



THE UNIVERSITY of EDINBURGH
School of Engineering



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

2022



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wave energy
SCOTLAND

Supergen  Offshore
Renewable
Energy

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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.policyandinnovatedinburgh.org/>

Supergen ORE

The Supergen programme was set up in 2001 by the Engineering and Physical Sciences Research Council (EPSRC) to deliver sustained and coordinated research on sustainable power generation and supply. For phase four of the programme, the Supergen Wind and Supergen Marine Hubs were combined into the Offshore Renewable Energy Hub. The Supergen Offshore Renewable Energy (ORE) Hub builds on the work of the former Hubs, and looks at synergies between offshore wind, wave and tidal technologies as well as building on current research in each area. Led by the University of Plymouth, Supergen ORE provides research leadership to connect stakeholders, inspire innovation and maximise societal value in offshore renewable energy.

Find out more about Supergen ORE at <https://supergen-ore.net/>

Wave Energy Scotland

Wave Energy Scotland (WES) is driving the search for innovative solutions to the technical challenges facing the wave energy sector. Through our competitive procurement programme, we support a range of projects focused on the key systems and sub-systems of Wave Energy Converters. The aim is to produce reliable technology which will result in cost effective wave energy generation. WES was formed in 2014 at the request of the Scottish Government and is a subsidiary of Highlands and Islands Enterprise. The aim of WES is to ensure that Scotland maintains a leading role in the development of marine energy.

Find out more about Wave Energy Scotland at <https://www.waveenergyscotland.co.uk/>

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Cover Images:

Upper left: Waveswing testing at EMEC's Scapa Flow test site (Credit: AWS Ocean Energy)

Bottom: Installation of Nova Innovation tidal turbine in Shetland (Credit: Nova Innovation)

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1 OVERVIEW

The UK's position as a leading nation in the global effort to slow climate change has now become synonymous with our position as one of the leading nations in the research, innovation and development of the ocean energy sector. The value of this position has only been emphasised in light of Russia's ongoing illegal invasion of Ukraine, with the UK looking to further develop renewable energy technologies, such as wave and tidal, that can complement and strengthen the existing domestic energy mix. The maturation of the sector continues to move at pace, with tidal stream looking to move from single device deployment to arrays and the wave sector seeing increased tank testing and deployment of prototypes. With regards to the policy landscape, recent government energy strategies, both at a UK and devolved level, make explicit reference to the untapped potential of the ocean energy sector for energy generation and energy security. This is only bolstered by the success of market pull mechanisms such as the Contracts for Difference scheme, which has delivered increased sectoral confidence as a number of device developers were granted contracts. Across the UK, industry, academia and government continue to tie the ocean energy sector to net-zero ambitions, energy security strategies and the Just Transition. However, there is still a pressing need for a reduction in the overall costs of ocean energy to ensure the sector becomes competitive with more mature renewable technologies, there is reason to believe that both wave and tidal energy have a vital role to play in the future of UK energy production.



The O2 in operation (Credit: Orbital Marine Power)

Wave

Wave energy continues to move from strength to strength, with concerted efforts to continue its drive towards higher TRLS and overall commercialisation:

- Wave Energy Scotland (WES) continues to drive wave energy R&D activity in the UK and to build confidence in the sector's technology. In 2022, WES concluded its Novel Wave Energy Converter (NWECC) programme with AWS Ocean Energy's 16kW Archimedes Waveswing wave energy converter becoming the second participant to deliver its open-sea testing project.
- Mocean Energy continue to advance their technology towards commercialisation and have recently collaborated with energy storage company Verlume to showcase an operational renewable remote power system, showcasing their Blue X wave energy converter.
- In preparation for Phase 3 of the Europewave Programme, which will see prototype wave energy converter systems deployed for 12 months, Europewave has reserved a berth at EMEC's Billia Croo test site from 2022 to 2025.
- The Scottish government's draft energy strategy, released in early 2023, recommends continued support for Wave Energy Scotland and suggests that an appropriate target for wave energy could be the testing of up to four wave energy converters (250 kW each) at European Marine Energy Centre (EMEC) by 2027 [3].

Tidal Stream

2022 was a pivotal year for the tidal sector, both with regards to achieving long-term funding support and the continued progression of several key technology developers:

- The UK government awarded Contracts for Difference (CfDs) to the tidal sector for the first time, with a total of 40.82MW of tidal energy projects granted contracts at a strike price of £178.54/MWh [1].
- Orbital Marine Power have continued to help lead the sector, with their current flagship device, the O2, having been in continuous operation since 2021 and reporting a peak power of 2.5MW.
- In February 2022, Nova Innovation announced the award of an Option Agreement from Crown Estate Scotland to develop a 15MW tidal array at Yell Sound, Shetland – the company's largest array to date. This site has the potential to meet over a third of household electricity demand in Shetland [2].
- The Scottish government's draft energy strategy, released in early 2023, outlines the vast potential of tidal stream technology and plans to consult across government on ambitions for realising its potential [3].

2 SUPPORTING POLICIES FOR OCEAN ENERGY

2.1 National Strategy

The design and implementation of energy policy within the UK is made more complex by the presence of the different devolved administrations in Wales, Scotland and Northern Ireland, all of whom have differing levels of autonomy with regards to the decision making processes within their own borders. This is further complicated, as each nation currently has a different majority ruling party, each of which has its own unique vision regarding the role that renewable energy sources should play in the national energy mix.

Energy policy within the UK is the responsibility of the Department for Business, Energy and Industrial Strategy (BEIS). Within the UK, energy policy is largely devolved to the Northern Ireland Executive, yet it is only partially devolved to Wales and Scotland. However, the ability to enact policy that is designed to tackle climate change, through policy levers such as the promotion of renewable energy, energy efficiency and electricity generation and transmission development are fully devolved matters, allowing the devolved governments some powers in governing the overall energy mix.

United Kingdom

2022 represents a critical moment in the UK's journey towards Net Zero. Despite facing a turbulent year domestically, the UK remains one of the few nations with credible emissions targets in line with the long-term goals of the Paris Agreement. The UK remains committed to achieving its legislatively bound target of Net Zero emissions by 2050 [4] and is largely supported by a sound policy framework that addresses the challenge with the requisite scale and pace. Renewable uptake in general across the UK is growing steadily and the role of both solar and wind as the foundation of our new Net Zero energy system is now clearly defined [5]. However, it is becoming increasingly clear that UK energy policy must ensure that a diversified and resilient energy mix is created. To this end, there is now a growing consensus that wave and tidal energy resources can help to underpin and strengthen our national energy mix [6].

In light of the need to reach Net Zero and at the same time address heightened concerns regarding energy security, a number of high-level policy documents published by the UK government emphasise the importance of exploiting all of the potential sources

of renewable energy across the UK:

- The "Net Zero Strategy: Build Back Greener", published in 2021, aims to keep the country on track for meeting the UK carbon budgets, our 2030 Nationally Determined Contribution, and net zero by 2050. In addition to this the report also acknowledges that the UK possesses some of the best ocean energy resources in the world and highlights the ongoing efforts to explore their role in meeting our net zero targets [7].
- The publication of the British Energy Security Strategy (BESS) has seen the UK double down on its commitments to Net Zero, which will be achieved in part through the increased provision of renewable energy resources. The BESS also highlights the need to aggressively explore tidal energy as a future source of clean energy and the potential importance of funded collaboration with international partners and projects [8].
- The Environmental Audit Committee has also set out plans for how the UK can accelerate the transition away from fossil fuels and secure energy supplies that tackle the energy affordability, security and sustainability crises. This report calls for a greater focus on the potential of tidal energy to contribute to the UK's long term energy security baseload all year round [9].
- The UK government is also planning to hold a Review of Electricity Market Arrangements (REMA), with consultation currently ongoing. This is particularly relevant for the future of the CfD scheme and the role it would play in a revamped electricity market [10].

The ocean energy sector can also draw confidence from a strong ongoing relationship with the European Union and our continued ability to successfully bid into the Horizon Europe program, with the UK government announcing an extension to the Horizon Europe Guarantee scheme until 2023 [11]. Not only will this ensure that successful applicants receive the full value of their funding at their UK host institution for the lifetime of their grant, but it will also help to ensure strong international collaboration opportunities for UK research, despite the uncertainties associated with Brexit.

Bluemull Sound (Credit: Nova Innovation)

Wales

In 2022, the Welsh government released its Net Zero Strategic Plan, detailing their commitment to embed a response to the climate and biodiversity emergencies in everything that they do [12]. Like the UK, the Welsh government is legislatively bound to achieve net zero by 2050, compared to 1990 levels [13], however it has also set the ambitious target of achieving net zero within the public sector by 2030 [12]. In addition to this, there are targets for Wales to meet 100% of its electricity demand from Welsh renewable electricity sources by 2035, of which at least 1.5GW of this capacity will be locally owned, excluding heat pumps. [14]. These ambitious targets rely heavily on ensuring that the expansion of the renewable energy sector in Wales continues to accelerate and benefit from targeted support. The Welsh Government remains committed to unleashing the energy potential contained in Welsh waters and has underlined their desire to see Wales established as the location of choice for tidal stream developers and their subsequent supply chains. The Welsh government has consistently stated its commitment to providing strong policy support for the ocean energy sector, with an aim of capturing at least 10% of the potential tidal stream and wave energy off the Welsh coastline by 2025 [15]. There is a strong belief that Wales has the potential to be a world leader in the ocean energy sector, both as a developer and demonstrator of domestic technology and as an exporter of ocean energy, technology and skills. This aim is bolstered by the confidence shown in the Welsh ocean energy sector, both nationally and internationally. Current European Regional Development Fund (ERDF) grants support a number of projects aimed at establishing Wales as a centre for ocean energy production. This includes the Marine Energy Test Area (META) and Morlais project demonstration zone, as well as technology developers such as Bombora, Minesto, Nova Innovation and Marine Power Systems.

The responsibility for coordinating the research and development of the ocean sector in Wales lies largely with Marine Energy Wales (MEW), the industry-led stakeholder group representing the wave, tidal and floating offshore wind industries. MEW brings together project and technology developers, test centres, wider sectoral alliances, the supply chain, academia, and the public sector to establish Wales as a global leader in sustainable offshore energy generation. To date, the cumulative investment and spend in Wales by the ocean energy sector is approximately £159 million, with £13.7 million worth of that investment coming in 2022.

Research is the most heavily invested area, with £4.6 million spent across Welsh academic institutions such as Bangor University, Swansea University and Cardiff University. The Welsh supply chain has also seen investment totalling £3.7 million, as companies begin to respond with confidence to the emergence of clearer business opportunities, underpinned by government funding. The MEW 2022 State of the Sector report indicates that in the last year alone, there has been an increase of 188 full time employees working in the ocean energy sector [16].

Major developments with benefits for ocean energy in Wales announced in 2022 include:

- Marine Energy Wales has received its longest ever funding package from the Welsh Government, having been awarded a three-year grant worth £150,000 a year to support their work until 2025.
- The Morlais project in Anglesey, North Wales, will benefit from £31 million of funding in what is likely to be the last large grant from the EU's regional funding program, with the aim of establishing Wales as the location of choice for tidal stream developers.
- As part of the fourth CfD allocation round Magallanes Renovables has been awarded a 5.6MW contract at a strike price of £178.54/MWh, which will be deployed at the Morlais project.
- The construction of a new supersize slipway at the Port of Milford Haven waterway has begun, providing maximum flexibility in the deployment and recovery of ocean energy devices, a key step in the development of green growth across the region.
- Swansea-based ocean energy developer Marine Power Systems, has signed up to deliver a multi-megawatt wave energy commercial scale-array at the European Marine Energy Centre (EMEC), booking two berths from 2025 to 2026.
- Australian wave energy developer Bombora Wave Power mWave energy device is entering its final test and assembly phase, as it prepares to validate its 1.5MW device.



The Morlais Tidal Energy Zone (Credit: Welsh Government)



Shetland Tidal Array Deployment (Credit: Nova Innovation)

Scotland

The Scottish Government has committed to achieving net zero emissions of all greenhouse gases by 2045 [17]. In December 2020, the Scottish Government updated its Climate Change Plan, reflecting the increased ambition of the targets set by the Climate Change (Scotland) Act 2019 [18]. Scotland's transition to net zero is supported by the Scottish Government's vision for the future of the energy sector and includes a target for the equivalent of 50% of the energy for Scotland's heat, transport and electricity to come from renewable sources by 2030 [19].

In January 2023 the Scottish Government published a draft Scottish Energy and Just Transition Plan which presents a vision for Scotland's decarbonised energy system and the collective actions needed to deliver this [3]. It suggests a potential ambition to deliver at least 20GW of additional low-cost renewable electricity capacity by 2030, which could help to generate the equivalent of around 50% of Scotland's current total energy demand. An outline vision for ocean energy is included as part of the draft Plan, and as part of the consultation the Scottish Government is seeking views on the introduction of a specific level of ambition for wave and tidal energy and the near-term supportive actions required to build on the achievements of Scotland's ocean energy sector to date.

Scotland's ocean energy sector continues to make substantial progress as both tidal and wave energy continue the journey towards commercialisation. In 2022, Scottish companies Simec Atlantis Energy and Orbital Marine Power secured the majority of support provided from the fourth allocation round of the UK Government's Contracts for Difference (CfD) funding mechanism. This will deliver a substantial increase in installed capacity from tidal stream over the next five years. The Scottish Government, together with industry itself, continues to advocate for long-term certainty for the ocean energy sector through the CfD and will closely monitor developments relating to the fifth allocation round, due to take place in 2023. A number of Scottish developers, including Nova Innovation and Sustainable Marine, made further progress in 2022 in exporting their technology and expertise to the emerging global market for tidal stream energy.

Through the Wave Energy Scotland (WES) programme, wave energy technology from both Mocean Energy and AWS Ocean Energy have been successfully deployed and tested in real sea conditions in Orkney (EMEC), demonstrating that they have the potential to take their place in the future net zero energy mix. WES is working with the Basque Energy Agency and Ocean Energy Europe to deliver EuropeWave, a European programme which mirrors and builds on the WES competitive development approach to further propel wave energy towards commercialisation.

At a national level, marine planning in Scotland's inshore and offshore waters is governed by the Marine (Scotland) Act 2010, establishing a legislative framework to ensure that increasing demands for the utilisation of the marine environment are managed responsibly and sustainably. Crown Estate Scotland (CES) is a public corporation that holds responsibility for the licensing of renewable energy generation in Scotland's offshore waters. All profit generated by CES is returned to the Scottish Government and capital is reinvested in the Scottish Crown Estate, with a record £15.7 million returned in the 2021/22 financial year to aid in public spending and Scotland's green economic recovery [20]. A major highlight for CES in 2022 was the support that they provided to the hugely successful leasing round for ScotWind, resulting in a total of 20 seabed agreements totalling 27.6GW of potential energy generation [21].

Northern Ireland

Within Northern Ireland, The Department for the Economy published the new Energy Strategy for Northern Ireland in December 2021 [22]. The vision of the Strategy sets out how NI will achieve net zero carbon and affordable energy, in line with UK Government commitments, by 2050. The Energy Strategy identified a new target of ensuring that 70% of all energy consumed in NI, will come from renewable sources. This target has since increased to 80% through the Climate Change Act (Northern Ireland) 2022.

In 2022, the Department for the Economy published the Energy Strategy Action Plan 2022, outlining 22 commitments for this year [23]. The action plan includes an action to consult on a renewable electricity support scheme in 2022 (Action Plan 12), for delivery in 2023. Such a scheme is essential to deliver on the Northern Irish Executive's Energy Strategy targets and ensure that Northern Ireland can effectively attract investors to benefit from green growth opportunities. The Strategy recognises the need to diversify the renewable electricity generation mix, including less intermittent technologies. Tidal stream energy has been identified as having the potential to play a key role in that regard and, as such, it is anticipated that any new renewable energy support mechanisms brought forward by the Department for the Economy will consider a range of established and nascent renewable energy technologies.

In addition to this, the Department for Employment in Northern Ireland also intends to publish a public consultation on design considerations for a support scheme for renewable electricity generation in Northern Ireland in January 2023.



Marine Energy Council

Since its formation in 2018, the UK Marine Energy Council (MEC) has facilitated collaboration between, and represented the interests of, leading wave and tidal technology project developers, supply chain companies, consultants and renewable industry associations in the UK. MEC has been instrumental in improving the policy landscape and outlook for the sector through coordinating engagement and communicating clearly to the UK Government, devolved administrations and other key stakeholders with a unified voice. The MEC have also played an active role in helping to guide the formation of the upcoming CfD AR5, ensuring that the long-term support required for commercialisation of the ocean energy sector continues.

In 2022, the BEIS Select Committee invited the MEC to present evidence to its inquiry into the Government's plans to decarbonise the UK's power supply sector, in line with government targets to achieve a fully decarbonised power sector by 2035 [24]. A summary of the MEC's contributions are as follows:

- The MEC welcomed the leadership showed by the government in establishing a tidal stream ring-fence in the CfD AR4 and called for increased clarity on future support.
- The MEC highlighted that the industry is well-aware that ongoing ring-fenced support, establishing a 1GW tidal energy target for 2035 and easing the consenting process will all be essential for the potential of wave and tidal energy to be fully realised.
- The MEC sought to underline the importance of strong policy frameworks that reflect accurately the benefits of the different renewable technologies that exist within the current energy mix and emphasised their importance to energy security and a cost-effective energy system.

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



Orbital O2 turbine blade at EMEC (Credit: Orbital Marine Power)

2.2 Market Incentives

Contracts for Difference

The Contracts for Difference (CfD) scheme is the UK government's flagship programme for supporting the generation of low-carbon electricity. Based on top-up payments between a wholesale market reference price and a strike price, CfDs offer long-term price stabilisation and are awarded via competitive auctions. The CfD scheme incentivises investment in renewable energy by providing developers of renewable energy projects, normally projects with high upfront costs and long lifetimes, protection from volatile wholesale prices.

To date, there have been four allocation rounds (AR) which have seen a number of different renewable energy technologies compete in auctions for a contract. Historically ocean energy technologies have struggled to gain a CfD through the competitive auction process, primarily because they have been in the same CfD 'pot' as established, mature technologies such as offshore wind.

However, following on from the government's announcement in 2021 that there would be a separate £20 million ring-fenced fund available solely for the use of the tidal stream sector, AR4 has delivered a major milestone, with four CfD contracts being awarded to tidal energy projects. A total capacity of 40.82MW of tidal energy were granted contracts at a strike price of £178.54/MWh [1]:

- Orbital Marine Power won two separate CfDs totalling 7.20MW for tidal energy deployments at EMEC's Fall of Warness site
- Simec Atlantis secured 28.00MW to further develop the MeyGen tidal array
- Magallanes was awarded 5.62MW for a tidal energy project located at the Morlais Project in Wales.

These CfD awards will help the UK's ocean energy sector to continue developing its technology and lower its operating costs at a rate similar to the countries world-leading offshore wind industry. The delivery of this fund and subsequent contracts is evidence of the strong collaborative atmosphere across the sector and underlines desire to see the UK become the leading nation in ocean energy technology and development.

In December 2022, the parameters of AR5 were set with plans to move from three auction pots to two, reflecting the success of the CfD scheme in helping to bring down the per unit cost of offshore wind, which was previously in its own auction pot. There will now be an auction pot reserved for established technologies, and a second auction pot reserved for newer projects, such as wave and tidal stream. In AR5, the administrative strike price for tidal stream energy projects has been set at £202/MWh, while the administrative strike price for wave energy projects has been set at £245/MWh [25]



2.3 Public Funding Programmes



Engineering and
Physical Sciences
Research Council

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 £8bn budget funded primarily through the Science Budget by the Department for Business, Energy and Industrial Strategy (BEIS). The research councils and bodies operating within UKRI are Innovate UK; Research England; Engineering and Physical Sciences Research Council (EPSRC); 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); and the Science and Technology Facilities Council (STFC).

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

The Engineering and Physical Sciences Research Council (EPSRC)

The EPSRC is the main funding body for engineering and physical sciences research in the UK, investing in various fields such as chemistry, energy, engineering and materials and physics. The EPSRC aims to create knowledge and fund innovation with the capability to benefit both society and the economy by supporting research through the provision of fellowships, studentships, research and training grants, competitive funding, and prizes. The EPSRC funds and co-invests with industry, at both national and international levels, helping to deliver advanced research facilities and resources for engineering and physical sciences, including wave test facilities and tidal tank testing. From 2017 until 2022, EPSRC funding for the offshore renewable energy sectors amounted to over £55 million and covers a range of technology push policy support mechanisms, such as the Centre for Doctoral Training (CDT), Fellowships, Managed Activity, Standard Grants and Programme Grants.

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



Tank testing at University of Plymouth's COAST Lab (Credit: University of Plymouth)



Innovate UK

Innovate UK is the UK's primary innovation agency, which provides funds and support to help businesses grow by developing and commercialising new products, processes, and services. Innovate UK is part of the UKRI and provides services for UK-based companies in all sectors and industries, from pre-start-up to large multinationals. Innovate UK is a key delivery body for the Government's Innovation Strategy for the UK to be a global hub for innovation by 2035 [26].

The facilities and resources support provided by Innovate UK to businesses are achieved through several innovation networks, including the following:

www.gov.uk/government/organisations/innovate-uk

Wave Energy Scotland

WES has continued to use Scottish Government funding to develop solutions to the technical challenges facing the wave energy sector. The WES programmes aim to drive innovative technology projects towards commercialisation through a competitive stage gate process. The stages of R&D activities guide projects from concept to prototype testing. Within the WES programme, separate funding streams have driven the development of novel wave energy devices, power take-off systems, control systems, quick connection systems and materials. The headline achievements of 2022 were the deployment of the AWS Waveswing device in Scottish waters and demonstration of three mechanical and electrical quick connectors which are attracting interest in other offshore sectors, most notably floating offshore wind. WES has to date awarded £50 million through 132 contracts, including 300 organisations from 18 countries [27].

www.waveenergyscotland.co.uk/



Quocean's Q-Connect quick connection system (Credit: Quocean)

3 RESEARCH & DEVELOPMENT



3.1 Key R&D Institutions



Supergen Offshore Renewable Energy (ORE) Hub

The Supergen ORE Hub was established in July 2017 with an initial £5 million of funding from the EPSRC, and a subsequent second award of £4 million in June 2019. Led by the University of Plymouth, the Supergen ORE Hub brings together 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. Some key updates as announced by the organisation in 2022 are as follows:

- The Supergen ORE Hub Fourth and Autumn Annual Assemblies took place both virtually and in person from 18 – 20 January 2022 and 28 – 30 September 2022 respectively, bringing together over 675 delegates between the two events.
- The Supergen ORE Hub had awarded almost £3,000,000 to 30 projects at UK institutions through its flexible funding scheme, designed to support ambitious research in offshore renewable energy.
- The Supergen ORE Hub has awarded an additional £150,000 to 37 projects at UK institutions through its Early Career Researcher fund, targeted at supporting and developing existing research activities, or developing ECR career skills further.

- Supergen ORE Hub and the Policy and Innovation Group at Edinburgh University, published a new study quantifying the potential economic benefit that the UK stands to gain through the deployment of innovative offshore technologies [28].
- The Supergen ORE Hub attended both COP26 and COP27, which included the launch of a briefing paper on the role of offshore renewable energy in delivering net zero, a video highlighting the role of offshore renewable energy research in mitigation climate change.

Throughout 2022, the Supergen ORE Hub has engaged with the offshore renewable energy community through 15 events and have responded to UK Government consultation on proposed amendments to Supply Chain Plans and Contracts for Difference Delivery, in consultation with Offshore Renewable Energy (ORE) Catapult, MEW, MEC and other industry stakeholders. The Supergen ORE Hub has also responded to the “BEIS Marine energy consultation - A call for evidence on the potential of marine energy projects in Great Britain” alongside the Marine Energy Council [29].

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



The ORE Catapult

Offshore Renewable Energy (ORE) Catapult is the UK’s flagship technology and innovation research centre for offshore energy and a key actor in helping to deliver the UK’s net zero targets. ORE catapult plans to accelerate the creation and growth of UK companies in the offshore renewable energy sector by combining their unique research and development capabilities and access to demonstration and testing facilities. Since 2013, ORE Catapult had supported 1040 Small Medium Enterprises (SMEs) with the development, demonstration and commercialisation of their technologies, engaged in 705 academic collaborations and been involved 1051 industry collaborations across the globe.

In 2022, as part of the Interreg funded TIGER project, the ORE Catapult produced the following report, “Cost Reduction Pathway of Tidal Stream Energy in the UK and France” [30]. This report emphasises the rapid decrease in LCOE experienced by the tidal stream sector, from an estimated £300/MWh in 2018 to an awarded CfD strike price of £178/MWh in 2022, a reduction of almost 40%. The report also predicted, that with adequate and targeted support, that the LCOE could be reduced further, with estimates of £84/MWh by 2035, £60/MWh by 2042 and £50/MWh by 2047, with various associated socioeconomic benefits.

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

3.2 Key R&D Projects

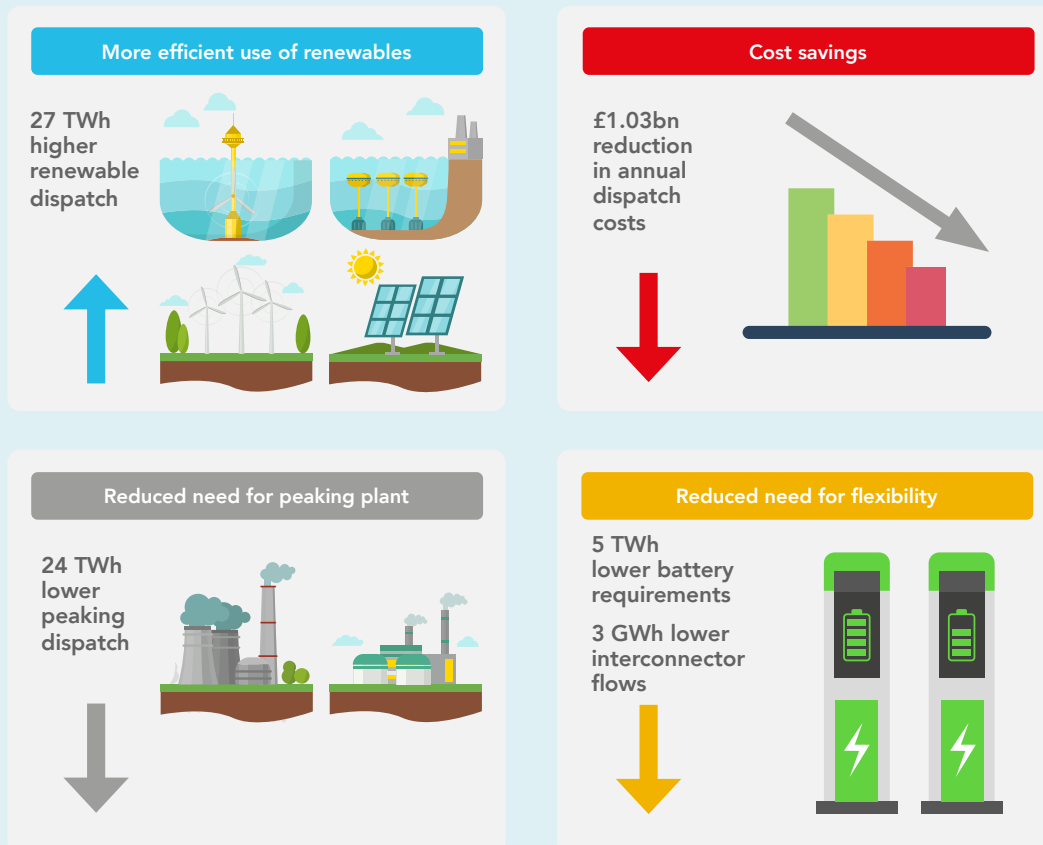
EVOLVE

Although the implementation of renewable energy technologies is accelerating across Europe, providing a consistent and stable supply of power from variable energy sources like wind is a key challenge. The EVOLVE project, funded by Scottish Enterprise, Swedish Energy Agency and Fundação para a Ciência e a Tecnologia, will aim to quantify how ocean energy can not only supply power to our electricity grids, but also enable a more diverse energy mix and cost-effective matching of energy supply and demand. The project aims to develop an understanding of the system benefits of ocean energy within future high-renewable power systems, using the analysis of production, supply and demand profiles and credible future energy supply scenarios. As the project draws to a close, the key findings show that including a

higher proportion of wave and tidal energy within our future electricity mix consistently results in higher renewable energy dispatch for the same total of renewable energy availability [31]. This is primarily due to the generation profiles of wave and tidal being able to offset periods of low wind and solar generation, negating the need to bolster the grid using fossil-fuel energy sources. The ability to dispatch more renewables results in lower fossil fuel and peaking plant dispatch, and thus lower total dispatch costs and carbon emissions.

<https://evolveenergy.eu/>

What are the 2050 GB power system benefits from 12.6GW of wave and tidal stream?



Infographic from EVOLVE project (Credit: Policy and Innovation Group/Superagen)



Wave Energy Scotland (WES)

2022 saw a number of projects achieving significant milestones in the WES stage gate research, development, and innovation programmes. AWS Ocean Energy completed construction of their Waveswing device, and successfully deployed at EMEC. After seeing favourable results in early operation and analysis, AWS returned to the water for further testing later in the year. The 2021 award of £1.8 million to Apollo Offshore Engineering, Blackfish Engineering Design and Quocean was rewarded in 2022 with the full-scale demonstration of three technologies for quick connection and disconnection of wave energy converters. These promise to help reduce operating costs, improve the safety of offshore deployment and ultimately lower the overall cost of wave energy, with opportunities for transfer into floating wind. WES, in partnership with EVE and Ocean

Energy Europe, announced five successful projects for Phase 2 of EuropeWave, a 3-phase programme co-funded by the European Commission which will lead to the deployment of three wave energy converters in Scotland (EMEC) and the Basque Country (BiMEP). WES continued to build international and sector collaborations, letting a contract with OWC Ltd. to investigate the benefits of sharing infrastructure, services and supply chain with the rapidly growing floating offshore wind sector. This project is expected to identify attractive technical and economic benefits for wave and wind, which will be investigated through further collaborative activity in 2023.

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



Mocean Energy Blue X prototype testing (Credit: Mocean Energy)

3.2 Key R&D Projects



Enabling Future Arrays in Tidal (EnFait)

EnFAIT is a flagship €20 million EU H2020 project led by Nova Innovation and supported by ORE Catapult, running since 2017. It aims to demonstrate development, operation and decommissioning at the world's first offshore grid-connected tidal array of up to six 100kW turbines, with the aim of accelerating cost reductions and providing a step change in the lifetime cost of energy for tidal power. These cost reductions are essential for ensuring that tidal energy becomes competitive with other forms of renewable energy. Following successful demonstration in 2020 of Nova's first direct drive turbine, Eunice, activity in 2022 has

focused on building two additional direct drive turbines, turbines 5 (Grace) and 6 (Hali Hope). The Shetland Tidal Array continues to set new benchmarks that showcase the growing maturity of the tidal energy sector. By December 2022 the array had achieved a world record performance of 60 months of continuous monthly power output to the grid. No negative effects on marine life have been recorded in over 11 years of environmental monitoring at the site.

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



Deployment of turbine 5, Grace, for Nova Innovation (Credit: Nova Innovation)



Marine Energy Alliance (MEA)

The Marine Energy Alliance (MEA) is a European Territorial Cooperation project running from May 2018 to May 2022. The project has a total budget of €7.2 million and is supported by Interreg North West Europe, who provide €4.3 million of ERDF funding. The project was extended to March 2023 with funding from the 2nd Call for Capitalisation with an additional €0.7 million of ERDF funding, with the aim of establishing a business plan on how to sustain the alliance. The MEA partners (DMEC, EMEC, MaREI, Centrale Nantes, Exceedence, Innosea, Marin, University of Edinburgh, and Navingo)

supported 41 SMEs / marine energy technology companies to progress their technical and commercial maturity level up the TRL stages, with the overall goal of reducing the risk of device failure in subsequent demonstration phases. Through participation in the Marine Energy Alliance (MEA), the companies all gained access to the project partner's world-leading expertise in Marine Energy development. Each service offer was intended to put the company's technology and business on the road towards successful commercialisation.



Tidal Stream Industry Energiser (TIGER)

Led by ORE Catapult, the TIGER project is an ambitious €48.4 million project running from October 2019 until 31 July 2023. With the European Regional Development fund contributing €32.8 million of the overall funding, the project falls within the category for low-carbon technologies of the Interreg France (Channel) England Programme. So far the TIGER project has installed nearly 4MW of new turbine capacity, supported consenting at tidal sites Ramsey Sound, Raz Blanchard and PTEC and provided new infrastructure at Paimpol-Bréhat, with over 75 new designs in development. Through events and workshops, TIGER has grown the UK/FR supply chain, launching a supply chain database with over 3,000 entries and has worked with policy makers and the

public to raise awareness of the merits of tidal stream energy generation. The project has also provided evidence to the Marine Energy Council to inform the case for subsidy support for tidal stream in the UK. Across the Channel, data from TIGER and subsequent support to French developers Hydroquest and Sabella, has led to ADEME starting discussions around a French Feed in Tariff. The ultimate aim of the project, the largest across the Interreg programme, is to utilise the learning opportunities to make a stronger, cost-effective case for tidal stream energy as part of the UK/France energy mix and as a result the project will install up to 8 MW of new tidal capacity.

<https://interregtiger.com/>

MEECE

Marine Energy Engineering Centre of Excellence (MEECE)

MEECE is a collaboration between Offshore Renewable Energy (ORE) Catapult and the universities of Swansea, Cardiff, Bangor and Cardiff Metropolitan. MEECE also works closely with the Marine Test Area (META) which comprises a series of pre-consented test sites in the Milford Haven Waterway. MEECE is a project led by ORE Catapult, and funded by ERDF (through the Welsh European Funding Office WEFO). One of MEECE's main activities is to support Welsh SMEs to demonstrate and validate their innovations. MEECE cannot give out grants, but can use its funding to deliver small innovation projects on behalf of SMEs at no or very low financial cost to the SME involved. MEECE is more than just a single project, it is also the brand under which ORE Catapult operates in Wales. The Wales 'team' delivers the Milford Haven Energy Kingdom project, and is developing a pipeline of projects that will continue beyond the end of the ERDF-funded MEECE project. MEECE promotes and supports delivery of the wider range of programmes and initiatives that ORE Catapult delivers across the UK. MEECE is also one of four projects that make up the Pembroke Dock Marine City Deal project.

<https://www.meece.org.uk/>



MEECE Research Buoy (Credit: MEECE)



Effective Lifetime Extension in the Marine Environment for Tidal Energy (ELEMENT)

ELEMENT is a €5 million EU H2020 project led by Nova Innovation alongside - an international consortium of 10 members. In a world-first, the ELEMENT team is using behavioural modelling and machine learning to control tidal energy turbines to improve efficiency and reduce costs. This approach will reduce the dependency on external instrumentation and sensors which can struggle to withstand the immense forces exerted by the tides. As well as improving reliability and lowering costs, the project is turbo-charging the collection and analysis of ocean

data, providing valuable learnings that can feed into future turbine designs. By extending tidal turbine lifetime, improving efficiency and increasing availability, the project is expected to deliver a 17% reduction in the levelised cost of tidal energy over the life of the project. As of December 2022, the team is optimising turbine performance using real-time ADCP data in Shetland and preparing for the deployment of Nova's RE50, 50 kW turbine, in the Étel estuary, Brittany.

<https://element-project.eu/>



Enunice tidal turbine before deployment (Credit: Nova Innovation)

Collaborative Offshore Renewable Energy Subsea Systems (COSS) research accelerator

Led by the University of Plymouth and the Offshore Renewable Energy (ORE), the COSS will tackle some of the key engineering challenges to accelerating the roll-out of new technologies in wave, tidal stream and floating wind. This new facility will be focused around the hydrodynamics of floating offshore structures, offshore engineering and control systems. It will comprise a suite of advanced engineering facilities for use by academic researchers, industry and businesses working in collaboration with the University and ORE Catapult staff. It will be used to test how innovative wave, tidal and floating offshore wind platforms respond to ocean conditions, and build on work to study and develop

autonomous marine systems that can carry out the inspection, maintenance and repair of offshore systems. The ultimate aim is to enhance the resilience of structures and reduce the cost of operations, increasing the competitiveness of offshore renewables compared with other energy sources. These laboratory facilities will be augmented by access to test rigs located across the South West, the real seas trials site Smart Sound Plymouth, and include access to national test facilities operated by ORE Catapult across the UK.

SELKIE

SELKIE

Launched in 2019, SELKIE is a €5.2 million project 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 and Gavin Doherty Geosolutions. Since its inception, this project has focussed on developing a streamlined commercialisation pathway for the ocean energy industry by establishing a cross-border network of developers and supply chain companies in Ireland and Wales. It has also sought to create a set of multi-use technology, engineering and operation tools, templates, standards and models for use across the ocean energy sector.

2022 has seen some significant milestones for the project. At the start of the year, SELKIE launched a tank testing call for Irish and Welsh developers and have since had three developers complete SELKIE funded tank testing at the Lir National Ocean Test Facility. In October, SELKIE launched its long-awaited Operations & Maintenance decision support tool and hosted a workshop at the end of the year to provide training. The project is scheduled for completion in May 2023.

<https://www.selkie-project.eu/>



Ocean Demo

Ocean DEMO, a €12.85 million project led by EMEC and supported by DMEC, SmartBay, Ocean Energy Europe and Ecole Centrale de Nantes, will provide funding to developers of ocean energy renewable technologies to test their products or services in real sea environments, specifically targeting multi-machine ocean energy installations. This will allow developers to move closer to market by demonstrating their technologies at full commercial scale. To date, Ocean Demo has

supported the demonstration programmes of many tidal and wave energy companies, including Orbital Marine Power, Magallanes Renovables and Mocean Energy. In 2022, Ocean Demo supported the live sea testing and demonstration of AWS Waveswing at EMEC and saw California-based tidal energy developer Aquantis, Inc sign up to test its Tidal Power Tug, also at EMEC. Ocean Demo is funded by Interreg North-West Europe.

<http://www.oceandemo.eu/>

FORWARD 2030

Forward-2030

In 2022, Orbital Marine Power and partners commenced the design phase of the €26.7 million FORWARD-2030 project set up to deliver the accelerated commercial deployment of floating tidal energy. The FORWARD-2030 project consortium received €20.5 million of grant support from the European Union's Horizon 2020 research and innovation programme to develop a system that will combine predictable floating tidal energy, wind generation, grid export, battery storage and green hydrogen production. As both the project coordinator and lead technology developer, Orbital Marine Power will oversee the installation of the next iteration of the company's turbine, which will feature a range of cost reduction innovations, and be coupled with a hydrogen production and battery storage facility at EMEC.

The project also will develop and assess large scale integration of tidal energy to the European energy system, develop a smart energy management system and an operational forecasting tool. EMEC will host the demonstration, facilitate hydrogen production, deliver a comprehensive environmental monitoring programme, and develop a live environmental monitoring system and test programme. The University of Edinburgh will deliver techno-economic analysis of tidal energy, and the MaREI Centre at University College Cork will be responsible for addressing marine spatial planning issues for wide scale uptake of tidal energy.

<https://forward2030.tech/>



Orbital O2 operating at EMEC test site (Credit: Orbital Marine Power)

MAXBlade

Awarded in 2022 and launched at the University of Edinburgh's FastBlade test facility in early 2023, MAXBlade is a €10 million project funded by the European Union and UKRI. The project aims to investigate the performance and full lifecycle of tidal turbine blades from fabrication to decommission, embedding a circular economy element in their design. Working with tidal technology company Orbital Marine Power, the project will implement longer blade designs, increasing the swept area and reducing the overall cost of tidal energy.

Innovations from MAXBlade will be integrated with findings from its sister project, FORWARD2030, to enable large-scale production of Orbital's O2 turbine technology. MAXBlade is led by TechnipFMC and includes Orbital Marine Power, Marasoft, TECNALIA, Edinburgh University, EMEC, Laborelec and European Composites Industry Association. It is supported by Edinburgh Innovations, Edinburgh University's commercialisation service.

SEETIP Ocean

SEETIP Ocean is a multi-partner project, coordinated by Ocean Energy Europe, involving the University of Edinburgh, Wave Energy Scotland and a number of European partners, with the aim of enhancing the cooperation and collaboration of stakeholders both inside and outside the European ocean energy sector. This project will look to build on the work of the finished projects, ETIP Ocean and SET Plan Ocean Energy IWG and continue to promote knowledge transfer and collaboration at an industry and government level.

This will be achieved through promoting knowledge exchange between individuals and organisations, the avoidance of duplication of research aims, the creation of new ideas and the building of more and deeper connections. Widespread knowledge-exchange will be facilitated via webinars and workshops. Based on these exchanges, SEETIP Ocean will publish accessible studies and reports that will be widely disseminated across and beyond the ocean energy sector. SEETIP Ocean is a €788,254 project funded by the European Commission

4 TECHNOLOGY DEMONSTRATION



Orkney Vessel Trials project (Credit: Aquatera)

4.1 Existing Open Sea and Blade Test Sites

European Marine Energy Centre (EMEC)

Established in 2003 and now entering its twentieth year of operation, EMEC is the world's leading centre for testing and demonstrating wave and tidal converters. As a plug-and-play facility EMEC helps reduce the cost, time and risk of testing offshore with pre-consented grid-connected demonstration sites. EMEC is the world's only accredited test facility for ocean energy, accredited by the United Kingdom Accreditation Service (UKAS), and is the first International Electrotechnical Commission (IEC) Renewable Energy Testing Laboratory (RETL) for ocean energy. EMEC has to date hosted the highest numbers of ocean energy converters around the world and has been engaged in many of the live sea tests, demonstrations and deployments listed in this UK chapter, including Mocean Energy's Blue X and AWS Ocean Energy's Archimedes Waveswing.

Throughout 2022, EMEC has continued to monitor, maintain and evaluate its Billia Croo wave test site, reviewing the position and condition of subsea cables and any changes to site topography and geology. This increased understanding of site characteristics will provide invaluable assistance to prospective developers as they prepare to deploy. In 2022 alone, Marine Power Systems (MPS) booked out two berths for the testing of a multi-megawatt wave energy array in 2025/26; the PelaGen wave energy converter will be deployed on a modular floating platform, PelaFlex; and EMEC announced the launch of a €19.6 million project

WEDUSEA, co-funded by EU Horizon Europe and Innovate UK, culminating with a two-year grid-connected demonstration of OceanEnergy's OE35 WEC at their Billia Croo wave test site. Having played a substantial role in arguing for the creation of a ring-fenced CfD pot in AR4 to support the tidal sector, EMEC is pleased to see many of their sector colleague's benefit, with Orbital Marine Power having been awarded two CfDs totalling 7.2MW for tidal energy deployments at the Fall of Warness test site.

Finally, EMEC has continued to collaborate globally, hosting visitors from countries including Japan, Malta, Norway, Canada and New Zealand. EMEC has also hosted several members of Scottish and British parliaments: Michael Matheson MSP, Lorna Slater MSP, Richard Lochhead MSP, and Rt Hon Greg Clark MP and facilitated a highly engaging visit from Crown Estate Scotland Board members. EMEC continues to host the International WaTERS (Wave and Tidal Energy Research Sites) network to encourage collaboration, knowledge sharing and cross-border project development with ocean energy test centres around the world and this year welcomed 34 delegates from 17 different ocean energy test centres.

<https://www.emec.org.uk/>



Perpetuus Tidal Energy Centre (PTEC)

The Perpetuus Tidal Energy Centre is a 30MW commercial tidal stream project situated off the south coast of the Isle of Wight and has the potential to be England's first multi-megawatt tidal stream power generation project. In recent years PTEC has moved decisively to ensure that it is well prepared to build upon increased interest and investment in the tidal sector, securing key consents for onshore and

offshore activities and an updated grid connection offer. In late 2022, PTEC entered into a 20-year seabed lease from the Crown Estate, enabling the site to move into the final stages of development. In 2022, PTEC agreed a partnership with Orbital Marine Power to deliver up to 20MW of tidal energy, opening up opportunities for future CfD bids in AR5 and beyond.

<https://perpetuustidal.com/>



Morlais

The West Anglesey Tidal Demonstration Zone, referred to as the Morlais project, encapsulates 35km² of seabed around the promontory of Holy Island. The zone, which has been leased for 45 years, boasts powerful tidal current resources and relatively low wave regimes, representing a prime site for future exploitation of tidal energy. Having secured the planning permission from Welsh Government, a marine licence from Natural Resources Wales and funding from the Welsh European Funding Office, the infrastructure works to enable the export of electricity generated from tidal stream devices in the Morlais project to the Scottish Power Energy Network

infrastructure commenced in early 2022. This work will be completed in the second half of 2023. There continues to be high levels of interest in the Morlais project from developers from around the world, with one, Magalannes, having secured subsidy support under the CfD scheme from the UK Government during AR4 in 2022 with other developers showing interest in bidding for subsidy support to deploy at Morlais in AR5 during 2023.

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

FaBTest

FaBTest is a 2.8km² non-grid connected pre-consented nursery test site consisting of three test berths situated within Falmouth Harbour. The relatively sheltered location of the bay from the west allows for ocean energy converter concept devices and components to be tested, whilst being occasionally exposed to more significant

weather from the east. As a result, FaBTest provides a step in the device development process, between tank testing and demonstration deployment.

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

Marine Energy Test Area (META)

META, situated in the Milford Haven Waterway, is managed by Marine Energy Wales and is part funded by the ERDF through the Welsh government, the Coastal Communities Fund and the Swansea Bay City Deal. Aiming to bridge the gap between tank testing and the Welsh Demonstration Zones, this series of 8 non-grid-connected sites are suitable for a range of wave and tidal component, sub-assembly, scale and full-scale device tests. In 2022 META continued to add value to the

test sites through environmental data collection campaigns and expanding the envelope of the consented activities. Currently operational on the META sites are a tidal turbine designed by Swansea University and the MEECE buoy which is supporting various component tests, including a novel mooring damper.

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



Marine Energy Test Area (Credit: Marine Energy Wales)



THE UNIVERSITY
of EDINBURGH



FASTBLADE

Based in Rosyth, Scotland FastBlade is an innovative research facility that uses regenerative hydraulic technology to allow high-quality, low-cost accelerated testing of composite and metal structures including tidal blades, composite bridge sections and carbon fibre aircraft wing boxes. Developed by the University of Edinburgh, the facility will use a Digital Displacement

regenerative hydraulic actuation system to reduce the energy requirements of fatigue testing. As the world's first dedicated fatigue test facility for tidal blades, it will help secure Scotland's leadership role in ocean energy. Officially opened in May 2022, the FastBlade test site will provide support to numerous projects, including both the MAXBlade and Forward2030 tidal energy projects.

<https://www.fastblade.eng.ed.ac.uk/>



FastBlade Test Site (Credit: University of Edinburgh)

4.2 Arrays and Demonstration Projects in the Water

This section is a non-exhaustive list of key projects tested, installed in the sea, and operating in 2022.

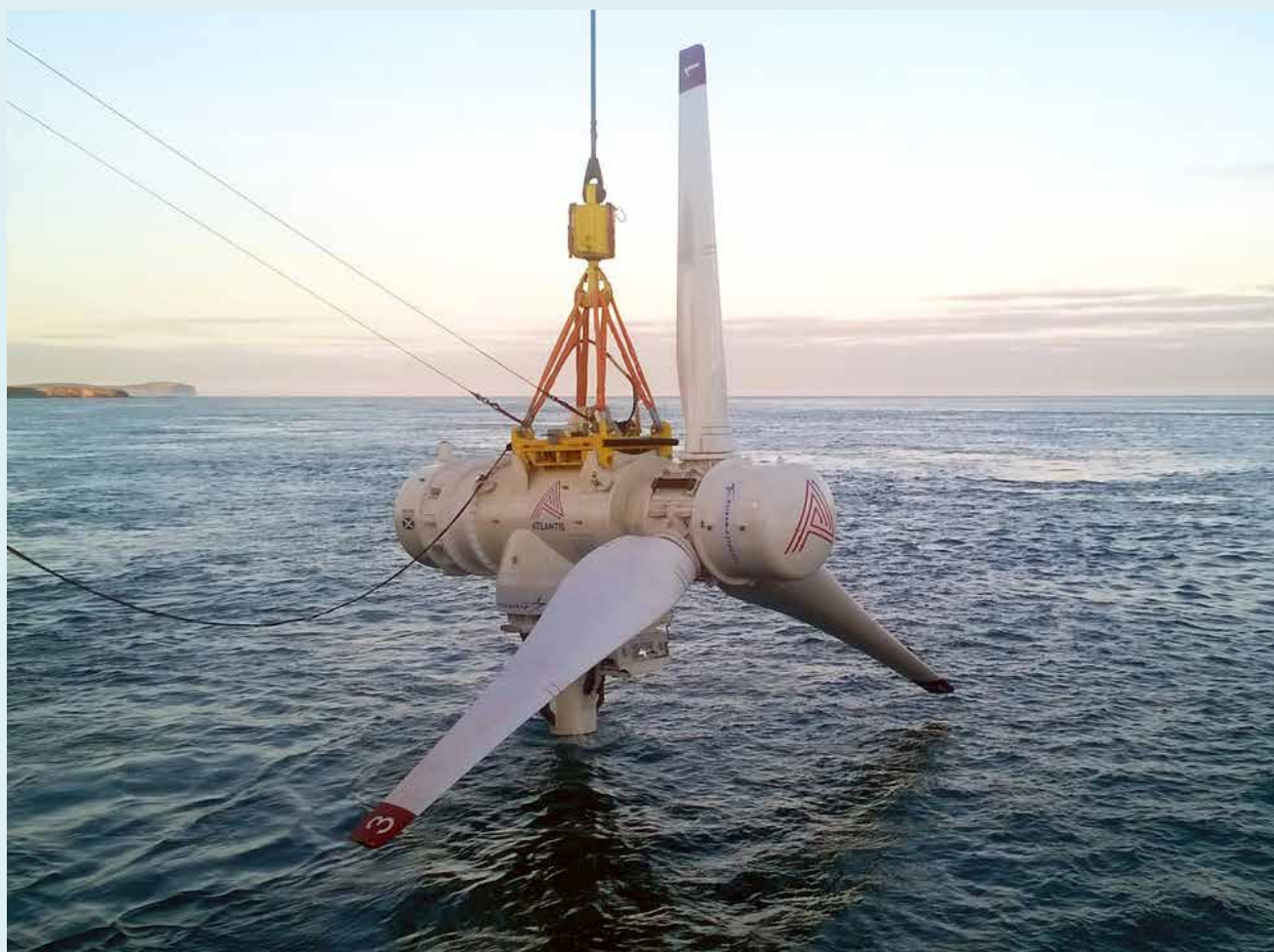
Tidal Stream

MeyGen

The MeyGen project, established in 2010 in the Pentland Firth, is the largest planned tidal stream project in the world. With consent currently awarded for 86MW, and the option to develop up to 398MW, the MeyGen project is split into 4 phases of delivery. In operation since 2018, MeyGen Phase 1 comprised of the installation of four 1.5MW turbines that, as of October 2022, have delivered over 45GWh of renewable electricity available for export into the local Shetland distribution network. Phase 1 incorporated two different turbine technologies, Simec Atlantis Energy's AR1500 and Andritz Hydro

Hammerfest AH1000 MK1. MeyGen Phase 2 plans to deliver an additional 28MW of tidal energy generation capacity with a target commissioning date of 2027. This will be enabled by the successful award of a CfD in AR4 for 28MW at a strike price of £178.54/MWh, a transformational moment for the project, that will ensure that MeyGen delivers the world's first commercial scale tidal array.

<https://saerenewables.com/tidal-stream/meygen/>



AR1500 tidal turbine being deployed at MeyGen (Credit: SIMEC Atlantis)

Magallanes Renovables

Spanish tidal developer Magallanes Renovables' second generation tidal turbine device, the ATIR, was successfully re-deployed at EMEC's grid-connected Fall of Warness tidal test site in 2021. The testing of the ATIR has been supported by the Horizon 2020 Fast Track to Innovation Ocean_2G project, and the Interreg Ocean DEMO and MaRINET2 projects, part of the EU's Horizon 2020 research and innovation programme.

Magallanes was one of three tidal turbine developers to receive a CfD in the UK government's most recent round of auction, successfully bidding for a 5.6MW contract awarded at a strike price of £178.54/MWh. This important milestone will see Magallanes look to deploy their first commercial deployment at the Morlais project in Anglesey, Wales, bringing long-term jobs, opportunities and socioeconomic benefits to the region for a number of years.

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



Magallanes Renovables ATIR turbine (Credit EMEC/Colin Keldie)

Minesto

Swedish marine energy developer Minesto has had a physical presence in Hollyhead, Wales since 2015, where it has been testing and validating its first commercial-scale system, the 0.5MW Deep Green 500 device, along with other technologies. This site, known as Hollyhead Deep, already includes an Agreement for Lease for a 10MW installation, a state-of-the-art assembly hall and a highly skilled commissioning and operations team. There are long-term plans to see this site transformed into a large-scale 80MW array with the potential to be a world-leading tidal energy generation site. In 2022

Minesto launched a detailed plan for large-scale build-out of tidal energy arrays in the Faroe Islands, outlining four new verified sites that would supply 40% of the nation's growing electricity consumption. This long-term goal will be underpinned by the deployment of the 100kW Dragon 4 tidal energy converter in Vestmannaund, Faroe Islands. At the close of 2022, Minesto's Dragon 4 tidal energy converter had recorded new record levels of energy production and a second Dragon 4 unit had been successfully installed, operating in parallel to double production capacity.

<https://minesto.com/projects/holyhead-deep>

Nova Innovation

In 2016, Nova Innovation installed the world's first offshore tidal energy array, the Shetland Tidal Array, at Bluemull Sound in Shetland. In 2018, Crown Estate Scotland granted an extension to Nova's existing seabed lease, increasing the overall potential capacity from 0.5MW to 2MW and extended the lease period until 2041.

This extension allowed the progression of the EnFAIT project, with a further three 0.1MW Nova M100 turbines to be installed, bringing the overall installed capacity to 0.6MW. In 2022 Nova Innovation built three 100kW direct drive turbines: two have been shipped for deployment in Bluemull Sound, Shetland, and one has been exported to the company's Nova Tidal Array in Petit Passage, Canada. In addition, a 50kW demonstrator turbine will be deployed by Nova Innovation in France

in 2023 under the ELEMENT project. In addition, in 2022 Nova Innovation developed a feasibility study for a 7MW tidal array in the Larantuka Strait in Indonesia in the InnovateUK funded FLITE project, and has developed tools and techniques to reduce the cost of tidal turbine deployment and recovery in the BEIS-funded CREATE project. The company also signed a grant agreement for the UpTEMPO project, in which they will develop and demonstrate their next-generation tidal turbine. This project will be funded under the UK Treasury Guarantee, having been successful in winning funding under the EU European Innovation Council (EIC) Accelerator programme.

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



Nova Innovation Eunice turbine (Credit: Nova Innovation)

Orbital Marine Power

The company continued to put its flagship device, the O2 turbine, through its paces at EMEC's Fall of Warness tidal test site as part of a long term demonstration programme. The O2 features a range of innovations focussed on driving down the cost of tidal stream energy, including twin 20 metre rotor diameters - the largest swept area on a single tidal energy converter to date, pitching hubs for floating tidal energy and a 'gull wing' leg retraction system to allow low cost, onsite access to the entire generating unit. In July 2022, Orbital was awarded two CfDs in the UK AR4 process. This will support the delivery of 7.2 MW of new tidal stream energy at EMEC and once

grid-connected will power up to 7,200 homes. Orbital also secured new investment from the Scottish National Investment Bank and individuals via the Abundance Investment platform to finance the ongoing operation of the O2, the company's 2MW+ floating turbine. These debt facilities will be serviced by the long-term sale of electricity from the turbine, forecast at around 100 gigawatt hours of energy, delivered to the UK grid or hydrogen electrolyzers over its project life.

<https://orbitalmarine.com/>



Orbital Marine Power's O2 turbine (source: Orbital Marine Power)

Wave



Mocean Energy

Mocean Energy successfully deployed its first prototype device, 'Blue X', at EMEC in Orkney in June 2021. The project, funded through the WES's Novel Wave Energy Converter (NWE) programme, provides learning towards Mocean's "Blue Horizon" technology for large-scale power and "Blue Star" device for subsea power applications. The Blue X was tested for 5 months, where it experienced sea states up to 2.3 m Hs, generated sustained power outputs of 5kW, and provided invaluable data and learning towards numerical model validation

and future developments. Following the success of its prototype testing, the next step for Mocean Energy is to deploy Blue X along with subsea equipment to demonstrate reliable power and communications in a real-world application, further the development of the Blue Horizon technology through the EuropeWave programme, and commercialise the small-scale WEC product lines for launch in 2024-25.

<https://www.mocean.energy/>



Mocean Energy Blue X device at EMEC (source: Mocean Energy)

Bombora Wave Power

Australian wave energy developer Bombora Wave Power has established its key operations in Pembrokeshire, Wales and is currently progressing the 1.5MW mWave™ Pembrokeshire Demonstration Project supported by ERDF funding through the Welsh Government. This project has progressed at pace throughout 2022, with the 1.5MW mWave™ beginning its final test and assembly phase before ocean deployment. In 2022 it was also announced that Bombora Wave Power had received an investment of £3.54 million from Japanese shipping company Mitsui O.S.K. Lines Ltd., to further commercialise its mWave™ energy generation technology and grow its presence and supply chain capabilities in the region.

Bombora has continued to engage with global Engineering, Procurement, Construction and Installation (EPCI) contractor TechnipFMC on the InSPIRE project, with the aim of developing a combined floating offshore wind and wave foundation device, incorporating Bombora's mWave™ technology. As part of the EuropeWave Programme, Bombora has successfully completed tank testing of a floating foundation system suitable for implementation into the InSPIRE project.

<https://bombora.com/>



The mWave (Credit: Bombora Wave Power)

AWS Ocean Energy

2022 has been another exciting year for AWS Ocean Energy, with successful at-sea testing of its prototype 16 kW Archimedes Waveswing wave energy converter at EMEC's test site in Scapa Flow, Orkney, UK. AWS is also in the process of completing a study expected to confirm the feasibility of large-scale multi-absorber wave energy platforms based on the Waveswing technology. These platforms will address the fundamental challenge of scale, and the practicality of offshore maintenance, both of which are essential to the delivery of affordable utility scale power. AWS's prototype Waveswing is a modular fully submersible pressure differential absorber, suitable for integration into multi-absorber platforms or single use

remote power applications. The development was the recipient of a £3.4 million grant from the WES programme, highlighting another successful instance of industry collaboration. The successful testing of AWS's device at EMEC's Scapa Flow test site has proven the key technology sub-systems necessary to allow the concept to work at real-world scale. AWS is now looking for partners to participate in the development and demonstration of a 2MW multi-absorber pre-commercial prototype, whilst also pursuing other exciting opportunities for deployment of smaller systems in remote applications.

<https://awsocan.com/>



AWS device testing at EMEC Scapa Flow test site (credit EMEC)

4.3 Projects Planned for Deployment

It is hoped that the success of the CfD AR4 will provide the basis for a number of future tidal energy projects, with Orbital Marine Power, Simec Atlantis and Magallanes aiming to deliver an additional combined total of 40.82MW of tidal energy generative capacity by 2027 at the latest. Moving forward, there is also hope that there will be continued and sustained innovation in the design and application of financial mechanisms that support the development of the ocean energy sector. As this chapter

highlights, the successful collaboration of government, industry and academia has helped to deliver a thriving ocean energy sector, which is well positioned to move from strength to strength. The application of bespoke and tailored funding packages, guided and shaped by knowledge exchange at the highest level, can only help to accelerate the commercialisation of the wave and tidal sectors.

5 SPECIFIC INITIATIVES FOR INTERNATIONAL COOPERATION

This is a non-exhaustive list of examples of different bilateral/regional cooperation initiatives involving the UK.

Clean Energy Transition Partnership (CETP)

The CETP programme is a transformative Research, Technological Development and Innovation (RTDI) program, designed to accelerate clean energy transition through annual funding calls. The CETP exists as an international collaboration involving 32 countries and over 50 funding agencies, supported through the Horizon Europe R&I programme. Within Government,

Highlands and Islands Enterprise and South of Scotland Enterprise. The CETP programme made up to £6 million available for support, with projects being awarded on a competitive basis. The programme closed in November 2022.

<https://cetpartnership.eu/>

European Energy Research Alliance (EERA)

The UK continues to chair the European Energy Research Alliance (EERA) Ocean Energy Joint Program (JP), providing the UK the opportunity to continue to guide and assist in the development of the Horizon2020 and now HorizonEurope European funding and work programmes. Comprising of 9 full participants and 4

associate partners, the EERA Ocean Energy JP has identified areas of research, based on existing research roadmaps, which are considered critical for meeting the necessary requirements for the successful growth of the industry.

<https://www.eera-set.eu/>

International Energy Agency (IEA)

The UK was a founding member of the International Energy Agency in November 1974 and has maintained a close relationship since then, utilizing its position of

leadership to strengthen energy security, spur economic development and advocate for the implementation of cleaner forms of energy.

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

6 RELEVANT NATIONAL EVENTS

Relevant events for the ocean energy sector that took place in the UK in 2022 include:

18th – 20th January – Supergen ORE Hub Annual Assembly, virtual

22nd – 23rd March – Marine Energy Wales Conference, Llandudno

3rd May – Wave Energy Scotland Annual Conference, Edinburgh

11th – 12th May – All-Energy, Glasgow

25th May – Scottish Renewables Marine Conference, Edinburgh

1st – 7th September – Orkney Science Festival, Orkney

29th September – Supergen ORE Autumn Assembly, Oxford

The UK will also be hosting some important events in 2023:

21st – 22nd March – Marine Energy Wales Conference, Swansea

9th – 10th May – All-Energy, Glasgow

25th May – Scottish renewables Marine Conference, Edinburgh

Tidal Array Cabling Project (Credit: EMEC/Colin Keldie)

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