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CORDIS Results Pack on

ocean energy

A thematic collection of innovative EU-funded research results

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Promising new technologies to help Europe achieve its ambitious climate goals

Research and Innovation

Contents

Editorial

Promising new technologies to help Europe achieve its ambitious climate goals

As Europe aims to be carbon-neutral by 2050 and invest significantly in renewable forms of energy over the coming decades, there's one source of green energy that shows great promise – and it's not even green, more of a blue. The oceans offer enormous potential as a source of clean, green energy, and the technologies to realise this, whilst still to fully mature, should definitely be on the radar. In this CORDIS Results Pack, we introduce you to 10 EU-funded projects that are paving the way for the wider development and deployment of these ocean energy innovations.

Ocean energy technology is an emerging technology and there is still some way to go on the road to full commercialisation. But anchored in innovative demonstrations across Europe, often led by inspired and idealistic SMEs, they truly offer an exciting opportunity for green investors. In short, they deserve to be much more widely considered as a viable long-term form of renewable energy, alongside their more widely known solar and wind cousins. It has even been forecast that by 2050, under the right conditions, ocean energy could contribute around 10 % of EU power demand.

The benefits of ocean energy

One of the key benefits of ocean energy technologies is that if well designed and well constructed, ocean energy installations are much less likely to negatively impact ocean biodiversity. In many regions, land is a precious resource, therefore siting onshore solutions such as wind and solar can be controversial to local populations. This is not the case with ocean energy technologies, particularly subsea installations as they are hidden under the surface of the water, out of sight, and not competing for scarce land.

Another important factor for the consideration of ocean energy solutions is their reliability – unlike solar power or wind power, tides and ocean currents are almost 100 % predictable, with the endless flows guaranteeing continuous energy availability. Finally, these technologies tend to be energy-rich – moving water is much denser than moving air, creating excellent conditions for efficient energy conversion.

From a socio-economic point of view, installing ocean energy technology can also greatly benefit coastal communities, as they bring high-skilled jobs to the area and boost local economies. The manufacturing of the devices will most likely take place close to where they are to be deployed, and maintenance of the devices, when necessary, would most logically be sourced from local communities.

Indeed, the ocean energy sector could be worth up to EUR 53 billion by 2050, potentially translating into 400 000 jobs in Europe, with many of those being based in coastal regions close to the installations.

From demonstration to the market and beyond

Horizon 2020 has been active in providing support to projects that have been working to demonstrate the reliability and robustness of ocean energy technologies, as well as to make ocean energy cost-competitive with other technologies and clearly demonstrate its market potential. In particular, the Results Pack highlights 10 such EU-funded projects.

New software suite will strengthen future wave and tidal energy projects

In their quest to reduce the cost of wave and tidal energy technologies, the DTOceanPlus consortium have identified design software as a key stepping stone. The project's results will help to decrease the technological risks for the next development stages and significantly contribute to an increase in technology performance.

DTOceanPlus (Advanced Design Tools for Ocean Energy Systems Innovation, Development and Deployment) considers potential users' needs from the get-go. It started off with a consultation process, during which the project team approached a wide panel of over 70 prospective users and stakeholders. They quickly found out that their tools' most important function would be to give confidence to both public and private investors.

"Wave and tidal stream-based energy surged from less than 5 GWh in 2009 to almost 50 GWh in 2019, but technologies are not yet mature enough. The energy sector needs software tools that will reduce the technical and financial risk of opting for ocean energy technologies. This will allow for the deployment of competitive wave and tidal arrays," says Pablo Ruiz-Minguela, project coordinator and head of wave energy at Tecnalia.

Work in progress

DTOceanPlus didn't start from a blank sheet. A first generation of design tools had already been developed under a former FP7 project named DTOcean and made freely available to stakeholders. These tools were successfully used for leading projects such as the four-turbine 6 MW MeyGen tidal array in the UK and a wave energy application made by Sandia National Laboratories in the USA. Yet, some stakeholders still wished for improvements.

"DTOceanPlus goes further by taking all stakeholder feedback into account to develop a better, more comprehensive set of second-generation design tools," adds Ruiz-Minguela.

The energy sector needs software tools that will reduce the technical and financial risk of opting for ocean energy technologies.

The new suite is comprised of five tools covering the full lifespan of the farm. It includes: a tool for concept creation, selection and design; a tool assisting decision-making in technology development; as well as deployment design tools supporting optimal device and array deployment. The suite also covers post-deployment phases. It includes assessment design tools informing users on the suitability of a technology and project, as well as a framework for design sharing and reuse.

All tools are currently in stand-alone alpha versions. They have already been made available to industrial partners. "Over the next 6 months, their key functionality will be verified and feedback will be fed into beta versions," Ruiz-Minguela explains. "The embedded versions will then be validated by applying experience and lessons learned from real-world projects."

Opinions collated so far indicate that usability, flexibility and expandability are most important to stakeholders. Transparency is also critical. Finally, the tools will need to deal with varying degrees of complexity both at different stages in the project lifecycle and for different user requirements.

"The response has been very good, with nearly all respondents indicating that they were likely or very likely to use DTOceanPlus at some stage of their project's lifecycle," Ruiz-Minguela notes.

A TRL timetable

The DTOceanPlus team hopes to bring its technology to TRL 6 by the end of the project in April 2021. Ruiz-Minguela is optimistic that it will fill a significant gap in the market by providing a single, integrated open-source solution supporting the entire innovation, development and deployment process.

Whilst the project is firstly aimed at technology developers, project developers, public funding bodies and private investors, its outputs will also be of great value to policymakers, regulators, standardisation bodies, insurance providers and the supply chain. All tools will be made freely available to the entire ocean energy sector in order to maximise impact.

PROJECT
DTOceanPlus – Advanced Design Tools for Ocean Energy Systems Innovation, Development and Deployment

COORDINATED BY
Tecnalia in Spain

FUNDED UNDER
Funded under H2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/785921

PROJECT WEBSITE
dtoceanplus.eu

Cost-efficient, high-performance tidal technology soon coming to Orkney, Scotland

Orbital Marine Power's first commercial floating tidal turbine demonstrator will soon showcase its full potential in real-life conditions. The O2 will be the world's most powerful technology of its kind able to meet the annual electricity needs of over 1 700 UK homes.

Supported under the Horizon 2020 FloTEC (Floating Tidal Energy Commercialisation project) project, the O2 is a wonder of tidal technology. It offers greater energy capture and reduces the cost of floating tidal energy to less than EUR 200 per MWh.

"Our ambition was to provide more energy at a lower cost," says James Murray, programme manager at Orbital. "Innovations include 20 m rotor diameter blades – which increase yield by up to 50 % – as well as a range of design innovations to ensure that all systems are highly accessible on-site for low-cost maintenance. It will be the first time this has been achieved for a tidal energy turbine at large scale."

FloTEC is providing EU funding for the commercialisation of this new technology to the tune of EUR 10 million. It is also developing a range of associated supply chain innovations and research activities. Whilst engineering began in 2016, it builds upon a long-term development programme started in 2002. Recently, the company tested a 2 MW prototype, the SR2000, which generated over 3 200 MWh of electricity.

We at Orbital have always believed that the key enabling technology for tidal stream energy is the platform.

"We at Orbital have always believed that the key enabling technology for tidal stream energy is the platform. We have therefore developed a highly optimised solution that ensures safe installation, access and maintenance of all generation subsystems. Operators can use small, low-cost, locally based workboats for all operations even at commercial unit scale," Murray explains.

A long-term demonstrator

The FloTEC project is scheduled for completion in February 2021. The new design meets all project objectives related to cost reduction. The turbine is currently under construction, with efforts involving a pan-European supply chain.

When completed, the Orbital O2 turbine will take the form of a 72-metre-long floating superstructure. It will support two 1 MW turbines for a nameplate power output (or to put it another way, the intended full-load sustained output) of 2 MW, at a tidal current speed of 2.5 m/s. Thanks to rotor diameters reaching 20 m, it will boast a 600 m2 rotor area, the largest ever seen on a single tidal energy generation platform.

Power will be exported from the turbine via EMEC's subsea cable and onshore substation, and will feed the national grid on the archipelago of Orkney when fully operational. During tests carried out there until 2018, the SR2000 provided up to 25 % of the Orkney Islands' electricity requirements.

Orbital aims to launch its O2 in the latter half of 2020. "We are planning to fit in as much operation and on-site validation as possible before the end of the FloTEC project. Either way, the O2 will run as a 'demonstrator' for over 15 years, ensuring that a highly detailed long-term dataset on power performance, component reliability and environmental monitoring is compiled," Murray concludes.

In the long run, Orbital hopes its O2 will turn out to be a key enabling technology for the tidal energy sector. It will, undoubtedly, be a benchmark for stakeholders looking for low-cost tidal energy and future-proof design.

PROJECT
FloTEC – Floating Tidal Energy Commercialisation project

COORDINATED BY
Orbital Marine Power Limited in the United Kingdom

FUNDED UNDER
H2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/691916

PROJECT WEBSITE
orbitalmarine.com/flotec

New wave energy power take-off system reaches for universality

Over 6 years ago, UMBRAGROUP was contacted by one of its customers. They had a new technology and required the Italian company's expertise to make it safer. UMBRAGROUP ended up creating the electromechanical generator – a device harvesting energy from alternative movement. The technology is on its way to technology readiness level 5 and is already considered a serious option for converting wave motion into electricity.

Let's picture the current status of the marine energy industry for a second. To be successful, it essentially requires three elements: a robust and reliable supply chain, consolidated design standards, and technologies that are both cost-competitive and reliable.

A power take-off (PTO) system like the one developed under the IMAGINE (Innovative Method for Affordable Generation IN Ocean Energy) project could be crucial to meeting these requirements. It promises to increase the efficiency of wave energy to grid-compatible electricity conversion by 70 to 80 %, to reduce capital expenditure by 50 %, and to increase PTO lifetime to 20 years. Finally, it can be adapted to different types of wave energy converters (WECs).

"Wave energy technologies have yet to converge," says Luca Castellini, energy R&D and business development manager at UMBRAGROUP and coordinator of IMAGINE. "We knew that sites with different environmental characteristics may also have different design requirements, so we came up with a technology that converts linear mechanical motion into electricity for most scenarios. Our electromechanical generator (EMG) can harvest energy from four WEC typologies: point absorbers, attenuators, oscillating wave surge converters, and submerged pressure differential devices."

The EMG is compatible with over 80 % of all WECs currently under development. But its strengths go beyond this versatility. Compared to state-of-the-art PTO systems, the EMG minimises the need for active materials (and therefore reduces final cost). It has minimal friction thanks to the use of rolling contact elements (for increased mechanical efficiency), as well as a higher power density as a result of a limited number of components and more compact architecture. The system has already proved its reliability in safety-critical applications.

Beyond wave energy

Thanks to EU support under the IMAGINE project, UMBRAGROUP started building a prototype for performance and lifetime 'HardWare in the Loop' (HWiL) bench testing in 2018. The team's objective is to prove that the system meets its cost reduction and performance improvement targets, thereby reaching technology readiness level (TRL) 5. They are currently manufacturing the test parts and hope to begin the test campaign in late summer.

But there is more to IMAGINE than the PTO solution itself. "The project also focuses on developing streamlined design processes, which can contribute to the creation of recommended practices for PTO solutions in WEC technologies. Given the absence of standards, we developed an approach derived from the wind energy sector: We use wave energy classes to define a suitable PTO sizing for a WEC," adds Castellini.

Our electromechanical generator (EMG) can harvest energy from four WEC typologies.

Using numerical modelling, the wave energy class allows for the EMG's loading envelope to be defined based on interactions between the WEC and its environment. UMBRAGROUP has considered a wide range of EMG loads to ensure its safety. "The EMG faces extreme load and power requests even when the selected site class and converter type are in the power range of the deployment site. To be able to generate energy even under these extreme loads, we have introduced an EMG parallelisation architecture," Castellini explains.

It will probably take a while for the technology to reach TRL 9. But stakeholders and technology developers are already considering the EMG. The technology's potential even reaches beyond the wave energy sector, with possible applications for the tidal energy, automotive, oil and gas industries.

PROJECT
IMAGINE – Innovative Method for Affordable Generation IN Ocean Energy

COORDINATED BY
UMBRAGROUP in Italy

FUNDED UNDER
H2020-ENERGY

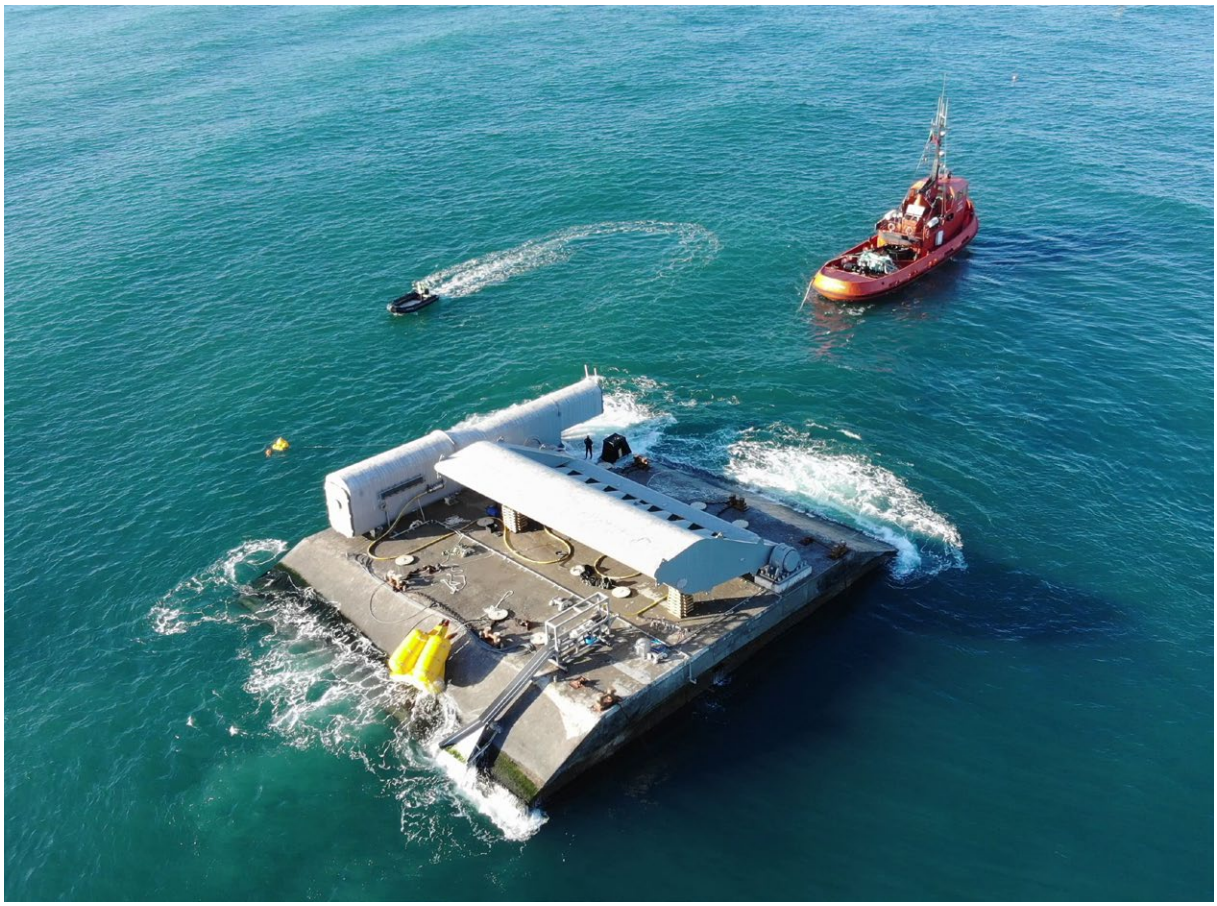
CORDIS FACTSHEET
cordis.europa.eu/project/id/764066

PROJECT WEBSITE
h2020-imagine.eu

Lower energy cost for future wave energy conversion systems

The MegaRoller project has been engineering a new power take-off system to make WaveRoller® devices more efficient. The project brings the emerging wave energy market closer to profitability.

Now that WaveRoller® technology has successfully contributed to the ongoing efforts to put wave energy on the map, the sector is looking for more commercially attractive solutions to convert waves' mechanical energy into grid-compliant electricity. Its ability to find such solutions could be make or break for this growing market.



© AW Energy

Enter the MegaRoller (Developing the PTO of the first MW-level Oscillating Wave Surge Converter) project. Its 10-strong consortium sets out an entirely new approach to power take-off (PTO) and control systems. "Our goal is to introduce new functionalities to WaveRoller®. We increase unit power, improve efficiency, apply innovative control algorithms and monitor system reliability along the design process. The results can benefit the whole wave energy community," says Jussi Akerberg, CTO of WaveRoller® creator AW-Energy.

Since May 2018, the project consortium has been building a full-sized PTO system – a device taking power from its source (waves) and transmitting it to an application (the electricity grid). The project is currently halfway through.

"We have already achieved interesting and groundbreaking results. We have modelled the prime mover interaction with the waves and found a PTO damping solution that will significantly increase the amount of captured energy," adds Akerberg.

We have modelled the prime mover interaction with the waves and found a PTO damping solution that will significantly increase the amount of captured energy.

One of the project's main innovations lies in its algorithms. The PTO damping algorithm takes wave prediction as its input, while the wave prediction algorithm uses machine-learning-based algorithm-adaptation methods from computational neuroscience. "It mimics the auditory cortex of the brain," Akerberg explains. By building its prediction in such a manner, MegaRoller provides superior performance and robustness in terms of both parameter choices and the sea state from which the data are generated.

The MegaRoller consortium opted for a modular design of its new-generation PTO, which has already been completed. As Akerberg says: "The greatest advantage of modularity is that the modules can be changed and adjusted according to varying wave resources, ambient conditions (such as sea water temperature) and customer requirements. Modularity is also an advantage for maintenance."

Reliability has also been enhanced in the process. "We applied the Failure Mode Effects and Criticality Analysis (FMECA) method early on during the design phase. Robust components intended for electrical vehicles have been brought into this design, and we also designed couplings adding resilience to the system and easing its assembly and maintenance," Akerberg notes.

Making a case for wave energy

Last but certainly not least, the project proceeded to a case study based on a western Mediterranean scenario for 2030. Results show that wave energy actually delivers more value for money than its solar and wind counterparts. This is due to its specificities: Although wave energy does not follow a clear day-night pattern, it has a clear summer-winter pattern with larger waves during the winter. Since electricity prices are usually higher during the winter, wave energy is the solution generating the highest revenue.

So, what's next for the team? "We are in the implementation phase of the project," says Akerberg. "We are building a dry-land test facility comprised of a test bench and a full-sized PTO, which will enable us to verify whether we have achieved our design goals. It will probably be the largest of its type anywhere in the world."

By delivering an advanced, state-of-the-art PTO for the wave energy sector, MegaRoller provides the renewables industry with the means to scale up and optimise energy production. It's an important step towards a solution that meets end user needs while bringing profit to operators.

PROJECT
MegaRoller – Developing the PTO of the first MW-level Oscillating Wave Surge Converter

COORDINATED BY
Hydroll in Finland

FUNDED UNDER
H2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/763959

PROJECT WEBSITE
sintef.no/MegaRoller

Optimising ocean energy, one wave at a time

A multi-year project on harnessing wave energy generates useful results for an evolving green industry.

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When it comes to waves, Europe is truly blessed. The potential energy to be harnessed along the continent's multiple coasts could cover around 10% of its electricity needs, while cutting carbon emissions and helping the transition to a carbon-free economy. EU businesses keen to exploit this blue and green energy source are racing ahead with research and development, and have put Europe at the forefront of the field.

However, European engineers still have knowledge gaps about the full extent of the challenges related to operating wave energy technology in the open ocean. To this end, the OPERA (Open Sea Operating Experience to Reduce Wave Energy Cost) project embarked on a 31-month trial of an electricity-generating floating ocean device, to both test the viability of the technology, and harvest vast amounts of data critical to the advancement of the research field.

"OPERA's main goal is the long-term reduction of wave energy cost by at least 50%. We wanted to achieve this through the validation and de-risking of four industrial innovations: novel biradial air turbines; advanced control algorithms; elastomeric mooring tether; and shared mooring systems. The team also set out to deliver open access, high-quality open-sea operating data to the wave energy development community. This way, the project will avoid repeating early engineering mistakes and bring wave energy to the market more quickly," explains Pablo Ruiz-Minguela, head of wave energy at Tecnalia and OPERA project coordinator.

Fruitful years at sea

The device chosen to brave the open ocean, for three consecutive winters, was a floating wave energy converter, MARMOK-A-5. The conditions weren't easy for this hardy piece of technology, which draws energy from a wave-powered rotating air turbine. "MARMOK-A-5 has demonstrated survivability in rough seas up to 14 m maximum wave height and displayed increasing availability reaching 90%," says Ruiz-Minguela.

Though the prototype was designed to validate the technology's potential rather than focus on energy production, it also generated some electricity, and was grid-connected through an umbilical power cable to an onshore substation. According to the results, a full-scale MARMOK device could generate enough energy to supply electricity to 150 households.

The experimental results confirm that the innovations can improve turbine efficiency by 55%, increase the overall power production by 30% and reduce the peak loads in the mooring lines by 50%.

The OPERA research team also gained over 1 000 man-hours of operation and maintenance experience. The team feels confident in MARMOK's performance and robustness at sea. "The experimental results confirm that the innovations can improve turbine efficiency by 55%, increase the overall power production by 30% and reduce the peak loads in the mooring lines by 50%," adds Ruiz-Minguela.

Aside from its success as a proof of concept prototype, MARMOK gathered vast amounts of data during its time in the ocean. These data, which will be vital for companies operating in the wave energy industry, are grouped into five categories: environmental monitoring; mooring performance; biradial turbine performance; power output; and power quality.

Passing on the knowledge

The testing delivered insights about making wave energy more competitive. "The wave energy community could leverage this information to better understand the sector challenges," notes Ruiz-Minguela.

Project partners are already using the new datasets to fine-tune their designs for wave energy technology and associated system infrastructure. Associated proposals based on the key exploitable results include a new floating device with a shared mooring configuration, new tethers for mooring systems, and advanced control algorithms.

"The operating experience in OPERA is not restricted to datasets. It also provided various lessons learnt and recommendations for the sector spanning data management procedures, application of international standards, planning of marine operations, as well as economics of wave energy, life cycle and social benefits," Ruiz-Minguela concludes.

PROJECT
OPERA – Open Sea Operating Experience to Reduce Wave Energy Cost

COORDINATED BY
Tecnalia in Spain

FUNDED UNDER
H2020-ENERGY

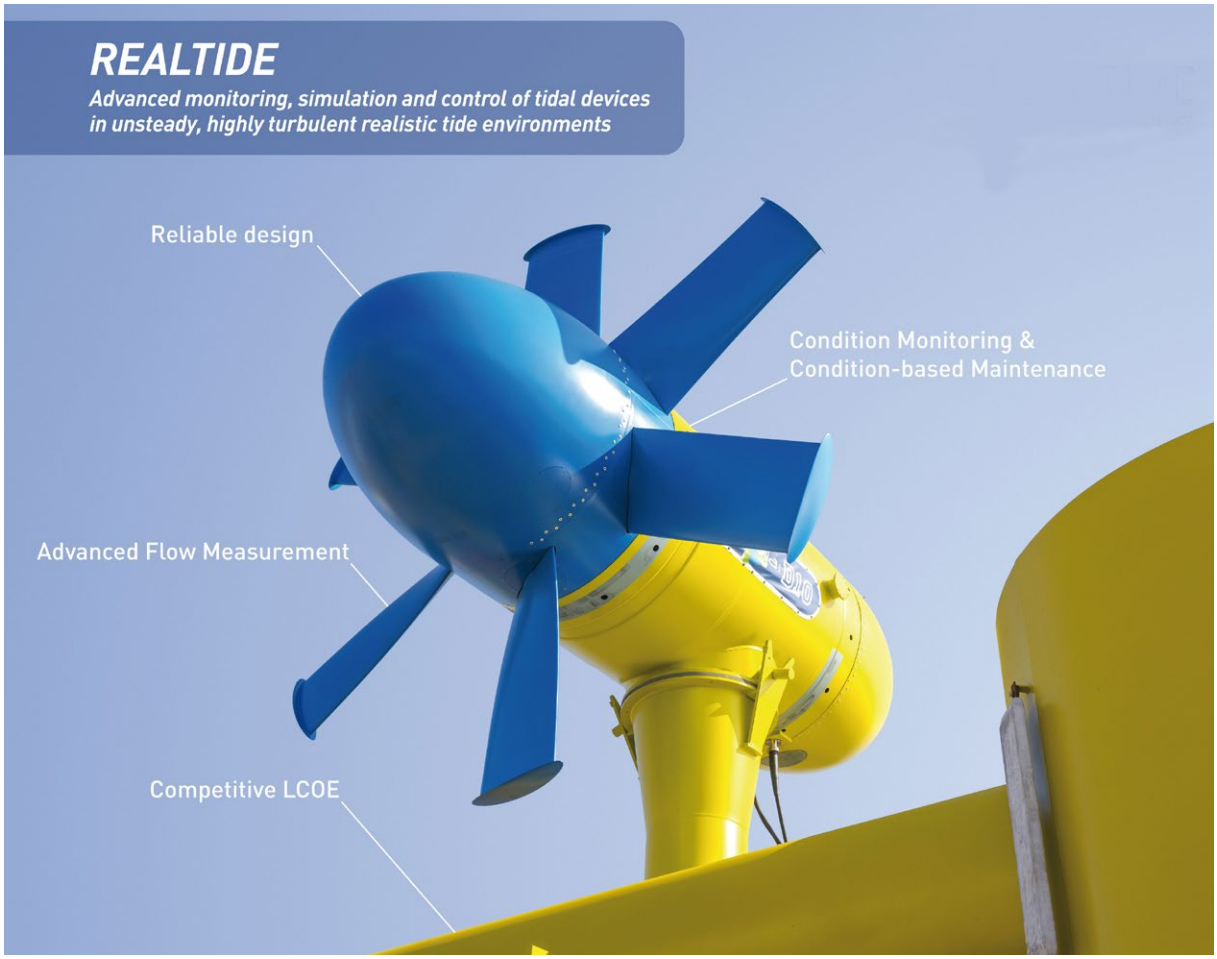
CORDIS FACTSHEET
cordis.europa.eu/project/id/654444

PROJECT WEBSITE
opera-h2020.eu

Tackling turbine failures enhances tidal energy viability

Identifying the key factors behind tidal turbine failure – and proposing solutions – represents a critical step forward in making this renewable energy sector more efficient and economically viable.

Tidal energy converter devices transform the kinetic energy of moving fluid into the motion of a mechanical system, which can then drive a generator. The kinetic energy in tidal currents – the flow of seawater induced by rising and falling tides – can be converted to electricity by a variety of devices.



"Many tidal current turbines look much like a wind turbine placed on the seabed," says RealTide (Advanced monitoring, simulation and control of tidal devices in unsteady, highly turbulent realistic tide environments) project manager at Bureau Veritas Marine & Offshore in France. "The tidal currents move the rotors, generating electricity. When the tide reverses, the rotors reverse direction and continue to generate electricity."

We have demonstrated that increases in performance and reliability are possible.

Electricity is then sent to the grid on shore via a cable. In contrast to highly variable wind or solar electricity production, electricity from tidal energy is predictable. This, says Cabral, makes it a potentially valuable supplement to variable sources, once operational costs have been reduced.

A key challenge in terms of achieving cost-effective operations is the fact that tidal devices are prone to failure. "Devices need to be very robust and capable of unattended operation, given that they are situated underwater," explains Cabral. "The marine environment is extremely harsh, with risks including turbulence, overload due to excessive waves and algae growth."

Addressing points of weakness

The RealTide project was launched in January 2018 with the aim of identifying the main causes of tidal turbine failure at sea. The data gathered have been used to rethink and redesign key components, namely the blades and power take-off (PTO) systems, in order to better adapt them to the complex environmental conditions. PTO is the technology responsible for converting the kinetic energy of wave or tidal power into usable energy.

During the project, advanced monitoring systems were integrated with these identified subsystems, and new maintenance strategies developed. Lab tests, together with tank tests and sea trials were carried out to measure and model real tide flow conditions.

"Our overall objective was to find ways of increasing reliability and improving performance over the full tidal turbine life," notes Cabral. "This was only possible through the collaboration of highly specialised partners."

Competitive renewable energy

Having run for more than 2 full years, the project has produced some important findings. Numerous failure modes induced by the specific operating conditions of tidal turbines were identified, enabling the team to make recommendations on ways of increasing reliability. These recommendations will feed into future designs.

Monitoring technologies most suitable for tidal turbines were also identified. "We also made progress in achieving more efficient blade design," adds Cabral. "This includes integrating embedded fibre optics into the blades for monitoring purposes."

Cabral is confident that the results achieved to date underline that the project is moving in the right direction. Tidal technology is still at a relatively early stage, which means that the gathering of data is critical to identifying existing weaknesses and pinpointing the right developmental path to follow.

"We have demonstrated that increases in performance and reliability are possible," he says. "Reducing the tidal turbine downtime due to failure and maintenance activities, while increasing electricity production and subsequent revenue, will make tidal energy more competitive. New machines using the outputs of RealTide will therefore be more financially viable and attractive to investors."

PROJECT
RealTide – Advanced monitoring, simulation and control of tidal devices in unsteady, highly turbulent realistic tide environments

COORDINATED BY
Bureau Veritas Marine & Offshore in France

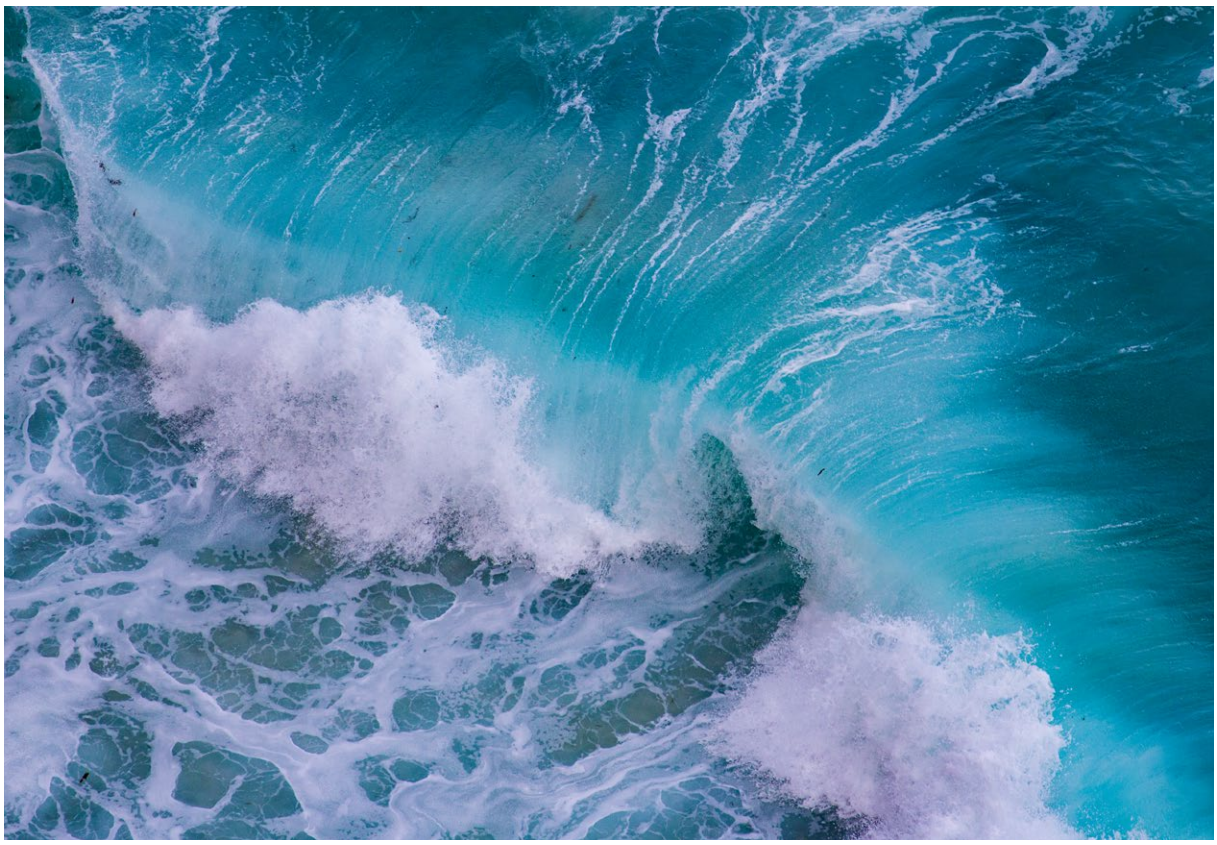
FUNDED UNDER
H2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/727689

PROJECT WEBSITE
realtide.eu

Open-source technology unleashes wave power potential

The development of reliable next-generation technology to convert wave power into usable energy could be a critical moment for a sector that needs to achieve economies of scale.



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The EU's Energy Roadmap states that renewable energy should make up at least 64 % – and up to 97 % – of electricity consumed by 2050. Wave and tidal energy remain an untapped source of power, which could prove critical to enabling Europe to meet this commitment.

For this to happen however, the wave energy sector needs to achieve economies of scale and have access to reliable technology and a dedicated supply chain. One particular challenge is the fact that there is no predominant power take-off (PTO) technology. This is the technology within a seaborne

device, such as a buoy, that is responsible for converting the kinetic energy of wave or tidal power into usable energy.

"This is still the early days of wave energy, which means there are lots of different technologies around," explains SEA-TITAN (Surging Energy Absorption Through Increasing Thrust And efficieNcy) project coordinator Francisco Garcia, CEO of Wedge Global in Spain. "When wind power got going in the 1980s, there were many different devices and inventions, before these technologies eventually converged."

Garcia sees the wave energy sector as following essentially the same path. Technological convergence is essential, he believes, to achieving cost efficiencies, which is why SEA-TITAN is focused on standardising PTO technology and making this accessible to all.

Reliable and accessible technology

The SEA-TITAN project follows previous work carried out by Wedge Global that addressed a common problem – the fact that PTOs installed in seaborne devices often tended to fail. This was in part due to the harsh environment in which they were expected to operate. Garcia and his team built a PTO out of copper and iron, which was shown to work well in the marine environment and provide efficient energy conversion.

"Our aim from the start of SEA-TITAN was to build on this and develop a next-generation PTO that could be applied to multiple wave or tidal power devices," says Garcia. "The technology will be open-source in order to encourage further innovation."

Designs for the next-generation PTO have been finalised and prototype construction is underway, in cooperation with Siemens-Gamesa. A key focus has been placed on increasing energy capture, in order to achieve high efficiency with low operational costs.

"We expect to start to see some real results by the end of this year, when we'll be able to move into testing and validation phases," adds Garcia. "We are also currently developing associated power electronics and components to ensure that the PTO runs smoothly. The great thing about validation is that you always come up with new ideas or find ways of making things work better."

Open-source innovation

One of the most interesting aspects of SEA-TITAN has been the fact that while this has been a private sector-driven project, the emphasis has been very much on open access to innovation. An External Industrial Exploitation Board (EIEB) has been created, with experts drawn from electricity generation utilities, renewable energy electrical machine manufacturers, energy associations and other relevant ocean energy stakeholders.

Anyone interested in this technology can join the board, providing them with access to results.

"Anyone interested in this technology can join the board, providing them with access to results and the opportunity to be part of a new wave energy ecosystem," notes Garcia. "This again will encourage technological convergence within the sector, helping to speed up innovation and eventual commercialisation."

SEA-TITAN is scheduled for completion in March 2021, by which time Garcia expects to see much more industry-wide collaboration, as well as positive steps towards technological convergence.

PROJECT
SEA-TITAN – Surging Energy Absorption Through Increasing Thrust And efficieNcy

COORDINATED BY
Wedge Global in Spain

FUNDED UNDER
H2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/764014

PROJECT WEBSITE
seatitan.eu

Creating new tidal and river power potential

Removing the need for watertight seals in marine hydrokinetic turbine generators could reduce the need for regular maintenance and lower operational costs – particularly attractive for remote regions of the world.

© ORPC

To become a viable source of renewable energy, tidal power needs to reduce its levelised cost of electricity to be competitive with other renewables such as offshore wind. In practice, this means being able to deliver electricity at a similar levelised cost over the lifetime of a project. A significant challenge in meeting this target is operational and maintenance costs, given the extremely harsh environment in which marine hydrokinetic (MHK) turbines must operate.

"The electrical generators of tidal turbines have typically been heavily reliant on seals to protect the inside of the generator from seawater," explains TAOIDE project partner James Donegan, director of European operations at ORPC Ireland.

"If seawater gets in the electrical air gap of a generator, this would typically lead to system failure and significant maintenance costs. We have been investigating for a long time whether it would be possible to have a generator where a flooded airgap is a normal operating environment, therefore removing the reliance on seals for generator protection."

Simplified, reliable technology

This was the key concept behind TAOIDE (Technology Advancement of Ocean energy devices through Innovative Development of Electrical systems to increase performance and reliability). The project was launched in November 2016 to develop a wet gap generator – an encapsulated generator that can be flooded – thus removing a key factor in turbine failure. As part of this development, the project team looked at the entire system, including bearings, seals, generators, electronics and turbines.

"How everything connects influences how we can reduce wear and tear as well as operational costs," says project coordinator Kevin Leyne, Marine and Renewable Energy Ireland project manager at University College Cork, Ireland. "Unlike with wind turbines, MHK systems operators cannot just send a technician up a ladder to perform routine maintenance."

Design simplifications were included wherever possible in order to further reduce the risk of mechanical failure and ensure the system's suitability for remote communities, where technical expertise and equipment might not be readily at hand.

"A good example of this is how we developed a single cantilevered bearing system for the generator, together with project partner SKF," adds Donegan. "Rather than having to take the entire generator apart for bearing maintenance, this unit can be taken out separately for simple maintenance work."

The project team has completed the design and manufacture of a prototype encapsulated wet gap generator, designed specifically for tough operating environments. Tests will shortly begin in Ireland.

Benefiting remote communities

The project will deliver a fully integrated wet gap generator, suitable for use in multiple marine renewable energy devices. "We have been very impressed with initial results from the project, and how ORPC's MHK systems can have a positive effect on rural communities," notes project partner John Doran, principal researcher at the Letterkenny Institute of Technology, Ireland.

"A key thing to note is that because ORPC's power systems are community-centred, they achieve community buy-in. Local resources are used to deploy and maintain their systems. This strikes a chord for us as a rural institute in the north-west corner of Ireland. It has been a great opportunity to work on this project with the likes of the UCC's MaREI and the Fraunhofer Institute in Germany. This project will further enable us to showcase this part of the world as a resource for the tidal energy industry."

This is where we can help communities to become more sustainable and independent.

Donegan agrees that the technology developed in TAOIDE could be of great benefit to peripheral regions which operate on diesel microgrids, where the cost of energy tends to be high.

"This is where we can help communities to become more sustainable and independent," says Donegan.

PROJECT
TAOIDE – Technology Advancement of Ocean energy devices through Innovative Development of Electrical systems to increase performance and reliability

COORDINATED BY
Marine and Renewable Energy Ireland, University College Cork in Ireland

FUNDED UNDER
H2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/727465

PROJECT WEBSITE
taoide.eu

New generator design reduces the cost of tidal power

After designing and building an innovative new generator for tidal technology, testing revealed it to be almost a third cheaper than current devices – making tidal power even more attractive for a sustainable energy mix.

If we are going to successfully build a sustainable future, we need to develop more sources of clean energy. Generating electricity from tidal sources is attractive because it is clean and predictable. The EU-supported TIPA (Tidal Turbine Power Take-Off Accelerator) project has developed technology that is completely submerged, leaving no visual impact on the landscape, unlike other sources such as wind and solar.

The prototype generator was tested onshore initially, at an Aachen University test centre in Germany, before subsea testing by project lead Nova Innovation at Babcock's Rosyth site in Scotland.

"It is no longer a question of if tidal energy happens – it's already happening – the question now is: how quickly can we reduce costs to really make it mainstream?" says Seumas MacKenzie, TIPA project manager.

Power take-off

With the help of modelling techniques, the TIPA team designed and built a new generator which converts the movement of the tidal blades into electricity. As this new power take-off (PTO) direct drive generator doesn't require a gear box, it can achieve high reliability and efficiency, with little maintenance of the system.

Traditional life cycle data analysis for systems designed to operate for decades takes years to conduct. To speed up the process, the team created a programme of accelerated life testing. This forces the system to age faster than under normal circumstances, by subjecting it to more intense conditions. These include stresses, strains, temperatures, voltage, vibration rate and pressure.

The analysis of the PTO's response allowed the team to then make predictions about the PTO's likely service life and maintenance needs.

The project set out with the goal of reducing the cost of tidal power production by 20 %, but in fact Edinburgh University analysis found that the new generator actually reduced the cost of tidal energy by 29 %.

To meet the climate change challenge and get to carbon neutrality, we need access to a full suite of renewable technologies – we need tidal energy in that mix.

"We're absolutely delighted that we've been able to surpass our targets and reduce costs faster than anticipated. This means that the cost of tidal energy is being brought down, making it more competitive, and on track to displace fossil fuels and nuclear in the longer term," explains MacKenzie.

Getting into the mix

Tidal power offers very real promise as part of a European renewable energy mix which could substantially displace reliance on fossil fuels. As well as the extensive testing in the project, the reliability of the PTO technology was independently verified by the organisation Wood. By bringing down costs, TIPA's innovation speeds up the competitiveness of tidal energy in the marketplace.

"Seeing the technology make real progress is terrific. To meet the climate change challenge and get to carbon neutrality, we need access to a full suite of renewable technologies – we need tidal energy in that mix," adds MacKenzie.

As TIPA is an essential part of Nova's technology development road map, insights gained from the project are already being applied to Nova's other EU-funded projects: D2T2 and EnFAIT.

MacKenzie estimates that the TIPA technology could be used in many tens of thousands of turbines around the world in the coming decades.

PROJECT
TIPA – Tidal Turbine Power Take-Off Accelerator

COORDINATED BY
Nova Innovation Limited in the United Kingdom

FUNDED UNDER
H2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/727793

PROJECT WEBSITE
tipa-h2020.eu

New technology trials strengthen wave energy business case

Data showing the reliability of cutting-edge new wave power technology underlines the potential of the ocean as a cost-effective and efficient source of renewable energy.

Power take-off (PTO) is essentially a system that turns movement into electrical energy. In the case of ocean energy, this movement comes from ocean waves as they pass a wave energy converter (WEC). The PTO mounted inside the WEC hull then produces electricity.

A key challenge in the roll-out of this technology has been a lack of available data from ocean deployment in the emerging sector. This has sometimes left investors unconvinced about the reliability of the technology and its slow roll-out.

"More established industries such as offshore oil & gas and wind benefit from a large amount of real deployment data," explains WaveBoost project coordinator Matt Dickson, technical project manager at CorPower Ocean, Sweden.

"This enables them to design out non-reliable components and also predict when, and how, other components of the system will fail, informing effective maintenance strategies. Although we can benefit from some cross-industry learning, a new field like ocean energy has to start from the beginning to build this understanding."

Real performance data

WaveBoost (Advanced Power Take-Off Solution for Wave Energy Converters (WECs)) sought to address this critical roll-out challenge by delivering real performance data, to demonstrate the technology's operational reliability in harsh ocean conditions.

The project team began by looking at some of the key reasons for PTO failure, and found the need for watertight low friction seals at the top of the list. "The hull of a WEC has rod-like pistons moving up and down into the hull as waves pass," notes Dickson. "To visualise it, roughly imagine how mountain bike suspension forks work; the seals need to be tight, but still allow for up-and-down piston movement, or the device won't function."

In order to gather information on how this aspect of technology could be improved, WaveBoost project partners built a bespoke state-of-the-art test rig in order to deploy a variety of scaled versions of these rod-like pistons. Different materials and coatings were trialled in order to gather information on friction, corrosion and sealing properties.

"We experimented with leading sealing suppliers and ultimately came up with a completely new and novel sealing design," says Dickson. "The seal is optimised for friction showing 70 % reduction compared with previous state of the art and mitigates all leakage."

The sealing system is a small but critical part of a new PTO system that also incorporates a revolutionary pneumatic module with 80 % fewer components and 98 % flow loss reduction. This has helped to reduce complexity and improve the reliability of the ocean-borne device.

Additionally, the PTO wave spring technology amplifies the movement of the PTO, helping to achieve breakthrough energy efficiencies not seen in the sector to date.

Final tests showed that with the new seal solutions, combined with other advancements in the PTO technology during the project, an improvement of over 27 % in annual electricity production should be possible and a 30 % reduction in the cost of wave energy, making wave energy a cost-effective and efficient source of renewable energy.

Industry-wide impact

WaveBoost's new PTO technology has been designed so it can be installed in a variety of WEC devices. "PTOs are at the heart of WECs," explains Dickson. "What we have developed can be transferred into a range of hull designs and sizes." This, Dickson hopes, will help to speed up the deployment and success of ocean energy technology.

This project was the necessary bridge to full-scale development.

"This project was the necessary bridge to full-scale development," adds Dickson. "The bridge had to be strong enough for us all to cross, and in the end, we developed a better PTO design than we ever anticipated."

WaveBoost's successful completion has unlocked CorPower's plans to deploy full-scale WECs in the first quarter of 2021. CorPower hopes to introduce certified and warrantied products onto the market by the end of 2023. "We have shown that wave energy is a bankable technology that can attract mainstream renewable energy project finance," concludes Dickson.

PROJECT
WaveBoost – Advanced Power Take-Off Solution for Wave Energy Converters (WECs)

COORDINATED BY
CorPower Ocean in Sweden

FUNDED UNDER
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CORDIS FACTSHEET
cordis.europa.eu/project/id/727598

PROJECT WEBSITE
corpowerocean.com/commercial-projects/waveboost

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CINEA – H2020 project manager

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HYDROGEN'S GROWING ROLE IN SUSTAINABLE ENERGY SYSTEMS

Hydrogen is a real contender for being the world's next big solution to ensuring more sustainable energy and transport systems and in this edition of Research*eu, we meet seven EU-funded projects that are demonstrating how hydrogen's time to shine may finally have dawned.

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