

SPACE FOR OCEAN ENERGY: USE CASES AND MARKET OPPORTUNITIES

The rise of the ocean energy sector

Ocean energy has a key role to play in the energy transition in countries with coastal areas and island territories. Progress on technological and industrial level can be observed with worldwide funding increasing as governments make bigger commitments to ocean energy as a means of strengthening the security of energy supply and strategic autonomy. While presenting a huge potential the technology overall for ocean energy is still at an early stage of development.

Nevertheless, the potential is also highlighted by International Renewable Energy Agency (IRENA) which indicates that in an energy transition scenario aligned with the 1.5C Paris Agreement target, that ocean energy cumulative capacity of more than 70 GW by 2030 and 350 GW by 2050 could be installed globally¹.

Tidal barrage and stream, wave energy, salinity and temperature gradient are the main sources of ocean energy. Wave energy and tidal stream converters are the most mature and applicable across different geographies. Global total tidal stream saw an increase of 1.7MW of new installations in 2022, accumulating to a total of 41.2MW since 2010. On the other hand, wave energy increased by 165kW in 2022, 24.9MW of cumulative installations since 2010. Additionally, salinity concentration and temperature gradients solutions are also being developed.

Global ocean energy potential and deployment, according to IRENA by source: 29 500 TWh (Wave), 1 200 TWh (Tidal stream), 1 650 TWh (Salinity gradient) and 44 000 TWh (Ocean Thermal Energy Conversion - OTEC).

While Europe is leading in cumulative capacity other major economies such as China and the USA are ramping up in annual capacity additions and increasing investments (US\$ 110 million annually boost as of 2022). The UK, France and Canada in particular are offering revenue support through government contracts with Canada having the 2nd biggest project pipeline which will generate 32MW. A comprehensive policy framework including capital grants, feed in tariffs and dedicated deployment sites is a key driver for further growth of this sector².

Small Island Developing States (SIDS) and some Least Developed Countries (LDC) are also expected to become major beneficiaries of the blue economy with ocean technologies helping to address acute energy and water challenges in small-island or remote coastal areas in developing states. Subsequently, also creating socio-economic opportunities such as job creation, strengthening people's livelihoods and improve health outcomes³. This is also echoed by the United Nations Industrial Development Organization (UNIDO) which launched the Global Ocean Energy Alliance (GLOEA) last year and will address the needs of SIDS and LDCs to access ocean energy technology, finance, and expertise.⁴

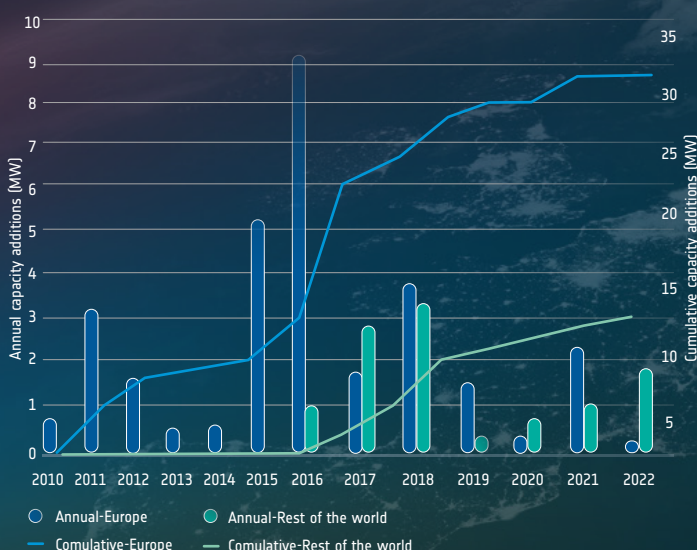


Figure 1: Installed global tidal stream capacity



1. OFFSHORE RENEWABLES...

2. Ocean Energy Europe: Key trends and statistics 2022

3. IRENA Offshore Renewables 2020

4. LAUNCH OF THE GLOBAL OCEAN...



European ocean energy landscape and players

Europe with its 5 sea basins has massive potential for ocean energy and a variety of technologies can harness renewable energy from the sea making it an important source for a clean energy transition.

Europe has held a key competitive advantage in ocean energy throughout 20 years of investment in R&D. The European Union (EU) countries in particular and private sector have invested more than €4 billion over the last ten years in research and pilot projects on ocean energy. Cost reduction will be key for ocean technologies and the EU has set this target for the next decade through the Strategic Energy Technology Plan⁵. This investment has led to a lot of competition in the European market with companies trying to impose their marine turbine or wave energy converter concepts for mass production. The tidal stream sector in that sense seems to be the most mature by launching its first commercial projects benefiting from power purchase agreements. The wave energy is however closely following with testing prototypes to deal with differing European coastal wave conditions⁶.

The EU strategy on offshore renewable Energy (EU offshore strategy) set development targets for ocean energy of 100MW by 2030 and 1GW by 2050. Non-binding agreements were reached within Member States' basins and funding increased by Horizon Europe (78 million euros)⁷. Meanwhile, the United Kingdom (UK) managed to create a market for tidal energy, as its government invested 20M euros to support the deployment

of 40MW of tidal pilot farms – equivalent to 40% of the EU offshore strategy's targets for ocean energy. For its part, the Spanish government invested 200M euros in grant programmes for ocean energy R&D⁸.

In 2022, 67kW of new capacity in tidal streams installations were added and cumulative installations amounted to 30.2MW installed in Europe since 2010. The European tidal stream sector exported 11.9GWh in 2022, led by flagship projects in Scotland including MeyGen, Orbital Marine Power O2 and Magallanes ATIR turbine, and the Tocado's Oosterschelde plant in the Netherlands. Biggest investments for tidal stream projects were Seacurrent⁹ (4.8M euros), Orbital Marine Power¹⁰ (4.5M euros), and Sabella¹¹ (2.5M euros). As of 2023, Nova Innovation will extend its tidal farm with two additional 100 kW turbines, being the largest array in the world.



Nova Innovation Gearless Tidal Turbine

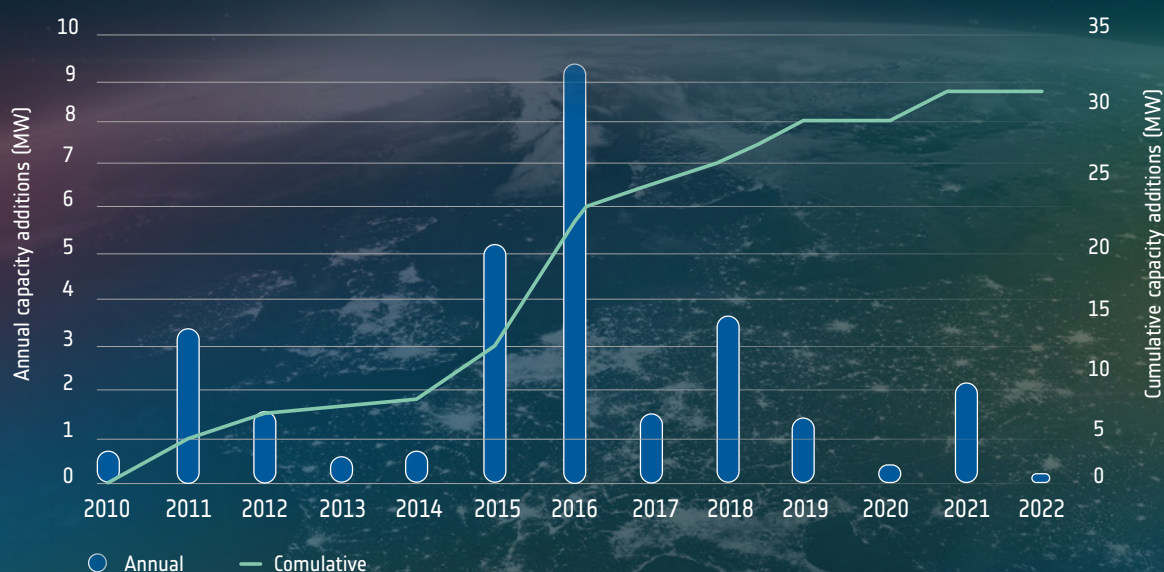


Figure 2: Annual and cumulative tidal stream capacity in Europa

5. OFFSHORE RENEWABLE ENERGY...
6. EuroObserv: Ocean Energy Barometer
7. OFFSHORE RENEWABLE ENERGY...
8. Ocean Energy Europe: key trends and statistics 2022
9. HOME - SEACURRENT...
10. ORBITAL MARINE POWER | LEADERS IN...
11. SABELLA'S TIDAL TURBINES: TIDAL STREAM POWER...



On the other hand, wave energy added 46kW of new capacity in 2022, amounting to a cumulative installation of 12.7MW in Europe since 2010. Funding programmes to foster innovation and boost future developments must continue, as for example the Archimedes Waveswing, deployed by Wave Energy Scotland under the EU funded Europe Wave programme. Moreover, three new European ocean energy developments in 2022 were built in Slovenia (30kW), UK (16kW), and Belgium (3.5kW). In Portugal in 2023, CorPower Ocean's flagship project plans to deliver four system wave array of 300kW each and create the biggest grid connected wave farm in the world¹².

Some of the challenges faced by the ocean energy sector are similar to those for offshore wind. Grid connections, supply chain developments and operation and maintenance under harsh weather conditions are to name a few. However, ocean energy is now at a critical stage, moving from prototype to commercialisation where a clear, stable and supportive policy framework will help in attracting further investment so that it can provide cost-effective, low-carbon electricity as well as new jobs and economic growth in Europe¹³.



CorPower Ocean's HiWave-5 Flagship project

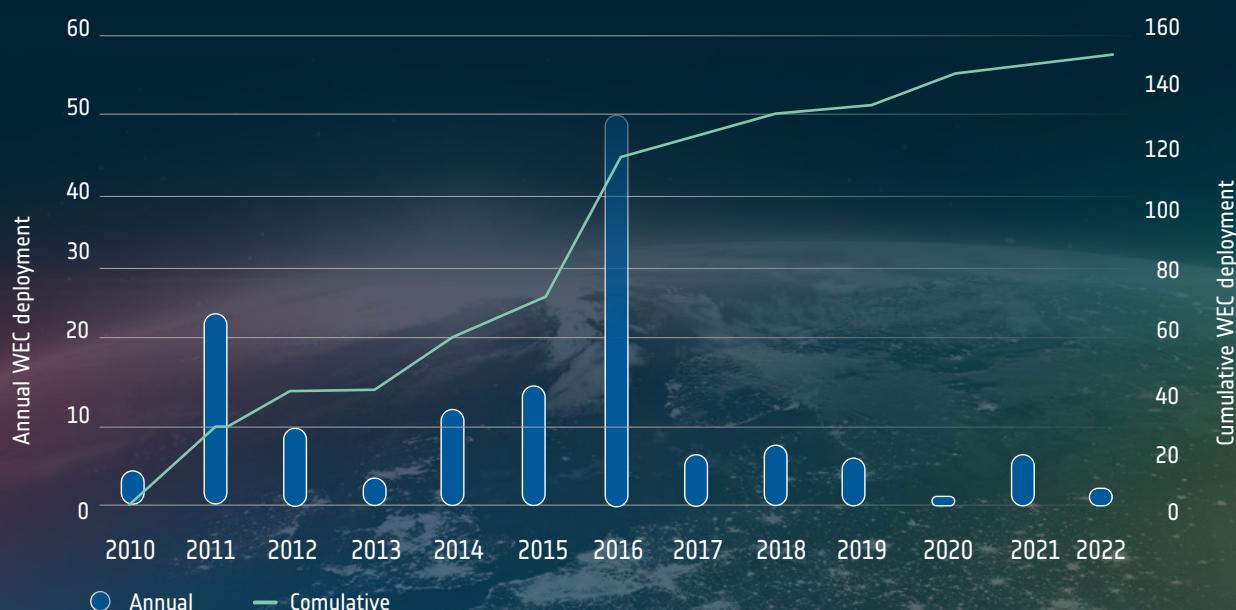


Figure 3: Annual and cumulative wave energy converter (WEC) deployments in Europe

12. Ocean Energy Europe: key trends and statistics 2022

13. Blue Energy – Action needed to deliver on the potential of ocean energy in European Seas and oceans by 2020 and beyond

Ocean energy needs and trends

LOCATION SCOUTING AND CLIMATE RELATED HAZARDS

Successful location scouting is critical to ensure a high production yield. The ocean is a hostile environment, which makes it even more important to monitor related climate hazards and choose locations that minimise the risk of damages to installations while assuring maximisation of ocean energy output. Data is key to make informed decisions on location potential, especially with regards to mapping of historical and forecasted data. Important indicators include ocean current speed and direction, water depth, ocean temperature, ocean salinity, distance to shore, wave height and frequency, and marine life.

BANKABILITY AND EFFICIENCY

Projects need to secure the financing from investors and banks, especially since ocean energy technology readiness is not entirely mature, which can limit its bankability. Resource assessment and planning of the overall economic feasibility of the project need to be assured. Moreover, regulations and permits need to be approved, as not all high potential energy areas can host ocean energy installations due to for example environmental preservation concerns (see next paragraph).

POLICY AND ENVIRONMENTAL IMPACT

The need for data collection for environmental policy monitoring and reporting across the energy value chain is given on all public levels. In spite of the environmental benefits of marine energy in terms of emissions reductions, there are potential negative and positive impacts that developments may have on the marine environment and coastal areas. In order to obtain relevant approvals and permits for installations and operations, environmental impact of commissioning and potentially decommissioning of marine energy plants need to be assessed and carefully monitored. The Blue Technology Barometer measures the degree to which economies are prioritising the protection of ocean health, through sustainable marine activity, blue innovation, and policy implementation¹⁴. Four European countries lead the worldwide ranking, these being: UK, Germany, Denmark and Finland.

SYSTEM PLANNING & TRANSMISSION

One of the challenges of the renewable energy transition remains energy system modelling for policy making including forecasting along mid- and long-term horizons (10-15 years). The increasing dependency on weather access to related databases with accurate past and present information, is fundamental for securing ocean energy supply. There is thus a need to digest raw data and transform them in useable information at planning and

system level. This capability is especially important at national level where countries are looking to tap into emerging offshore energy (wave, tidal, salinity gradient, ocean thermal energy conversion, offshore grid planning and installation), but also at regional level where cooperations are increasingly supporting ocean energy developments.

MAINTENANCE & MONITORING

Ocean environments can be highly erosive and hard to reach, making maintenance very complex, especially in areas with high wave power potential. There is a strong need for regular site monitoring and analysis in order to identify any anomalies and reduce the risk of costly maintenance visits. Weather windows are carefully monitored to send specialised teams, which will also rely on integrated monitoring solutions enabled by reliable and robust navigation and communication services, needed for the harsh and remote locations of the ocean energy power sites. The longevity and successful performance of these is thus highly dependent on adequate maintenance (clean sites, inspect, test, and perform repairs), which in return will play a key role in the overall commercial viability of these sites.

Overall, specific aspects of ocean energy systems, such as spatial planning, logistics and marine operations, environmental protection, integration in the energy system, and overall data transmission are some of the challenges that need to be addressed. Wave forecasts and long-term data are crucial, including sensors (currently often cameras are used) which will also enhance the need for data transfer in these remote areas as well as solutions for installation, maintenance and monitoring activities.



14. [THE BLUE TECHNOLOGY BAROMETER 2022/23...](#)



Space sector added value

In spite of the significant potential, the ocean energy sector is currently emerging and will depend on overcoming key challenges such as the technology readiness & maturity, bankability, efficiency & safety in operations and maintenance and its environmental sustainability.

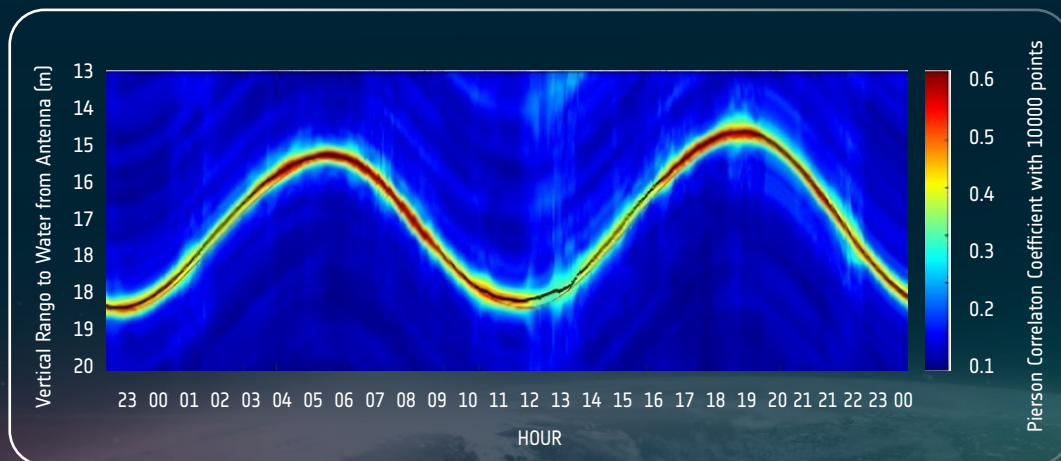
Space-based applications and technologies can play an important role to some of those challenges. For example, it can provide hydrodynamic models data, which are useful for revenues forecast, monitor the environmental impact and increase survivability of marine energy installations.

The Business Applications – Space Solutions (BASS) programme is one of the entry points to ESA which supports European companies including start-ups and SMEs to develop commercially sustainable services using space technologies and data. Considering the importance of the ocean energy sector and the European Marine Energy Landscape, the BASS programme launched in 2020 an Open Call related to Marine Energy.

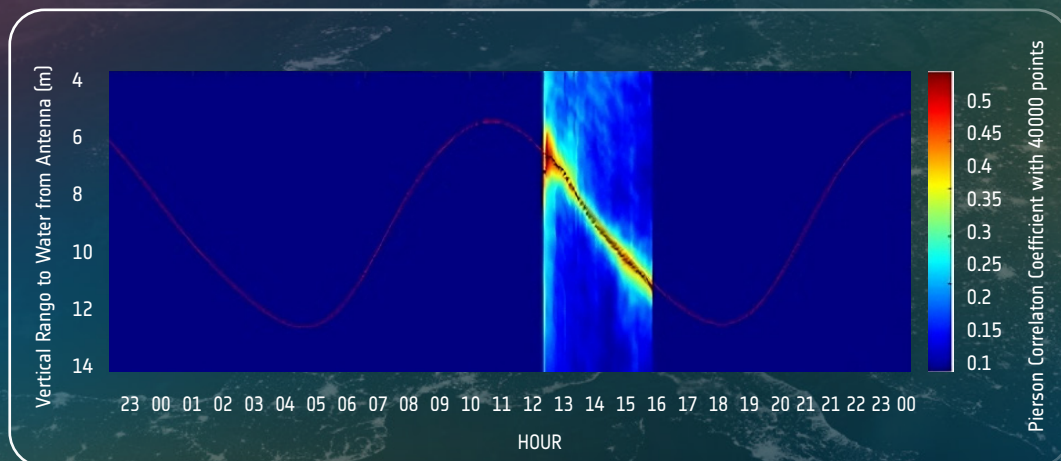
Under the flag of ESA's Earth Observation [Atlantic Regional Initiative](#), the National Oceanography Centre (NOC) of the UK, is working with the European Marine Energy Centre (EMEC), one of the world leading Marine Renewable Energy Test Centres, to improve sea state characterisation in high energy environments by using GNSS-IR technology. The European Space Agency also offers multiple EO datasets through its Third Party Mission programme which can pave the way towards the development of new ocean energy solutions.

Moreover, through the ESA's Business Incubation Centres (BIC), new ocean startups are being supported. Oceanenergy AG Technologies for example is building technology components to improve Wave Energy Conversion (WEC) devices so that it can bring the levelized cost of energy (LCOE) of tidal energy to the windows of more cost competitive renewable sources such as wind and solar.

Siglo RNLI Station GPS Reflectometry Water Levels: 02 Aug 2019



Alfred Dock Test: Ublox 9 GNSS Reflectometry Water Levels: 09 Aug 2021



GNSS Interferometric Reflectometry for water level detection

Also Marine Energy Space Control (MESPAC) (initiated from the BASS Marine Energy Call) resulted to the establishment of a new start-up company (MESPAC Srl.) incubated at the BIC. They are aiming to use earth observation and AI with surface sensors to provide analysis of met-ocean characteristics which can be suitable for bankability estimations, advanced design activities, monitoring and control of operations for new offshore energy projects.



Several of the previously exposed needs can be covered thanks to data coming from earth observation, communication, and navigation satellites.

Firstly, it can address the environmental concerns of new installations (e.g. pollution at sea, marine habitats, coastal ecosystem, detection of harmful liquid spills), as satellites are able to monitor key variables in the field of environmental impact assessment and pollution.

Secondly, system planning and forecasting can be vastly supported through space. The role of weather and other satellite-derived data is already highlighted by Copernicus and the European Centre for Medium-Range Weather Forecasts activities. The capability of planning and forecasting will allow a better balance and efficient use of the energy between countries, networks and regions. Satellites will be able to analyse ocean characteristics to optimise the selection of power stations and assessment of their power potential.

During the construction phase, met-ocean forecasts, and climatology for hazard prevention and mitigation on offshore infrastructure, will help reduce and anticipate delays. Also, autonomous vessels and communication between offshore and shore including M2M (for process automation and end-to-end business processes) and voice and data, may help to improve logistics efficiency during the construction and maintenance phases.

Navigation and communication systems allow remote control and access to large data sources for predictive maintenance and energy efficiency, detecting and quantifying vessel traffic management and coordination for transport and fishery. Navigation satellites can optimise transport routes to enhance energy efficiency, enable autonomous water vehicles, while providing weather and sea forecasts for routing of ships and planes.

All the Earth Observation related use cases are possible thanks to Copernicus Marine Environment Monitoring Service (CMEMS) and sentinel missions. CMEMS uses synthetic aperture radar (SAR) data to provide information on marine surface wind speed and direction, allowing offshore wind energy potential estimates to be calculated. The sentinels provide continuous data on the behaviour, use, and health of the oceans. Particularly, sentinel-1 provides an all-weather, day-and-night radar imaging capability. And Sentinel-3 provides a multi-instrument capability to support parameters as Ocean Colour (OC), Sea Surface Height (SSH) and Sea Surface Temperature (SST)¹⁵.

There are no alternatives to satellites supply forecasts based on current and historical data. The sector is in need for solutions on European, National, and regional level, which creates a commercial opportunity to strategically place data coming from satellites. Overall, the added value of space in the field of ocean energy is immense and in line with policy needs in Europe and worldwide.



ESA's SMOS mission observes ocean salinity

