Strategy and the newly-launched Offshore Renewables Strategy.

III. Barriers to progress

Exploiting the potential of ocean energy, and offshore renewables in general, will be crucial to reach carbon emission reduction targets and become climate neutral. Compared to offshore wind, which has seen a remarkable success since its beginning 30 years ago, ocean energy still has a long way to go. And in order to get there, certain key barriers will need to be removed.

Achieving TRL parity throughout the sector

There are wide differences in technology readiness levels (TRL) in the offshore renewable sector. Wind turbines are by some distance the most proven and mature technology, whereas other alternatives – such as floating solar panels or seabed-based solutions – are still in early-stage development.

In the case of both tidal and wave energy, technology costs remain high, and the industry has not yet settled on an optimal design. This is certainly the case for wave technologies: while the tidal energy sector is already building array demonstration projects, in wave power there are many competing designs in development. One particular technology that needs to be improved is the power take-off (PTO) hardware that converts wave power into electricity. Today, the amount of electricity generated by wave converters is insubstantial, meaning that the use of the technology is limited, which is increasing production costs.

Other challenges for the wave sector are reliability and survivability. Operating in the ocean means having to deal with rough conditions and sometimes unreliable wave behaviour, which can damage submarine equipment (and ultimately project budgets). In the past 10 to 15 years, start-up companies have been under pressure to get offshore systems installed as fast as possible, when a lengthier onshore process of step-testing and development might have delivered far better results.

Strengthening the case for investors

Combined, these factors have made investors sceptical about wave power. The picture is somewhat different for tidal energy. In the EU, the technology readiness of tidal energy is already mature (TRL 7-9), meaning that many projects are demonstrating performance in real operational conditions. The Commission's Joint Research Centre (JRC) forecasts that tidal power will become cost-competitive by 2030 and provide most of the installed ocean energy capacity. To get there, however, improvements in performance and electricity generation coupled with cost reductions are necessary.

Nevertheless, according to a JRC study, there is a clear positive trend under way, as the costs of both tidal and wave power are dropping faster than predicted in 2015. According to the Commission's SET-Plan, there are expectations that tidal electricity will fall to €0.10/kWh in 2030, with wave energy reaching the same costs in 2035. However, tidal is competing on the market with other, cheaper technologies.

Boosting policy commitments and partnerships

Speeding technology development and driving costs down are two important elements in making tidal and wave part of the renewable energy mix, but they are not sufficient. Steady, long-term government support is needed. For instance, greater subsidies are needed to reduce financial risks, which cannot be carried exclusively by private investors.

Today, despite the Commission's attempts to provide a unified European vision, the policy landscape is fragmented at member state level. Moreover, analysts argue the sector needs feed-in tariffs as in Australia and China, and more "power purchase agreements" – long-term contracts to buy renewable energy; in the sector, these kind of arrangements are called market pull arrangements, as they force customers in the energy marketplace to help carry some of the costs. There is also a concern that competitors elsewhere in the world – not least North America, which has better market pull mechanisms in place – will attract more European ocean energy companies in the future if their home countries do not design and implement similar policies. Currently, there are many funding mechanisms and programmes in Europe that focus on clean technologies in general, but not necessarily on marine renewable energy.

Fixing this requires political will. Though many EU countries have mechanisms to encourage the adoption of renewable energy in general, they are not sufficient for still-emerging tidal and wave technologies to compete with better-established solar and onshore wind systems. On a European level, if the SET-Plan implementation targets for ocean energy are to be met, coordination and a common vision among member states will be required. Depending on their natural resources and the state of their industry, different countries and regions have interests in different ocean energy technologies.

There is, however, great potential for co-operation between authorities on both common issues and individual technologies. Although today there is an international focus on ocean health and governance, a strong push for ocean energy is missing. Take the UN Decade of Ocean Science for Sustainable Development (2021-2030) as an example. While it has high ambitions to do something about the degradation of the oceans, overfishing, plastic pollution and protection of marine ecosystems, it makes little mention of offshore renewables and the potential contribution of ocean energy to planetary sustainability. Furthermore, as most ocean energy remains at pre-commercial stages, there is still a general lack of data on the environmental footprint of ocean energy projects.

Matthijs Soede, Programme Officer, DG Research, European Commission.

Susan Hunt, Chief Technology Officer, Ocean Supercluster Canada.

IV. New opportunities

On November 19, the day of the Science|Business expert roundtable, the Commission launched its new strategy for offshore renewable energy, setting out Europe's future ambitions and concrete targets as part of its long-term energy transition. These include ramping up the EU's offshore renewable capacity to 40 GW of ocean energy and 300 GW of offshore wind. With a current capacity of respectively 1 GW and 12 GW, the Commission acknowledges that these are highly ambitious projections, but maintains that they are realistic and attainable goals.

The potential benefits are clear. As stated in the strategy:

> ***"Achieving these objectives would deliver major gains in terms of decarbonising electricity generation, enable decarbonisation of hard-to-abate sectors with renewable hydrogen, as well as deliver major benefits in terms of jobs and growth, thus contributing to the post COVID-19 recovery and positioning the EU as a leader in clean technologies, to the joint benefit of its climate-neutrality and zero pollution goals."***

Nonetheless, to reach its targets, the Commission considers that investments of up to €800 billion – predominantly from the private sector – will be required by 2050, of which two thirds will be spent on financing the associated grid infrastructure, and one third on offshore electricity generation itself.

Beyond the money, however, the European vision is built around 28 specific actions to harness the full potential of the sector. The first step is to put the development of offshore renewables into the European Union's Maritime spatial planning, in which it invites proposals and comments on how to use the sea and how much space is needed. This kind of advanced planning would send important signals about governmental intentions to business and to investors.

Another goal of the Commission is to support offshore grid development in different stages, in order to build the infrastructure needed for large-scale deployment of renewable energy. This includes hybrid, cross-border projects that will ensure "significant savings in terms of costs and space used". This will require more cooperation among member states, regulators and transmission service operators. The Commission also aims to strengthen supply chains through the development of new skills, port infrastructures and manufacturing capacity. It also plans to review current state aid rules, and establish an offshore bidding zone for hybrid offshore energy projects.

To reach its €800 billion investment target for offshore renewable energy, the Commission says its own budget will "play a strategic catalytic role". It has already made some first steps with its Green Deal call, a €1 billion stimulus package for green research and innovation projects in Horizon 2020. It plans more in Horizon Europe, the next big EU R&D programme – with particular emphasis on large-scale grid demonstration projects and ocean energy designs. In parallel, the new InvestEU programme will provide further support and guarantees for emerging technologies. And through the combination of private and public funding, the EU aims to launch ten large-scale ocean energy demonstration projects by 2025.

Patrik Möller, CEO, Corpower Ocean.

Mark van Stiphout, Deputy Head of Unit, Innovation, clean technologies and competitiveness, DG Energy, European Commission.

V. Options

Even though marine renewable energy is lagging behind offshore wind and facing significant barriers to progress, there are several ways to help boost the sector. Here, we list five suggested by participants in the Science|Business meeting.

1/ Develop standards for testing and components

As mentioned previously, there is no agreement yet on the best technology to get energy from waves. But it would help build a consensus if we had standardised ways of testing that technology, or norms for specific components. That would, in turn, help industry build global supply chains. Policy makers can convene stakeholders and get agreement on licences, standards and monitoring protocols – which again can provide important reassurance to potential investors, public or private.

2/ Share data

Another option is to ensure better access to data. Today, many technology developers hesitate to share data lest they compromise their intellectual property – despite the fact that others could benefit from the insights the data provide. Thus, the lack of readily available, comparable data creates uncertainty about how to judge different technologies. A standardised, common public data pool, based on test methodologies and frameworks, could help. The public sector could take a lead through the creation of collaboration platforms. Sharing data will enhance knowledge – both of failure and success – which is important to improve reliability. Finding the balance between protecting competitive advantage and intellectual property, as well as proving the benefits of sharing data, could improve performance and de-risk projects.

3/ Provide more financial support

Another problem is that offshore devices operate in extreme environments, and so are not certain to last. That frightens investors. That means government must help bridge the investment gap between reluctant investors and huge construction costs. The story of offshore wind has shown that strong and supportive policies directly increase deployment, which in turn will bring economies of scale and drive costs down.

A number of studies from agencies such as the UK Energy Technologies Institute indicate that tidal energy can become competitive with other low carbon sources within a decade through scale and volume, but it requires sufficient support for innovation for that trend to be sustained. Plans to strengthen the EU's investment tools are already in the pipeline: the Commission intends to support ocean investment by the European Investment Bank and others through the InvestEU fund. Nonetheless, the first step will be to identify good projects through the Clean Energy Transition Sub-Programme and the SET-plan working group.

But we must also spend the money smarter. For instance, two of Europe's leading wave energy companies, Eco Wave Power and CorPower Ocean, developed and tested their technologies first onshore before installing them offshore. Through a carefully measured step-by-step process in a more predictable environment, they have successfully avoided many of the pitfalls and financial losses suffered by competitors, and are now operating full-scale systems. Bigger players, such as the UK's Offshore Renewable Energy Catapult, are now taking similar approaches, spurred by the idea of investing a few hundred thousand pounds on land to figure out what works, instead of a few million in the water to learn what doesn't.

Gesine Meissner,
Board Member,
Horizon Europe
Oceans Mission,
Former MEP.

Davide Magagna,
Scientific Officer,
Joint Research Centre,
European Commission.

4/ Think bigger – across sectors and technologies

As discussed, there are many ways to get energy from the ocean, from tidal, wave and salinity gradient to offshore floating solar cells and wind turbines. Best to combine them and– in the language of policy – find the “synergies” among them. A combination of different energy sources could lead to new models of shared costs, reduced operating and maintenance expenditures, and a more predictable and available power output. Even though tidal and wave will never reach the same level of production as solar and wind, they are highly predictable and well suited to provide base load power that complements other renewable energy sources. Another area of potential synergy is the shared use of grid infrastructure. One of the most significant costs in offshore renewable energy systems is the connection to onshore electricity grids. A shared electric connection for all these systems would save money.

5/ Work internationally

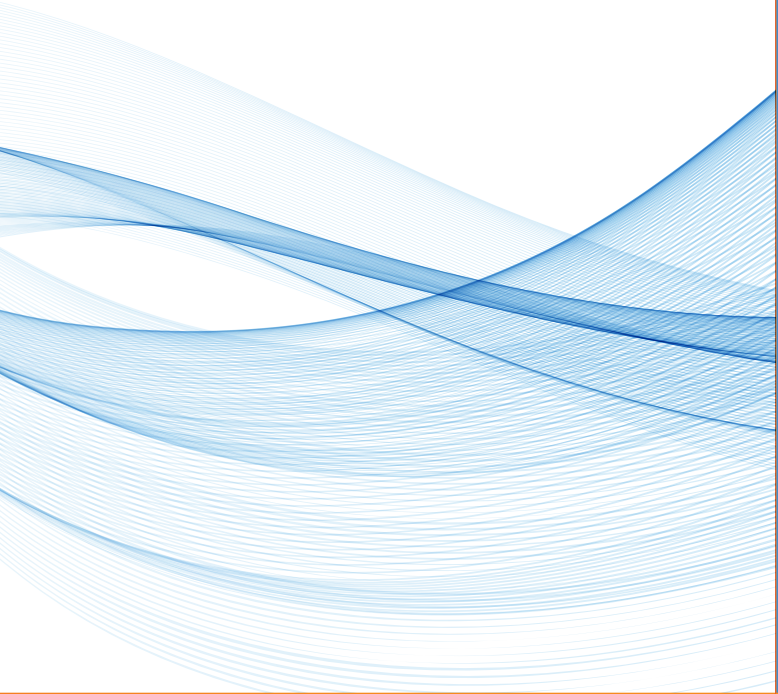
The opportunity to harness and build momentum clearly exists. Beyond the UN Decade of Ocean Science for Sustainable Development (2021-2030), the International Renewable Energy Agency has recently established a collaborative framework, backed by 40 countries, to define how to speed uptake of these technologies. Both initiatives show greater interest in collaboration on ocean energy, and could provide a strong framework for ocean energy knowledge transfer.

One way to encourage more cross-border and cross-sector collaboration could be finding a “common denominator” relevant to everybody – such as organising research around common environmental or sustainability problems. For instance, more knowledge is needed about underwater noise and disturbance and the alteration of sea-bottom habitats. This was the case when Canada’s Ocean Supercluster began. Building a large multisectoral cluster where different views, priorities and interests come together can be a challenge. However, all stakeholders managed to find a common denominator in early stages, which was sustainability. A similar approach could be used in different types of platforms, such as accelerators, catapults, international forums, and clusters.

In conclusion...

Against this backdrop, ocean and offshore renewable energy seem poised to enter a dynamic new era. In the marathon to reach sector maturity and a lucrative global market, the EU is a clear frontrunner. But there are dozens of laps still to be run. In that regard, Europe will need to juggle competing interests: on the one hand, to strengthen the competitiveness and excellence of its industry base in these domains, while on the other, to build R&D partnerships beyond its borders which address the more serious long-term challenges of climate change and planetary boundaries.

As such, the Commission is encouraged to increase the range and diversity of collaboration spaces that support ocean energy partnerships – not least given the ongoing impacts of COVID-19 on international scientific mobility. And as the crisis has shown, the principles of open access and open data have enormous value – to science, governments and society – and should be upheld as we prepare for the future.



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