



2023

TIDAL CURRENT ENERGY DEVELOPMENTS HIGHLIGHTS

Advances in Tidal Current Energy

Tidal current energy is global, abundant and a valuable source of untapped renewable energy. It is generated by the movement of ocean water volumes during changing tides, resulting in reversing current flows that can be intensified near coasts with constraining topography. This energy can be harnessed using either seabed-mounted or floating tidal current turbines. There is also technology designed to capture energy from ocean currents (nearly continuous and relatively constant unidirectional flow) and from river currents.

The tidal energy sector has been consistently delivering step changes in recent years, with developers focusing on building up experience with long term operation and the execution of maintenance programs, but also on the installation of new turbine designs, developing improved control systems and optimizing fully integrated power train solutions. These innovations aim to reduce the cost of tidal energy technology, increase rated power and enhance turbine performance.

Several projects under development are delivering local economic value for coastal communities. Developers are also delivering comprehensive environmental monitoring programmes and collaborating with several partners to address marine spatial planning issues for wide-scale uptake of tidal energy.

All these efforts are being supported by highly experienced partners who are dedicated to the delivery of tidal energy and committed to accelerating its future uptake with a meaningful impact. By working together, the sector is making progress towards the development of large-scale, commercially viable tidal energy projects, with a continued path of cost reduction alongside enhanced reliability.

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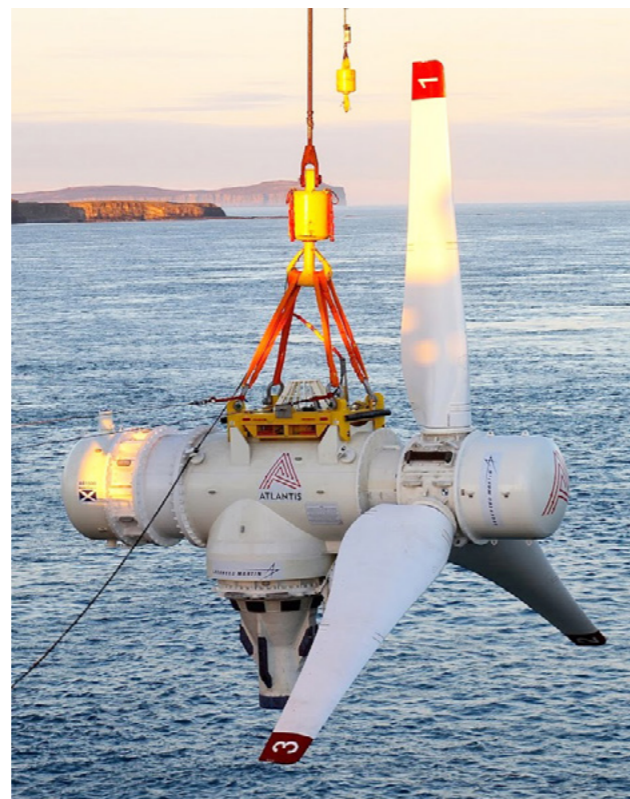
1. MeyGen, the world's largest tidal array has delivered over 50 GWh to the grid

The MeyGen project owned by SIMEC Atlantis Energy, established in 2010 in the Pentland Firth, north of Scotland, is the largest planned tidal stream project in the world, with consent currently awarded for 86 MW and the option to develop up to 398 MW.

The project is split into four phases. Phase 1 has been operational since 2018 and comprises four 1.5 MW turbines (6 MW demonstration array) that have generated over 50 GWh of renewable electricity. In this phase, two different technologies are used: Simec Atlantis Energy's AR1500 and Andritz Hydro Hammerfest AH1000 MK1.

In July 2022, SIMEC Atlantis Energy achieved the first contractual milestone for additional 28 MW: The successful award of a Contracts for Difference (CfD) in the UK Allocation Round 4 process at a strike price of £178.54/MWh will allow the development of MeyGen Phase 2.

SIMEC Atlantis Energy also has installed its demo tidal turbine of 500 kW in Japanese waters near the Goto Island chain, under a contract with the Japanese company Kyuden Mirai Energy.



SIMEC Atlantis deployed at MeyGen © SIMEC Atlantis



2. Nova Innovation Tidal Array at Shetland Islands has accumulated years of operation

Nova Innovation made history in 2016 by installing the world's first offshore tidal array in Shetland, Scotland. The array consisted of three 100 kW turbines connected to the national grid. The company successfully added a fourth tidal turbine in 2020 and a fifth and sixth turbine to the Shetland Tidal Array in January 2023.

By December 2022, the array achieved a world record performance of 60 months of continuous monthly power output to the grid.

Nova Innovation is continuing to develop its 1.5 MW tidal energy project in Petit Passage, Nova Scotia, known as the "Nova Tidal Array". During 2022 Nova built the first turbine for the project and shipped it to Canada. The turbine is due to be installed on the seabed of Petit Passage in 2023.

Nova M100-D tidal power turbine © Nova Innovation



3. Verdant Power completed its project in New York's East River with valuable insights on installation, operation, and maintenance

Verdant Power's Roosevelt Island Tidal Energy (RITE) Project has been developed in the East Channel of the East River, a tidal strait connecting Long Island Sound with the Atlantic Ocean in New York Harbor.

On October 2020, Verdant Power installed three Gen5 Free Flow System Turbines on a novel mounted system - TriFrame™ - at the RITE Project. This installation aimed to showcase a cost-effective solution for the installation, operations, and maintenance of tidal energy systems.

The company reported that the system had been highly reliable and predictable, and has achieved operating cost targets.

In January 2022, Verdant Power decommissioned the project site with valuable lessons learned regarding installation, operations, and maintenance. Over six months of continuous operation, Verdant Power's tidal energy TriFrame™ system achieved over 99% availability while generating 210 MWh.

4. Sustainable Marine launched a new prototype at the Bay of Fundy harnessing the power of the world's largest tides

Sustainable Marine Energy (SME) with its partner Schottel Hydro are continuing the development of their project in the Bay of Fundy, Nova Scotia, Canada.

A floating platform with 6 turbines was launched in 2022 at the Bay of Fundy. It's a larger version of the PLAT-I system tested successfully over the past two years. The device is installed in the demonstration site at Grand Passage and authorization is being sought from Fisheries and Oceans Canada to move it to the Fundy Ocean Research Center for Energy (FORCE), in the Minas Passage, where the tides are more powerful.

This 420 KW platform (PLAT-I 6.4) is the first unit of a 1.26 MW floating array project.

The company has developed an advanced environmental monitoring system, completed the manufacture of the first rock anchors that will be used to secure the device at the FORCE site, and completed construction of the Tidal Pioneer, an advanced inshore construction vessel that is now operating and will be used to perform complex tasks for the high-flow site at FORCE.



Sustainable Marine's PLAT-I 6.4 in Grand Passage, Nova Scotia © Sustainable Marine Energy



5. **Orbital Marine Power is already targeting the expansion of its project capacity, alongside the successful operation of the 2MW O2, the world's most powerful tidal turbine, at EMEC**

Orbital Marine Power's flagship device, the O2 turbine, continued to generate power at EMEC's Fall of Warness tidal test site.

The O2 turbine is a 72m long floating superstructure, supporting two 1 MW turbines at either side for a nameplate power output of 2MW. With rotor diameters of 20m, it has a 600 m² rotor area, the largest swept area on a tidal energy converter, and a 'gull wing' leg retraction system that allows for low-cost onsite access to the entire generating unit.

In July 2022, Orbital Marine Power was awarded two Contracts for Difference (CfD) through the UK Allocation Round 4 process, supporting the development of 7.2 MW of new tidal stream energy at EMEC.

Additionally, in 2023, the €10 million MAXBlade Project was launched to investigate the full lifecycle of tidal turbine blades and to increase the length of Orbital's blades to 13m. This will make them the longest of their kind in the world, giving Orbital's turbines a combined rotor swept area of over 1,000m², a factor which will have the single greatest impact on reducing the cost of tidal energy.

6. **Magallanes Renovables is progressing with its project in Wales after completion of a structured test programme at EMEC**

Magallanes Renovables, a Spanish tidal energy company, successfully completed the testing programme of its second-generation tidal turbine device at EMEC's grid-connected test site.

The company's "ATIR" concept is a 45-meter floating platform equipped with two counter-rotating rotors, with a total capacity of 1.5 MW. It was manufactured in Vigo, Spain before being towed to EMEC. The device generated

its first electricity into the UK national grid in March 2019 and it was re-deployed at EMEC in April 2021 and again in September 2022 after periods of maintenance.

Magallanes was among the three tidal turbine developers to receive a Contract for Difference (CfD) in the UK government's latest auction round, paving the way for their first commercial deployment at the Morlais project in Anglesey, Wales. Onshore construction is now underway.



Magallanes Renovables ATIR © Magallanes Renovables

7. **Tocado's Oosterschelde Tidal Power Plant in the Netherlands resumed its full continuous operations**

Tocado's Oosterschelde Tidal Power Plant (OTP) is located in one of the openings of the Oosterschelde Storm surge barrier. It consists of a 50 m long structure with five T2 turbines of 250 kW, with a total installed capacity of 1.2 MW. Commissioning was completed in 2016 and the project, during 2022, continued operations successfully.



Tocado's Oosterschelde Tidal Power Plant © Tocardo

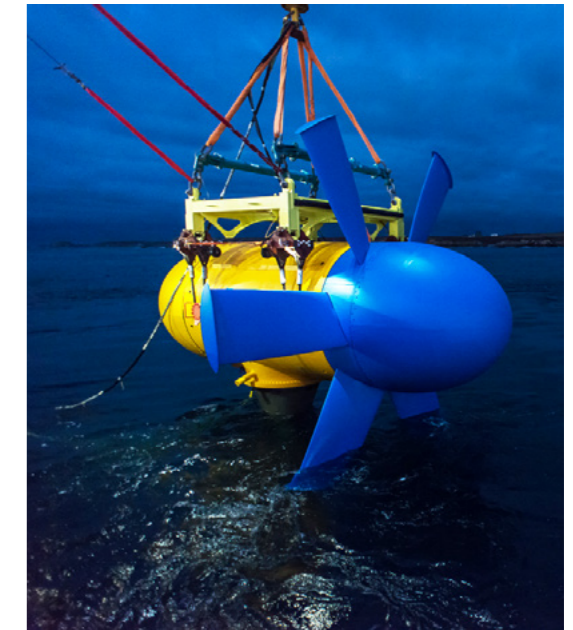
8. **Sabella's 1MW tidal turbine has been operating successfully off the Western coast of Brittany, in one of the French hotspots for tidal resource**

Sabella D10 project has been developed in the Fromveur Passage at Ushant Island, the second French hotspot for tidal resource off the Western coast of Brittany. It became the first tidal turbine to supply electricity to the French grid, in November 2015. The technology is composed of a horizontal axis rotor installed on a gravity-based structure laying on the seabed.

Full-scale D10-1 MW turbine was successfully redeployed in October 2019 in the Fromveur Passage at Ushant Island, and again in April 2022, after periods of maintenance. The turbine has been operating successfully accumulating operational hours.

In December 2022, Sabella connected a small electrolyser to the D10 turbine to experiment the green hydrogen production. The experiment has been successful, driving to new opportunities for energy storage.

The company is also working with Morbihan Hydro Energies for the design, construction, and deployment of two tidal turbines of 250 kW in the Gulf of Morbihan within the scope of the Interreg TIGER project.



Sabella D10 deployed at in the Fromveur Passage at Ushant Island © Sabella



9. HydroQuest is designing the next generation turbine to be installed at the Raz-Blanchard, Normandy, integrating the learnings from the 1 MW pilot project

HydroQuest and CMN (Constructions Mécaniques de Normandie), with the support of the University of Caen Normandie, successfully installed and connected in 2019 a 1 MW turbine on Paimpol-Bréhat test site in Brittany.

The project, known as OceanQuest, demonstrated performance of the technology in real conditions and has been retrieved in October 2021, after 2 years and a half of operation.

HydroQuest and its partners are now developing a 17.5 MW pilot farm at the Raz-Blanchard, Normandy, one of the most powerful tidal energy sites in the world. This pilot farm will consist of 7 next generation tidal turbines of 2.5 MW. This deployment is planned in the framework of the Normandie Hydro project which is supported by the FloWatt consortium formed by Hydroquest, Qair and CMN.

HydroQuest is also partner of the European funded project TIGER aiming to build cross-border partnerships between France and UK to develop new technologies, test and demonstrate up to 8 MW of new tidal capacity at a number of locations around the Channel region.

10. LHD Zhoushan tidal power station in Xiushan island, China exceeded 60 months of continuous operation

The LHD tidal current energy demonstration project is being developed near Xiushan island, Zhejiang Province, China, since 2016.

One innovative aspect of this project is the modular design of the bottom-standing platform which facilitates installation and maintenance, with the equipment being accessible from the surface.

This project was planned to be implemented in two phases. Since 2018, the construction of the second phase of LHD project has begun.

In 2016 and 2018, several turbines modules have been installed reaching an installed capacity of 1.7 MW in one platform.

In 2022, the new MWs turbine “Endeavor” developed by LHD. During testing operation, the new turbine’s maximum generating capacity has exceeded 1 MW.

The continuous operation time of the LHD tidal current energy demonstration project has exceeded 60 months until December 2022.



11. Uldolmok Tidal Power Pilot Plant in Korea completed two years of electricity generation

The Uldolmok Tidal Power Station is located in the Myeongnyang Strait at Jindo Island, Republic of Korea.

This plant is now integrated in the Korea Tidal Current Energy Center (K-TEC) led by the Korean Institute of Ocean Science and Technology (KIOST) and being used as an open test site for tidal current energy turbines.

Currently, a cross-flow Helical Turbine with 80 kW rated output is installed. From 14 September 2021 to 15 May 2022, 8.88 MWh of electricity was generated.

KIOST is also developing a tidal current energy converter (TEC) hybrid system for remote off-grid islands utilizing dual vertical axis Darrius turbines with a rated power of 100 kW. For accumulating electricity, the energy storage system (ESS) has a total capacity of 500 kWh. This hybrid system was manufactured and installed at the front side of the existing Uldolmok Tidal Power Pilot Plant to be tested in 2023.



Uldolmok Tidal Power Station © KIOST



12. Minesto's tidal energy kite has been successfully operating at Faroe Islands and is progressing with the installation of a second device

The Swedish marine energy developer Minesto is developing a technology, called Deep Green, that can produce electricity from low-velocity tidal and ocean currents, using a tidal kite system.

In 2020, Minesto launched its 100 kW DG100 tidal kite system in Vestmannastrandir, at Faroe Islands which was successfully connected to the Faroese grid, operational throughout 2021.

In summer 2022, Minesto deployed a new generation device, the 100 kW Dragon 4 in the existing grid-connected site in Vestmannastrandir. The kite, has been operating autonomously, remotely monitored through advanced systems. A second subsea infrastructure was installed at Vestmannastrandir for a second Dragon 4 unit, for the demonstration of a mini array with two units.

The development of Minesto's utility-scale power plant Dragon 12 (1.2 MW) is progressing with the installation of the Dragon 12 planned for 2023.

Minesto is also developing a project at Holyhead Deep, in close proximity to the West Anglesey Demonstration Zone, in Wales. The project is carried out in a number of phases. In an initial phase, a non-grid connected DG500 (500 kW) was deployed and tested in 2018. The long-term plan is to gradually expanding the site to a commercial project of 80 MW.

Deployment of the first Dragon 4 powerplant in Vestmannastrandir, Faroe Islands © Minesto



13. ORPC is operating projects at four locations in the U.S. and Canada and will soon add a fifth project in Chile

Ocean Renewable Power Company (ORPC) power systems generate electricity from river and tidal currents, either with direct power grid connection, or in remote communities with isolated power grids. ORPC's RivGen® Power System was deployed in the Village of Igiugig, Alaska, in October 2019. The Company expects to deploy a second system to complete its commercial project there in summer of 2023.

In 2022, ORPC deployed its first RivGen device in Canada at the Canadian Hydrokinetic Turbine Test Center in Manitoba where it will operate for over a year. ORPC plans to connect the device to a utility-scale grid and eventually move it to a First Nation community for permanent deployment. ORPC is manufacturing a fourth RivGen device which will be deployed in Chile in the fourth quarter of 2023.

ORPC deployed its first Modular RivGen device in a tailrace in Millinocket, Maine, in January 2023, and will install a second Modular RivGen device there in May 2023. Finally, 2023 will mark ORPC's return to the ocean with the May deployment of its next-generation TidGen® device in Eastport, Maine.

Other Upcoming Developments

Other developers are currently preparing to advance their tidal energy projects in different parts of the world:

SeaCurrent, a Dutch company, is moving towards a demonstration of its fourth TidalKite system at Ameland on the Wadden Sea.

Canadian company **BigMoon Power** is set to deploy its Falcon tidal power device in the Minas Basin of the Bay of Fundy.

Jupiter Hydro, also based in Canada, is making progress on its project featuring helical turbines in the Bay of Fundy.

NewEast Energy, another Canadian company, is working towards deploying its 800 kW project with four EnviroGen™ Power generators as part of a floating grid connected array in the Bay of Fundy's Minas Passage.

Meanwhile, **Yourbrook Energy Systems**, based in British Columbia, is continuing development of its Kamdis Tidal Power Demonstration Project in Masset Inlet, Haida Gwaii, which is designed to serve rural and remote communities.

GEM Ocean's Kite designed by the Italian companies ADAG and SeaPower s.c.r.l. have been tested in the Venice lagoon and there are plans to install a 300 kW prototype in the Strait of Messina.



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