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School of Engineering

POLICY AND
INNOVATION GROUP
**UK OCEAN ENERGY
REVIEW**

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Policy and Innovation Group

The Policy and Innovation Research Group is part of the Institute for Energy Systems (IES), which is one of the six research institutes within the School of Engineering at the University of Edinburgh. The group combines expertise on technologies, energy system organisations and institutions, and the wider policy and regulatory context for energy. They apply a range of quantitative and qualitative research tools and methods including innovation systems, energy system modelling and scenarios, and transitions management. This leads to preparation of strategy and investment roadmaps for organisations' funding, public and private investment and government departments.

Find out more about the Policy and Innovation Group at <http://www.policyandinnoationedinburgh.org/>

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Cover Image: Wave Energy Scotland
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1 OVERVIEW

With numerous projects in the water and thousands of MWh of electricity generation (including the world's largest tidal array MeyGen), 2019 was a growth year for the marine energy sector in the UK. The year saw numerous innovative cross-border collaborations, deployment of state-of-the-art projects and offshore tests being undertaken. The UK is home to the first tidal stream arrays in the world and has already deployed more wave and tidal energy devices than the rest of the world [1]. Even though most of these activities have been supported through Research and Development (R&D), a dedicated policy and revenue support for ocean energy is still required to deliver significant sustainable economic benefits. While the UK stands as a global leader in developing offshore renewable energy technologies, a reduction in technology costs is required for the sector to compete with alternative low-carbon technologies and contribute towards achieving the UK's net-zero target.

Wave

In 2019, the wave energy sector continued to engage in innovative R&D to drive the sector towards design convergence and commercialisation. Wave Energy Scotland (WES) continues to be the focus for wave energy R&D activity in the UK in terms of funding provision for wave energy innovation and demonstration. In 2019, the programme awarded £9m to eleven wave energy technology projects through various innovation projects and research activities. The Welsh European Funding Office (WEFO) in Wales also continues to contribute significantly to wave R&D with £30.4M being allocated for wave energy development since 2014.

Tidal Stream

In 2019, many tidal stream projects made significant progress towards commercialisation. By the end of 2019, SIMEC Atlantis' four-turbine 6 MW MeyGen project had clocked up over 23 GWh of generation with maintainability also demonstrated through recovery and reinstallation operations. The Nova Innovation three-turbine 0.3 MW array continued to operate, with the turbines accumulating over 20,000 hours generating power to the grid (as of Dec 2019). With the integration of a Tesla battery system, the turbines are now able to provide continuous power to the local grid. The Scottish tidal developer has also been granted licence to deploy a 1.5 MW tidal array starting 2020 in the Bay of Fundy area of Nova Scotia, Canada [2]. The 2 MW floating SR2000 device from Orbital Marine Power also achieved 3 GWh of generation over a year of continuous deployment. In 2019, Orbital Marine Power commenced construction of their optimised production model, the 2 MW Orbital O2, for deployment at The European Marine Energy Centre (EMEC) in 2020. Also in 2019, Minesto deployed their commercial scale low flow technology off the coast of Anglesey and have secured their first international orders for the Deep Green technology. The Tidal Stream Industry Energiser (TIGER) project was initiated in July 2019 planning to deploy up to 8 MW of new tidal capacity around the Channel region [3]. In October 2019, the Tidal Stream sub-theme report was also published as a part of the Business, Energy and Industrial Strategy (BEIS) commissioned Energy Innovation Needs Assessment (EINA) that described the potential of tidal stream in the UK's energy mix [4].

2 SUPPORTING POLICIES FOR OCEAN ENERGY



(Source: Orbital Marine Power)

2.1 National Strategy

The UK Government's Department for BEIS retains overall responsibility for energy policy in the UK while powers related to planning, fisheries and the promotion of energy efficiency are devolved to the governments of Scotland, Wales and Northern Ireland.

In May 2019, the Committee on Climate Change (CCC), the UK's independent climate advisory body published "Net Zero – The UK's contribution to stopping global warming" [5]. The report reassessed the UK's long-term emissions targets and recommended new greenhouse gas reductions targets for the UK, Scotland and Wales: 100% by 2050; 100% by 2045; and 95% by 2050 respectively. Following the recommendations, the net zero target for 2050 was passed into the UK legislation in June 2019, making the UK the first major economy to set a target to end its contribution to global greenhouse emission by 2050 [6].

The Clean Growth Strategy (CGS) published in October 2017 by the UK Government had set out comprehensive policies and proposals to accelerate economic growth and decrease emissions [7]. It stated that ocean energy technologies "could also have a role in the long term decarbonisation of the UK, but will need to demonstrate how they can compete with other forms of generation." The CGS was followed by the Industrial Strategy (IS), which includes sector deals, more recently updated for ten sectors (including offshore wind) and four Grand Challenges [8]. The IS aims to push the UK to the industrial forefront, maximising potential advantages from the global low-carbon energy transition. Progress updates for the CGS along with the inclusion of new sectors into the IS were published in October 2018 and June 2019, respectively; however no references were made to ocean energy.

To further inform budget setting for 2019 onwards, BEIS commissioned the EINA that brought together UK Government funding agencies from across the UK to prioritise and allocate R&D investment to low-carbon technologies, including ocean energy [4]. In October 2019, the EINA report on Tidal Stream that summarised innovation needs, market barriers and business opportunities for the tidal sector was published [9]. However, post elections, a clear policy for 2020 has yet to be set as it will be included in the next comprehensive spending review.

Scotland

The Scottish Energy Strategy sets out the Scottish Government's vision for the future of the energy sector to 2050. The Strategy is defined by a whole-system approach and includes a target to meet the equivalent of 50% of Scotland's heat, transport and electricity consumption from renewable sources by 2030. Following updated technical advice from the UK Committee on Climate Change (CCC), the Scottish Government amended its Climate Change Bill to a net-zero greenhouse gas emissions target by 2045. This is reflected in the first Annual Energy Statement published in 2019 that states the progress alongside the priorities and sets targets for the Scottish Energy Strategy [10].

The Scottish Government continues to champion the ocean energy sector, supporting the research, development, innovation and demonstration intended to maintain Scotland's position as a world leader in both wave and tidal energy. This includes providing ongoing support for Wave Energy Scotland (WES) and, in February 2019, establishing the Saltire Tidal Energy Challenge Fund (with a total funding of £10m) to accelerate the commercial deployment of tidal energy in Scottish waters [11]. To date, the Scottish Government has invested nearly £40m in more than 90 projects through the WES programme. Through various innovation projects and research activities, funding of £9m was awarded in 2019, including £6.6m for two Scottish wave energy devices to be deployed in 2020. The Scottish Government also continues to support the Scottish Marine Energy Industry Working Group, to secure future growth and further industry cost reduction.

Marine Scotland, the Directorate of the Scottish Government responsible for the management of Scottish seas, including planning and licencing of marine energy projects, opened a consultation in November 2019 to seek views on a draft Offshore Renewables Decommissioning Guidance document. The consultation will close in March 2020 ahead of the final publication of the guidance document [12].

The Crown Estate Scotland, which reports to The Scottish Government and manages seabed leasing for renewable energy projects out to 200 nautical miles (nm) will soon operate under The Scottish Crown Estate Act 2019. A new round of leasing for offshore wind in Scotland, ScotWind Leasing, will launch soon but applications for ocean energy projects of up to 30 MW are accepted at any time.

Wales

The Welsh Government is committed to unlocking the renewable energy potential from Welsh waters by supporting the delivery of marine energy projects. The Welsh Government has a 70% renewable electricity mix contribution target by 2030, a proportion of which should come from marine sources [13]. For this, the Welsh Government has allocated £100.4m of European Union (EU) structural funding over the next 5 years for marine energy through the WEFO [14]. The fund is aimed at establishing Wales as a centre for marine energy production by increasing the number of wave and tidal energy devices being tested including multi-device array deployments. Most recently, the Welsh Government has awarded €14.9m from the European Regional Development Fund (ERDF) grant to support the next phase of Minesto's tidal commercial development in Wales [15]. Furthermore, the Welsh National Marine Plan was launched in November 2019 to provide significant support for marine energy technologies.

Marine Energy Wales brings together technology developers, research institutions, supply chain and public sector bodies for establishing a sustainable ocean energy industry in Wales. The 2019 developments recently announced through this organisation include:

- A detailed business case for the £60m Pembroke Dock Marine project focussed on lowering the cost of marine energy was signed by the Swansea Bay City Deal's Joint Committee [16];
- The first wave energy marine licence for Bombora for the deployment and testing of their wave energy technology in Wales [17];
- A new €4.2m Wales-Ireland cross-border project aiming to boost the marine energy industry in both the regions [18]; and
- More than £12m of EU funding to support the next stage of Swansea-based Marine Power Systems' project to create and launch an underwater device capable of generating clean, affordable and reliable energy in Wales and around the world [19]

The Marine Centre Wales, which opened in 2018 with £5.5m funding, and the Marine Energy Engineering Centre of Excellence continues to support the Welsh marine sector with resources, skills and collaboration [20].

Marine Energy Council

The UK Marine Energy Council (MEC) was formed in 2018 by a collaboration of the leading wave and tidal developers, in order to engage with the Government and other stakeholders as a unified sector. The Council is comprised of representatives from the industry and those from leading industry associations Renewable UK, Scottish Renewables, Marine Energy Wales and the Offshore Renewable Energy Catapult, including members from technology and project developers, supply chain companies and consultants. The objectives of the MEC are to progress from the ORE Catapults cost reduction advisory group, encouraging collaboration across the sector and supporting the policy positions for delivery of marine renewables. In 2019, the MEC, along with Scottish Renewables, published the UK Marine Energy 2019

report that highlights the potential economic and low carbon benefits from government investment in the UK's tidal and wave power sectors [1].

The report proposes two new revenue support models: Innovative Power Purchase Agreements (IPPA) and Innovative Contracts for Difference (ICFD) aiming to increase the industry's cost competitiveness and deliver projects in the UK.

The Marine Energy Council will be formally incorporated in 2020, leading on developing the sector both in the UK and internationally and delivering a work programme to support the growth of the wave and tidal sector through the development of a UK market.

2.2 Market Incentives

Contracts for Difference (CfDs)

The UK Government continues to offer revenue support to a variety of renewable energy technologies through the Contract for Difference (CfD) programme. Based on top-up payments to a strike price, CfDs offer long-term price stabilisation and are awarded via competitive auctions. Ocean energy technologies are however yet to gain a CfD through the competitive auction process.

Ocean energy technologies are within the 'less established' technologies category as part of the CfD auctions, which also includes offshore wind and advanced conversion technologies. The third round of auctions opened in May 2019 delivering record low price for offshore wind; clearing at a price of £39.650/MWh

for year 2023/24 and £41.611/MWh for year 2024/25. The announced price was 30% lower than the strike price of £57.50/MWh announced in the previous 2017 CfD auction. Twelve projects, of which six offshore wind, four remote islands wind and two-advanced conversion technology projects secured the contracts. This opens up the possibility for offshore wind contributing heavily towards achieving the Net-Zero target by 2050, but at the same time poses challenges to other low-carbon technologies like ocean energy to match similar cost reductions. A breakdown of the outcome by technology, year and clearing prices (2012 prices) is shown in Table 1 below [21]:

Table 1: Results of third round of CfD auctions [21]

Technology		2023/24	2024/25	Total Capacity (MW)
Advanced Conversion Technologies	£/MWh	39.65	41.611	33.60
	MW	27.50	6.10	
Remote Island Wind	£/MWh	39.65	41.611	275.22
	MW	225.72	49.50	
Offshore Wind	£/MWh	39.65	41.611	5466.00
	MW	2612.00	2854.00	

2.3 Public Funding Programmes

In the last few years, the UK Government has made available some public funding alternatives to support the development of the ocean energy sector. Some of these programmes and initiatives are described in this section.

UK Research and Innovation (UKRI)

In operation since April 2018, UKRI brings together seven research councils to support and coordinate research and innovation in the UK. Independently chaired, UKRI has a £6 billion budget funded primarily through the Science Budget by BEIS [22]. The research councils and bodies operating within UKRI are the Engineering and Physical Sciences Research Council (EPSRC), Innovate UK, Arts and Humanities Research Council (AHRC), Biotechnology and Biological Sciences Research Council (BBSRC), Economic and Social Research Council (ESRC), Medical Research Council (MRC), National Environment Research Council (NERC), Research England, and the Science and Technology Facilities Council (STFC). The UKRI provides a range of funding opportunities to individuals and groups in pursuit of excellent innovation and research. In the recent year, the UKRI announced funding calls in the fields of healthcare, circular economy, marine resources, climate resilience etc. In November 2019, the UKRI rolled out invitations for the role of a Champion in Sustainable Management of UK Marine Resources (SMMR) [23]. The programme supported by NERC and ESRC in partnership with the Department for Environment, Food and Rural Affairs (DEFRA) and Marine Scotland, shall provide a fund of £12.4m. [24]

<https://www.ukri.org/>

Innovate UK

A member of UKRI, Innovate UK is a funding body that supports businesses in their development of new technologies and concepts, helping them to reach commercial success. Innovate UK awards grant and loan funding across all sectors to business-led and high-value innovation in the UK. The organisation also cultivates networks between innovators and investors, researchers, industry, policymakers and future customers on a domestic and international scale. [25]

<https://www.gov.uk/government/organisations/innovate-uk>

Wave Energy Scotland

WES – fully funded by the Scottish Government – is taking an innovative and unique approach to the development of wave technology. WES funds the progression of innovative technology towards commercialisation through stage-gate funding. Stages of R&D activities guide projects from concept to prototype testing. Funding is allocated within distinct technology categories, covering various subsystems, overall wave energy devices, materials and manufacturing. [26]

<https://www.waveenergyscotland.co.uk/>

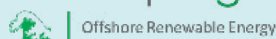
3 RESEARCH & DEVELOPMENT



Artemis Intelligent Power's Quantor PTO and test rig (Source: WES)

3.1 Key R&D Institutions

ORE Supergen



Supergen Offshore Renewable Energy (ORE) Hub

Established in July 2018 with £5m of funding from the EPSRC, the Supergen ORE Hub is coordinated by the University of Plymouth and brings together the expertise from multiple UK institutions including University of Edinburgh, University of Aberdeen, University of Exeter, University of Hull, University of Manchester, University of Oxford, University of Southampton, University of Strathclyde and University of Warwick. In June 2019, it was awarded another £4m to bring together research institutions across the UK to align activity, progress the sector to ambitious levels while cultivating a 'research landscape'. In its first year of operation, the Hub held an Early Career Researcher (ECR) networking event in May 2019 in Glasgow where they covered the ORE Research Landscape developed by the Hub.

Launched in November 2019, the interactive Research Landscape is a justified and collaborative interactive map of sector needs from a technological, funding and ecological perspective made for public consumption [27]. The Hub also held its second Annual Assembly in November 2019 at the University of Strathclyde where the latest opportunities, challenges and research within offshore renewable energy technologies were explored. To date, the Hub has awarded around £1m to UK universities to advance ambitious research projects in the offshore renewable energy sector. [28]

<https://www.supergen-ore.net/>



The ORE Catapult

Offshore Renewable Energy (ORE) Catapult is the UK's flagship technology and innovation research centre, combining research, development, demonstration and testing facilities with leadership, industrial reach and engineering expertise. ORE Catapult accelerates design, deployment and commercialisation of renewable energy technology innovation. By the end of financial year

2018/19, ORE Catapult had supported 801 Small Medium Enterprises (SMEs) and engaged in 469 academic collaborations and 648 industry collaborations [29]. Currently, ORE is involved in the Tidal Stream Industry Energiser (TIGER) project and the Ocean Energy Scale-Up Alliance (OESA) partnership. [30]

<https://ore.catapult.org.uk/>

3.2 Key R&D Projects

EnFAIT

Enabling Future Arrays in Tidal (EnFAIT)

Funded by EU Horizon (H2020), the Enabling Future Arrays in Tidal (EnFAIT) project is a €20.2m project, which began in July 2017 and will run until June 2022. Led by Scottish tidal energy developer Nova Innovation, the project is a partnership of nine European companies and academic partners. EnFAIT builds on Nova Innovation's existing operational tidal array in the Bluemull Sound, in Scotland's Shetland Islands. It will extend the Bluemull Sound array from three to six turbines and demonstrate that high array reliability and availability can be achieved using best

practice maintenance regimes. In 2019, the project achieved a world first by recovering three turbines from the site before servicing and redeploying all three turbines within one month. EnFAIT also demonstrated the local economic benefits that can be achieved by tidal energy with more than 60 Scottish companies in the project supply chain. The next three turbines will be installed in 2020/21. [31]

<https://www.enfait.eu/>



Deploying Nova Innovation Turbine at Bluemull Sound (Source: Nova Innovation)



DTOceanPlus

The EU H2020 funded DTOceanPlus will develop and demonstrate a suite of second-generation advanced design tools for the selection, development, and deployment of ocean energy systems. This builds upon the previous EU FP7 funded DTOcean project, which produced the first generation of freely available open-source design tools for wave and tidal energy arrays.

The DTOceanPlus suite of tools will align innovation and development processes with those used in mature engineering sectors:

- Technology concept selection will be facilitated by new structured innovation design tools
- Technology development will be enabled by a new stage-gate design tool
- Deployment optimisation will be implemented by new and improved deployment and assessment design tools

The integrated tools will be demonstrated in the setting of real-world technology deployment projects, with access to these projects being provided by the project's industrial and commercial partners. The project will also create a set of digital models to provide a common language for the entire ocean energy sector. The project is led by Tecnia and comprises 18 EU partners including, from the UK The University of Edinburgh, Wave Energy Scotland, Energy Systems Catapult, Orbital Marine Power, and Nova Innovation. [32]

<https://www.dtoceanplus.eu/Tools>



DTOceanPlus Team Photo (Source: DTOceanPlus)

Tidal Turbine Power Take-Off Accelerator (TIPA)

The TIPA project focused on the testing of an innovative Direct Drive Power Take-off (PTO) solution for tidal turbines, with the aim of reducing the lifetime cost of tidal power by 20%. Completed in late 2019, TIPA was led by Nova Innovation and funded by EU H2020. The project consortium comprised six European partners (both academic and industrial) including University of Edinburgh. The project included accelerated onshore and in-sea testing of a prototype PTO with third-party

validation and a commercialisation strategy for selling and licensing the product to ocean energy technology developers and related industries. The PTO successfully completed the accelerated onshore testing phase at RWTH Aachen University during summer 2018 and the in-sea testing phase in spring 2019 [33]. Cost savings achieved by the project were estimated at 29% – exceeding the 20% target. [34]

<https://www.tipa-h2020.eu/>

Floating Tidal Energy Commercialisation (FloTEC)

The FloTEC project, led by Orbital Marine Power and funded by the EU H2020 programme, is an ongoing project running from January 2016 to February 2021. Building on the success of their existing 2 MW floating tidal technology, the SR2000, the FloTEC project is focused on the design, construction and deployment

of Orbital's upgraded technology. The 2 MW Orbital O2 device will be deployed at the EMEC in 2020 to demonstrate how floating tidal systems can provide low-cost, high-value energy to the European grid mix. [35]

www.flotectidal.eu

Second Generation Technologies in Ocean Energies (Ocean_2G)

Funded by the EU H2020 programme and managed by Magallanes Renovables, the Ocean_2G project focused on testing, validating and pre-certifying Magallanes' second generation 2 MW tidal energy platform solution, the ATIR. The project undertook

a number of key innovations followed by a series of test programmes to demonstrate the operational performance of the prototype in open water conditions in Vigo, and then at EMEC where it was deployed in early 2019. [36]

www.ocean-2g.eu

Strategic Environmental Assessment of Wave energy technologies (SEAWave)

The SEAWave project, co-ordinated by EMEC, aims to address long-term environmental concerns around the deployment of wave and tidal energy converters in the marine environment. The project aims to adopt multi-WEC environmental monitoring campaigns developed through gap analysis on WECs demonstrated in Scotland. The findings from the comprehensive environmental demonstration strategy will be distributed across various

European networks to help understand the potential impacts of wave energy deployments. The project is co-funded by the European Maritime and Fisheries Fund (EMFF) of the EU and is supported by a diverse range of project partners across UK, Portugal, Finland, Belgium, Sweden and Ireland. [37]

www.seawaveproject.com

Ocean Power Innovation Network (OPIN)

A cross-sectoral and cross-regional collaboration for offshore renewable energy SMEs, the OPIN is a 3-year initiative from 2019 to 2021. It is led by the Sustainable Energy Authority of Ireland (SEAI) and is represented by Scottish Enterprise (SE) and ORE Catapult as the UK partners. It has a total budget of €2.6m, where Interreg North West Europe (NWE) from the European Research and Development Fund (ERDF) provides €1.5m of financial support.

The OPIN project plans to support around 100 companies by transferring already established expertise, capabilities and products from mature proven sectors into the ocean energy sector and thus reduce cost and initiate technology development. The partnering countries involved in this project include the UK, Belgium, France, Netherlands and Germany. [38]

<https://www.nweurope.eu/projects/project-search/opin-ocean-power-innovation-network/>

Tidal Stream Industry Energiser (TIGER)

Led by ORE Catapult, the TIGER project is an ambitious €46.8m project running from July 2019 to June 2023 and has been recently approved by the France-England programme. With ERDF providing a fund of €28m, the project falls within the category for low-carbon technologies of the Interreg France (Channel) England Programme. It aims to develop cross-regional

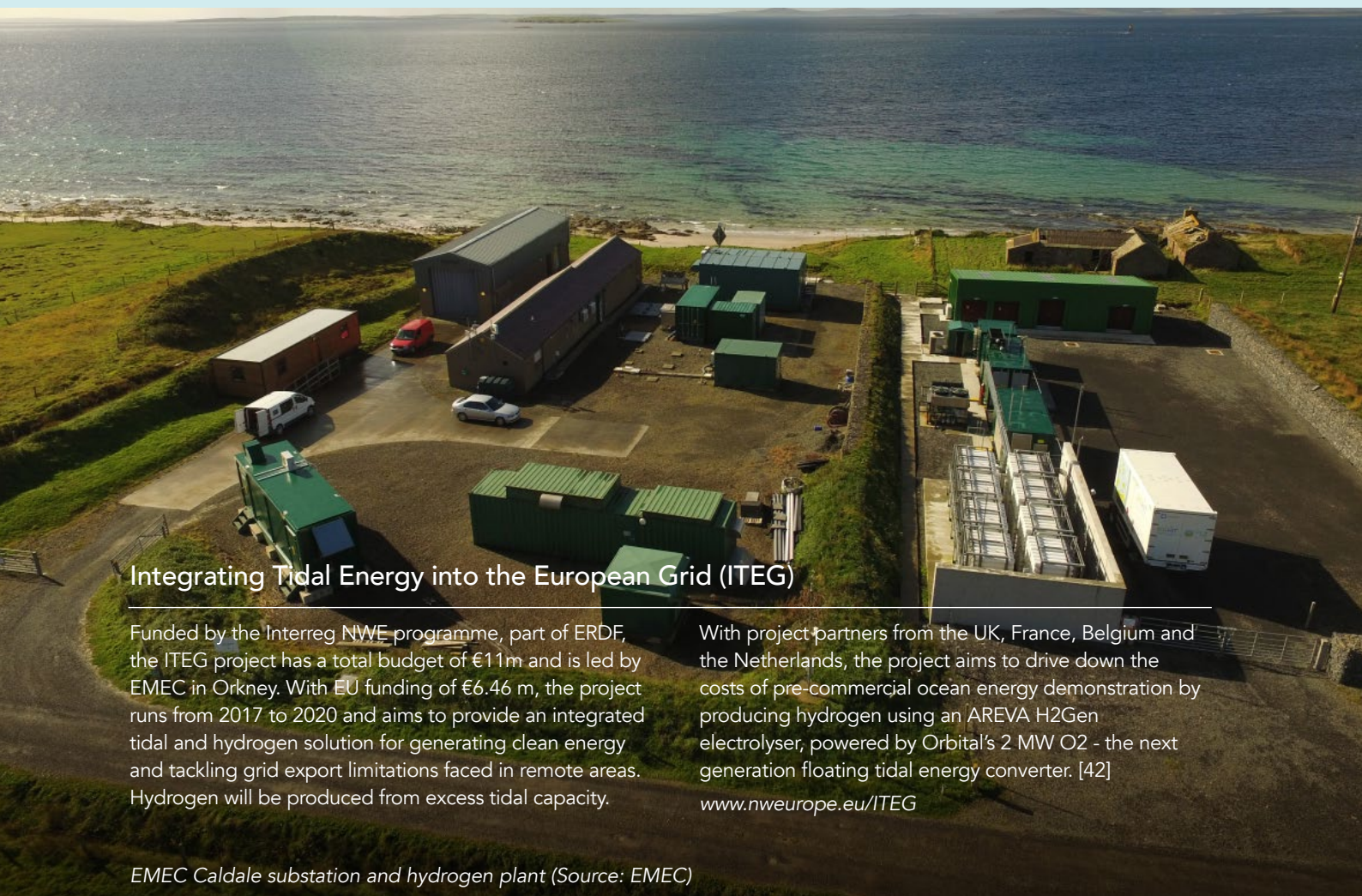
partnerships while developing, testing and demonstrating new technologies, installing up to 8 MW of new tidal capacity around the Channel region leading to new product and service development. As the biggest project across all Interreg programmes, it will establish tidal stream energy as a cost-effective source while driving growth within the energy mixes of France and the UK. [39] www.InterregTIGER.com

Ocean Energy Scale-Up Alliance (OESA)

Led by the Dutch Marine Energy Centre (DMEC), the OESA is a 3-year project running from January 2019 to December 2021. With a total budget of €6.2m, where Interreg NWE provides €3.1m of financial support, it is a European partnership of 13 international organisations specialising in offshore engineering, market development, ocean energy testing and technology development [40]. OESA aims to accelerate the development and

deployment of ocean energy technologies through an innovative Pilot Accelerator Programme in the North Sea Region (NSR). The project involves accelerating the deployment of 5 scaled-up ocean energy pilots worth 20 MW through strategic partnerships and international collaboration [41].

<https://www.dutchmarineenergy.com/our-projects/ocean-energy-scale-up-alliance-oesa>



Integrating Tidal Energy into the European Grid (ITEG)

Funded by the Interreg NWE programme, part of ERDF, the ITEG project has a total budget of €11m and is led by EMEC in Orkney. With EU funding of €6.46 m, the project runs from 2017 to 2020 and aims to provide an integrated tidal and hydrogen solution for generating clean energy and tackling grid export limitations faced in remote areas. Hydrogen will be produced from excess tidal capacity.

With project partners from the UK, France, Belgium and the Netherlands, the project aims to drive down the costs of pre-commercial ocean energy demonstration by producing hydrogen using an AREVA H2Gen electrolyser, powered by Orbital's 2 MW O2 - the next generation floating tidal energy converter. [42]

www.nweurope.eu/ITEG

EMEC Caldale substation and hydrogen plant (Source: EMEC)

Wave Energy Scotland (WES)

In 2019, WES continued to deliver strong progress through its stage-gate research, development and innovation programme, awarding £9m to 11 wave energy technology projects. In January 2019, it awarded £7.7m to two companies for building and deploying fully functional pilot devices. Both projects are on track for deployment in Scottish seas in 2020, having recently signed construction contracts with the supply chain. WES continues to advance the maturity of power conversion systems, with 5 power take-off technologies now

demonstrated at large-scale and an additional £1m applied to two control system design projects. To aid deployment and retrieval of wave energy device demonstrators, WES recently announced £460k to begin the development of Quick Connect Systems, successfully engaging further expertise from mature engineering sectors. The WES programme has now awarded nearly £40m to 95 projects and continues to be a driving force in the wave energy sector. [26]



Paul Wheelhouse, Minister for Energy, Connectivity and the Islands at the 2019 Annual Conference (Source: WES)

Funding Ocean Renewable Energy through Strategic European Action (FORESEA)

EMEC has led the €11m Interreg NWE project, FORESEA, since it was launched in 2016. Now nearing completion, the project has been hailed an overwhelming success and this year was nominated for the EU Sustainable Energy Week Citizens' Awards 2019. Having enabled 29 technologies to deploy across four European test centres (EMEC, DMEC, SEM-REV and SmartBay), FORESEA has enabled more ocean energy technologies to be tested

offshore than any other project, including CorPower Ocean, Orbital Marine Power, Naval Group and Whitford. With the project ending this year, EMEC have launched two follow on projects to further support real-sea testing: Ocean DEMO and Blue-GIFT. [43]

<https://www.nweurope.eu/projects/project-search/funding-ocean-renewable-energy-through-strategic-european-action/>

Ocean DEMO

Launched in January 2019 and funded by Interreg North-West Europe, the Ocean DEMO project is a €13m project. Built upon the FORESEA project, it aims to accelerate ocean energy's transition from single prototype to multi-device farms by providing free access to key European test centres: EMEC, DMEC, SEM-REV

and SmartBay. Under its first call that ended in July 2019, twelve offshore renewable developers were awarded the opportunity to participate in the project. The second call opened in September 2019 and closed in January 2020. [44]

www.oceandemo.eu

Selkie

Launched in 2019, Selkie is funded by the EU's Ireland-Wales co-operation programme and is led by University College Cork in partnership with Swansea University, Marine Energy Wales, Menter Môn, DP Energy Ireland and Dublin-based Gavin and Doherty Geosolutions.

The €4.2m project will see the development of a streamlined commercialisation pathway for the marine energy industry by establishing a cross-border network of developers and supply chain companies in Ireland and Wales. Multi-use technology tools and models will be created and trialled on pilot projects before being shared across the sector.

SEACAMS2

The SEACAMS2 project supports developing economic opportunities in Low Carbon, Energy and Environment through specialisation in commercial application of research and innovation in marine renewable energy (MRE), climate change resilience and resource efficiency in

Wales. The £17m project, a partnership between Bangor University and Swansea University, is part-funded by the European Regional Development Fund and focuses on the convergence region of Wales.

4 TECHNOLOGY DEMONSTRATION



Project Neptune (Source: University of Edinburgh)

4.1 Test Centres & Demonstration Zones

The European Marine Energy Centre (EMEC)

EMEC remains the world's only United Kingdom Accreditation Service (UKAS) accredited test and research centre focusing on wave and tidal power development. Apart from supporting the demonstration and validation of ocean energy technologies, EMEC also works on projects related to floating offshore wind, green hydrogen and energy systems. In 2019, Magallanes Renovables began testing their second-generation 2 MW tidal platform at EMEC's Fall of Warness tidal test site, generating their first power into the national grid shortly after cable connection. To support demonstration plans of EMEC's tidal energy clients, Crown Estate Scotland granted an extension to EMEC's lease for the Fall of Warness, now running until 2040. At EMEC's Billia Croo wave test site, Microsoft continued testing their subsea data centre, powered by Orkney's renewable electricity and cooled

by the ocean. In March, EMEC launched the €31 million AFLOWT project to accelerate the uptake of floating offshore wind that will utilise the offshore renewable expertise built up over the years from demonstrating wave and tidal technologies. EMEC also launched a number of new support programmes for offshore energy technologies in 2019, including Ocean DEMO and Blue-GIFT. EMEC is also supporting the development of other test facilities around the globe, including Ireland, China, South Korea and the USA, and leads the International WaTERS (Wave and Tidal Energy Research Sites) network. In 2019, the 6th International WaTERS workshop was held in Orkney with the support of the IEA-OES that involved intensive discussions and knowledge sharing among the 13 member countries. [45] <http://www.emec.org.uk/>



EMEC Billia Croo substation (Source: EMEC, Colin Keldie)

Wave Hub

Wave Hub is a pre-installed grid-connected site approximately 10 nautical miles (16km) off the north coast of Cornwall for the testing of large-scale offshore renewable energy devices. The site has a Section 36 electricity consent and holds a 25-year lease for eight square kilometres of seabed divided into four separate

berths. Wave Hub is owned by BEIS and operated by Wave Hub Limited. The test site is currently finalising plans to accommodate Floating Offshore Wind alongside wave energy technologies. [46]

<https://www.wavehub.co.uk/>

FaBTest

FaBTest is a 2.8km² test site at Falmouth Bay in Cornwall. The relatively sheltered location of the bay allows for smaller and concept devices and components to be tested. The pre-consented site, leased from the Crown Estate, has a 9 metre 1-in-100 year return period significant wave height.

In 2019, Marine Power Systems (MPS), followed by AMOG Consulting Ltd., more recently decommissioned their 'WaveSub' mooring system and 'AEP' wave energy converter, respectively, after testing and successfully generating power at FaBTest. [47]

<http://www.fabtest.com/>

Marine Energy Test Area (META)

META is a newly established test site developed by the Marine Energy Wales in the Milford Haven Waterway in Pembrokeshire, which has recently identified seven potential sites. The Area comprises a variety of sites with consent and grid connection, which will facilitate testing of component, sub-assembly and single-device stages. META aims to de-risk full-scale deployments, support innovation of global marine energy products and services, add value to the UK test centre network while

supporting supply chain initiatives. Development of the site is informed by strategic advice given by established test-centres EMEC and Wave Hub. It has recently secured £1.9m funding from ERDF, Coastal Communities Fund and Swansea Bay City Deal. META Phase 1 was officially opened in September 2019 [48].

<https://www.marineenergywales.co.uk/meta/>



Pembroke port – Phase 1 site (Source: J.Abbott, MEW)

Morlais Tidal Demonstration Zone

The site in West Anglesey was primarily set up for its tidal resource and access to local infrastructure. The 35km² site is being sub-let for testing and demonstrating activities alongside some of the first array scale commercial projects. This is a £33m project, which had been awarded £4.5m of EU and Welsh Government funds. The site is currently in the process of securing

consent for the development of the demonstration zone following which, necessary infrastructure would be put in place for testing commercial deployment of tidal stream projects. Nova Scotia based Big Moon Power, signed a deal on May 2019, to commercially deploy their tidal energy technology at the site [49].

<http://www.morlaisenergy.com/>



Looking out to the Morlais Tidal Demonstration Zone (Source: Morlais)

4.2 Arrays And Demonstration Projects

MeyGen

The MeyGen array is owned and operated by SIMEC Atlantis Energy in Scotland's Pentland Firth. In December 2019, the MeyGen project confirmed it has surpassed 23 GWh of generation onto the grid since project commencement. With no offshore maintenance interventions in 2019, the total system availability from January-October (latest available at the time of writing) averaged around 90%. [50]

<https://simecatlantis.com/projects/meygen/>



MeyGen deployment (Source: SIMEC Atlantis Energy)

Magallanes Renovables

Spanish tidal developer Magallanes Renovables' second-generation tidal turbine device, the ATIR, was successfully deployed at EMEC's grid-connected Fall of Warness tidal test site in February 2019. Funded by the Fast Track to Innovation pilot scheme, part of the EU's H2020 research and innovation programme, the device generated its first electricity into the UK national grid at EMEC in March 2019. It is now undergoing further testing to demonstrate its operational performance before being commercially available. [51]

<http://magallanesrenovables.com/en/proyecto>



Installation of Magallanes ATIR tidal platform at EMEC's Fall of Warness tidal test site (Source: Colin Keldie)

Marine Power Systems (MPS)

Swansea-based wave developer Marine Power Systems (MPS) successfully concluded testing and sea trials for WaveSub, its prototype wave energy generator after running it for a period of 12 months at FaBTest, Cornwall. This was a £5.5m project, which has received £3.5m Welsh European Funding Office & Welsh Government funding. More recently, MPS has been awarded £12.8m EU funds to support the manufacture and testing of a full-scale WaveSub wave energy converter that would allow the company to develop a full-scale prototype for providing renewable energy in and around Wales. Soon after this announcement, MPS received another £4.3m from the European Regional Development Fund (ERDF) to launch and accelerate the development programme of the DualSub technology, a floating offshore wind and wave technology that would allow for energy generation in deep-water locations. [52]

<https://www.marinepowersystems.co.uk/>



WaveSub towed out of Falmouth towards FaBTest (Source: MPS)

Minesto

Swedish marine energy developer Minesto received €14.9m of EU funding in May 2019, for the commercial development of Minesto's tidal energy scheme in Wales. After being upgraded to an enhanced PTO system, Minesto's DG500 kite system was commissioned at Holyhead Deep site offshore North Wales in September 2019. Minesto later retrieved the system back to carry out further tests and improvements at the site. [53]

<https://minesto.com/>



*Minesto initiates DG500 commissioning program
(Source: Minesto)*

Nova Innovation

Nova Innovation was granted an extension to their existing seabed lease by Crown Estate Scotland, significantly increasing the capacity of the site from 0.5 MW to 2 MW. This extension will enable Innovation to progress their EnFAIT project with the installation of three additional Nova M100 turbines, each rated at 0.1 MW. This installation will double the generating capacity deployed at the site and increase the number of turbines in the water from three to six. In October 2018, Nova Innovation installed a Tesla battery in the Shetland Tidal

Array to create the world's first baseload tidal power plant, capable of providing predictable, controllable and renewable power to the grid. By December 2019, Nova Innovation's turbines had accumulated over 20,000 hours generating energy to the Shetland grid. The Scottish tidal developer has also been granted licence to deploy a tidal array of 15 new turbines worth 1.5 MW starting 2020 in the Bay of Fundy area of Nova Scotia, Canada. The project will last until 2023 and will provide power to 600 homes. [54]

<https://www.novainnovation.com/>

Nova Innovation's Turbine (Source: Nova Innovation)

4.3 Planned Deployments

Wave

Bombora Wavepower

Australian wave energy developer Bombora Wavepower secured a £10.3m ERDF grant in 2018 to support the design and testing of a fully submerged membrane-style wave energy converter at Pembroke Dock. It is currently in the process of designing, building, deploying, testing

and validating its 1.5 MW mWave wave energy converter. In October 2019, the developer received the first Marine Licence for a wave energy device in Wales, for the deployment and testing of their mWave wave energy technology off the coast of Pembrokeshire, Wales. [55]
<https://www.bomborawave.com/>

AWS Ocean Energy

AWS has developed a fully submerged point absorber named the 'Archimedes Waveswing', which will be deployed at scale in the EMEC Scapa Flow site in 2020 as part of the WES programme. AWS was awarded £3.3m

from WES to develop their prototypes before deploying and testing them in Orkney. [56]
<http://www.awsocan.com/>

Mocean Energy

Mocean's 'Blue Horizon' technology is a floating hinged raft, whose innovation is in its geometry. Its wave channel features enable it to generate more than three times the power of traditional rafts. The technology will be deployed at scale in Orkney waters as part of the WES

programme. Mocean was awarded £3.3m from WES to further develop their prototype before deploying and testing them in Orkney. [57]
<https://www.mocean.energy/>



Mocean's Blue Horizon Technology (Source: Mocean)

Laminaria

With the production of Laminaria's full-scale 0.2 MW LAMWEC wave device underway, deployment is planned at EMEC's Billia Croo site in 2020 to 2021. The surge point-absorber device's design includes a bespoke storm protection system, which will maximise survivability and

optimise operability in all weathers. This has benefitted from MaRINET2 and FORESEA funding for test site access. [58]

<http://www.laminaria.be/lamwec.html>

Wello Oy

After seven years of many successful deployments, trials and lessons learnt from the testing period of the first Penguin WEC - WEC1, Finnish based company Wello Oy has ended the CEFOW (Clean Energy From Ocean Waves) project in Scotland. The learnings from WEC1 have been fed into the WEC2 design which was towed from Estonia

to Orkney for deployment at EMEC. The device is currently berthed at Hatston Pier in Kirkwall, however with the early closure of the EU-funded CEFOW project, Wello are considering their options regarding deployment locations. [59]

<https://wello.eu/>



Arrival of WELLO 2 (Source: Colin Keldie)

Tidal

Nova Innovation

In 2020/21, Nova Innovation plans to install three more M100 0.1 MW turbines alongside the three turbines currently in place at Bluemull Sound in Shetland. After a period of operation, the devices will be moved within the

array in order to investigate turbine wake interactions for the first time in an in-sea tidal array. [54]

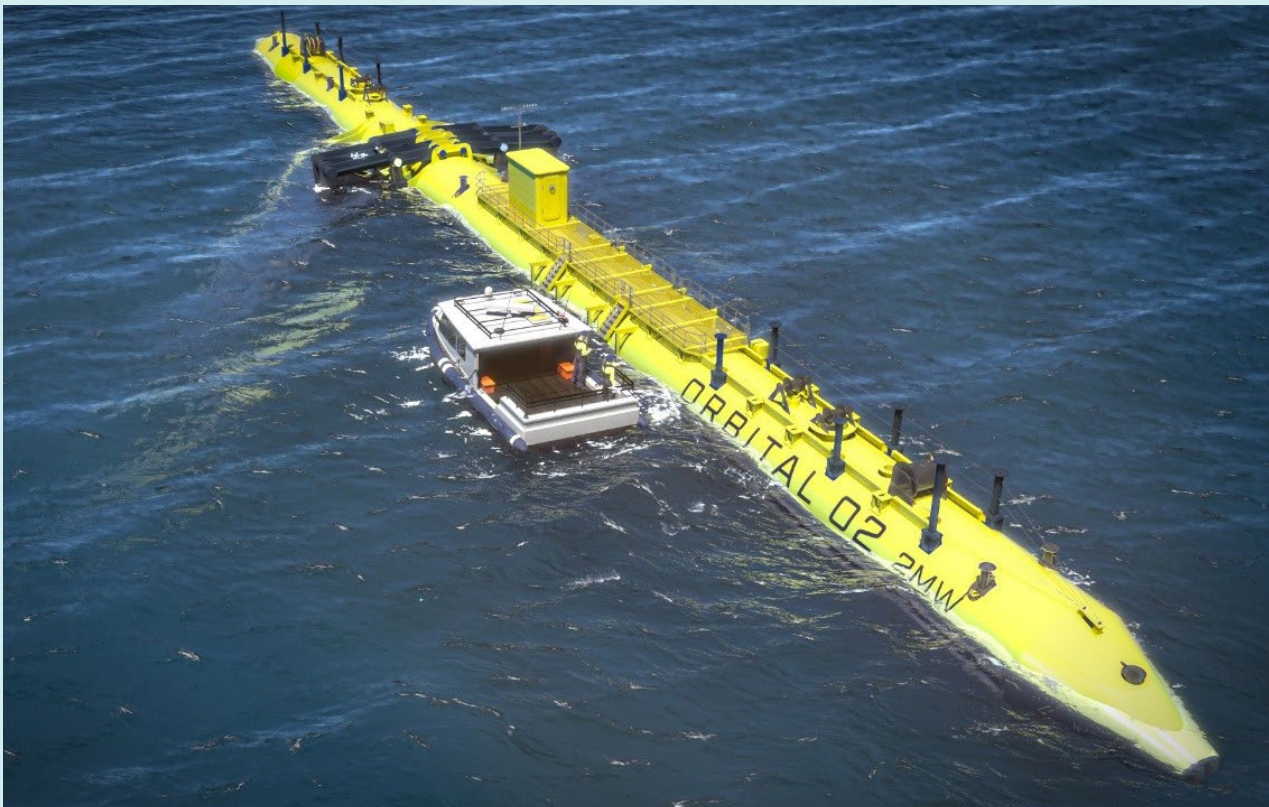
<https://www.novainnovation.com/>

Orbital Marine Power

In 2019 Orbital Marine Power, commenced construction of their optimised production model, the Orbital O2 2 MW, for deployment at EMEC in 2020. The O2 will feature two 20m rotor diameters, the largest swept area of a single tidal energy converter to date, blade pitch control for floating tidal energy and simplified onsite nacelle access through a new 'gull wing' leg retraction system. Orbital Marine Power received £7m of peer-to-peer Abundance investment in October 2018 to build the production model. The Orbital O2 is funded

under H2020 FloTEC (Floating Tidal Energy Commercialisation), with funding also from Interreg North-West Europe ITEG and the Scottish Government's Saltire Tidal Energy Challenge Fund. Orbital Marine Power is also a project partner for the ambitious TIGER project, the largest marine energy R&D collaboration by value to date. [60]

<https://orbitalmarine.com/>



Orbital O2 2MW (Source: Orbital Marine Power)

5 RELEVANT NATIONAL EVENTS

Some relevant events for the ocean energy sector that took place in the UK in 2019 include:

4th April 2019 – Marine Energy Wales Annual Conference 2019, Newport

15th – 16th May 2019 – All Energy 2019, Glasgow

9th – 14th June 2019 – Ocean, Offshore and Arctic Engineering (OMAE) Conference, Glasgow

9th – 10th September 2019 – Scottish Renewables Marine Conference 2019, Inverness

2nd – 4th October 2019 – 6th International WaTERS (Wave and Tidal Energy Research Sites) Workshop, Orkney

6th November 2019 – Supergen Annual Assembly, Glasgow

11th – 12th November 2019 – International Tidal Energy Summit 2019, London

5th December 2019 – Wave Energy Scotland Annual Conference 2019, Edinburgh

The UK will also be hosting some important events in 2020 that are of interest for the ocean energy sector such as:

13th – 14th May 2020 – All Energy 2020, Glasgow

9th – 19th November 2020 – Conference of the Parties 26 (COP 26), Glasgow

1st – 3rd December 2020 – Oceanology International 2020, London

(Source: Orbital Marine Power)

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