MARINE GENERATORS

High tide for marine energy

Not all marine energy project development has taken place in UK waters. Here, *Andrew Williams* reports on projects around the world that aim to move wave and tidal generators into commercial deployment.

In the ongoing quest to reduce carbon emissions and increase the amount of power generated by clean sources, technologies such as nuclear and solar have historically occupied a dominant market position. However, as marine energy continues to develop, there is growing evidence that wave and tidal technologies could emerge as a viable option for grid decarbonisation.

Industry has toyed with the idea of commercial-scale wave and tidal schemes for years, but so far actual rollout has been limited. However, if the sheer number of projects and companies in the space is any indicator – this is all about to change.

EU Projects

One of the most notable recent developments has been the commencement of the Ocean Energy Scale-Up Alliance (OESA) – a three-year initiative running from January 2019 to December 2021, which is backed by €6.2mn of EU support. The scheme aims to speed up the development of existing early-stage technologies and expedite their economic competitiveness by facilitating larger pilots in the North Sea region.

As part of this process, OESA has recently awarded funding to five projects under its Pilot Accelerator Programme. Organisations receiving funding include Scandinavian company SeaBased, a manufacturer and installer of grid-connected wave parks, and Dutch company Tocardo Solutions, which will further development of its turbine technology and an array structure called the Universal Foundation System.

Meanwhile, Swedish energy outfit SeaTwirl will work to fine tune the design of its 1 MW SeaTwirl S2 wind turbine, which utilises the buoyant force of the ocean to support its weight. Danish company Floating Power Plant has created an offshore-tested combined wind and wave device and will further its own efforts to deploy the device in the North Sea under the OESA programme.

The final funding recipient is German wave energy company NEMOS, which has created a device comprising a floating body that is excited by waves and transmits energy to an electric generator via a belt drive. The entire system is assembled in port and can be easily towed to its operating site and moored with a standard drag anchor.

Based on findings from wave tank investigations, Jan Peckolt, CEO at NEMOS, reveals that an innovative in-built trajectory and motion control system also enables hydrodynamic efficiencies of up to 80% – an impressive performance for a simple floater.

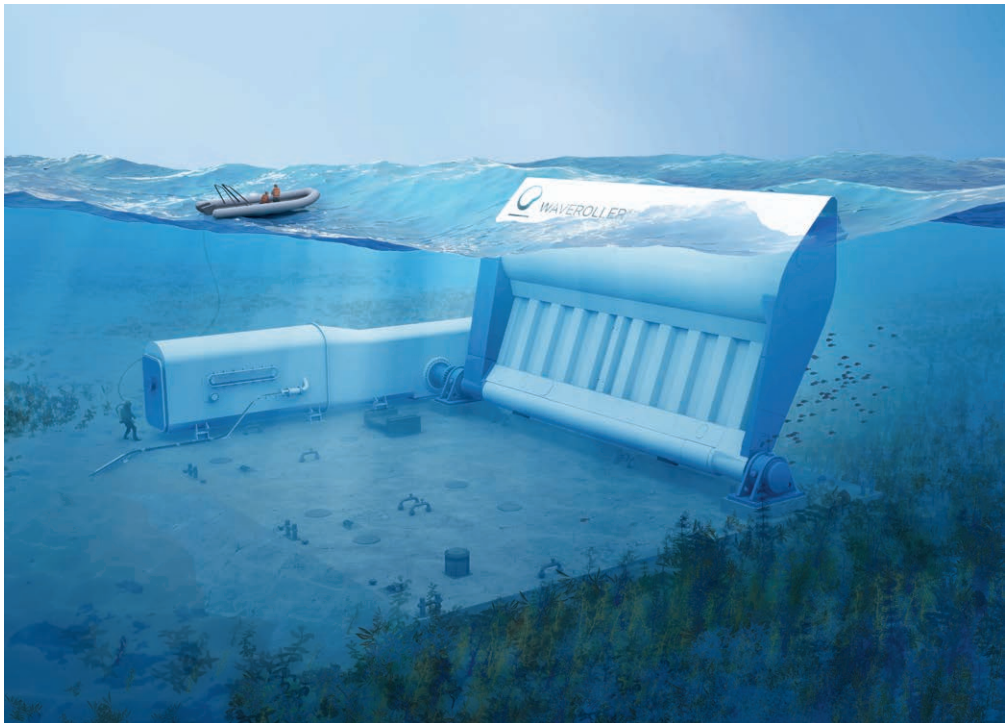
Following successful operational testing in scaled natural sea conditions at Limfjord, Denmark, the company is set to begin testing of the first North Sea prototype of the 8 m-wide device off the coast of Belgium. Beginning in 2020, the OESA project award will allow the company to scale the system to higher power levels by developing the device for more energetic sea conditions – with the outcome of the testing campaign forming the basis for the first commercial-scale device.

'The system has been designed to optimise the ratio between outputs and overall costs,' Peckolt explained. 'As a special feature to cope with the pulsating power of ocean waves, the power take-off system includes a mechanical energy buffer. A composite spring system also balances the output of the generator, which reduces its costs and increases its electrical efficiency.'

In parallel to the current testing activities, the NEMOS team is also preparing the company's first commercial-scale project. Several sites in the Atlantic Ocean that provide steady energy input, and that could be suitable for an installation in 2022, are already under investigation.

WaveRoller

Beyond the North Sea, another interesting initiative is in motion off the coast of Peniche, Portugal, where Finnish company AW-Energy is planning to install and test its WaveRoller device.



The WaveRoller consists of a submerged 18 m panel that is hinged at the seabed, and which extracts energy from the back and forth motion of swell waves

Photo: WaveRoller

The technology consists of a submerged 18 m panel that is hinged at the seabed, and which extracts energy from the back and forth motion of the subsea wave surge of swell waves – before feeding this energy into a power take-off (PTO) module mounted on the foundation.

The PTO translates the angular motion to linear motion energy that is fed into the power capture and storage system, before being released to a subsea cable and shore substation as required by the local grid. Swell waves are generated by weather systems far from shore, where winds cause water particles to circulate deep below the ocean's surface.

Christopher Ridgewell, CEO at AW-Energy, explains that, as a rule of thumb, the depth of this motion is about half the wavelength, meaning that the motion can extend down over 100 m for long swell waves – transferring the energy great distances before reaching the shoreline.

'At about 50 m depth, the bottom of the wave interacts with the seabed and two things start to happen – the wavelength reduces, and the circulating motion of the water particles becomes more elliptical, eventually becoming just a back and forth motion, as can be seen in shallow water. This is what WaveRoller uses,' said Ridgewell.

'If you've ever been paddling from the beach up to your knees in water and been pulled out by the surf, that's pretty much the same phenomenon,' he added. 'Just the force is much larger in the deeper water and with a wide panel.'

As part of the project – funded by the European Commission through its FP7 programme – the company led a consortium that designed, built and deployed the device as part of efforts to transition from prototype to commercial bankable asset stage.

First, the generated power for any given sea state was compared with a numerical model in order to validate the model using real sea trials. This was then verified by the classification society DNV GL, giving the company confidence when calculating expected levels of electricity generation for its project cash flows.

Following this stage, the methodology to calculate the structural integrity was validated – before the panel, PTO and foundation were kitted out with a range of instruments, including strain gauges, accelerometers and pressure gauges, and again deployed at the Portuguese site.

'The site is fully exposed to the Atlantic Ocean,' Ridgewell said. 'We collected data for the full matrix of wave heights, wave lengths and wave directions. Structural responses for these waves were calculated using our numerical method and then compared with the real sea measurements. This then allowed us to validate the model and determine safety factors that can be used in the design process for commercial projects.'

According to Ridgewell, the process created a strong foundation for the company to create a device that has now been certified by Lloyd's Register. Achieving this certification has also meant that the technology meets the criteria for what Ridgewell calls business interruption insurance – meaning that the project's electricity generation income is insured. 'To reach this goal has required a huge engineering effort but provides certainty in project cash flows and is a prerequisite for bankable projects,' he said.

Moving forward, the company is developing projects around the world in a variety of markets. This expansion strategy is made possible because WaveRoller is easily deployable in many countries that border large oceans. To date, the device has been deployed and demonstrated in Finland, Ecuador, Portugal and Scotland's Orkney Islands.

'The UK is another good example where WaveRoller could make a considerable contribution to the energy mix,' Ridgewell adds. 'All the important factors are in place: manufacturing facilities, wave resource and an electricity price that could support larger projects. To get there we need to build smaller projects, but even now we have projects that are projected to be profitable with the local tariff.'

Performance assessment

Elsewhere, the European Marine Energy Centre (EMEC), based in Orkney, has recently undertaken an independent performance assessment of Verdant Power's 5th Generation (Gen5) tidal turbine system. The technology is set to be deployed for commercial demonstration in New York City's East River in 2020.

The assessment will entail measuring the water velocity upstream of the device, on both the ebb and the flood, and measuring the electrical power generated for a minimum of two weeks to capture the full spring neap tidal cycle. This will enable the compilation of a power curve for the device which shows correlation of power output for a given water speed.

According to Anna Southall, Performance Test Engineer at EMEC, independent measurement of the device performance is an important step in assuring funders and demonstrates dependable data for future commercial developments.

'Performance assessments will be part of customer acceptance in future commercial contracts and are a vital component for accurate prediction of energy yields,' Southall says. 'The sector will only grow once credible performance has been demonstrated, which this type of assessment delivers. This type of testing is key to reducing uncertainty and assuring investors and insurers.'

Although EMEC has been an accredited test laboratory for testing marine energy converters since 2005, the key difference this time around is that it is looking to extend its accreditation activities beyond its own test sites, and become the first to issue a marine test report under the new IEC RE certification scheme. It is currently working on similar assessments in the MET-Certified, and FloTEC EU funded projects.

Each successful testing and assessment process brings wave and tidal systems closer to utility-scale readiness. In a world that is urgently looking to decarbonise, these technologies have the potential make a significant contribution in the decades to come.

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> **Christopher Ridgewell, A-W Energy**

Verdant Power's 5th Generation tidal turbine system is set to be deployed for commercial demonstration in New York City's East River

Photo: Verdant Power