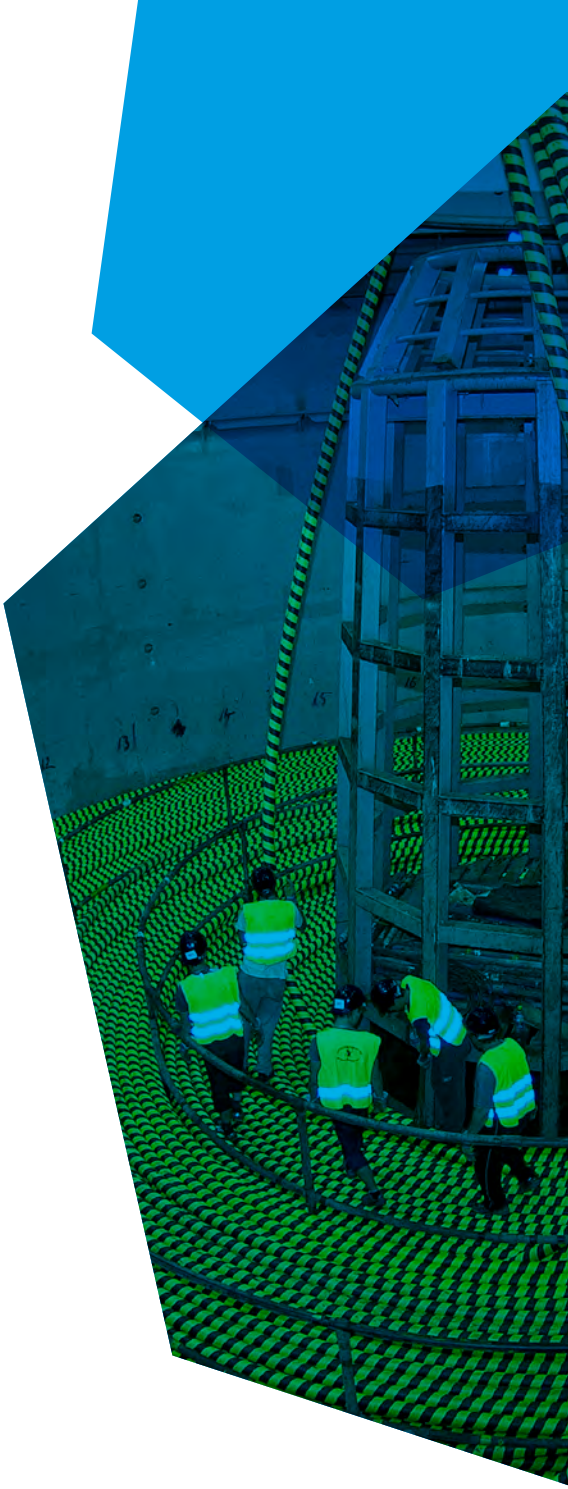
UK MARINE ENERGY 2019

A NEW INDUSTRY



aquatera environmental services and products

bombora wavepower

Carnegie CLEAN ENERGY

EMEC THE EUROPEAN MARINE ENERGY CENTRE LTD

GREENBACKERS Investment Capital

ITPENERGISED Earth. Smart. Solutions

MARINE ENERGY WALES YNNI MOROL CYMRU

MARINE POWER SYSTEMS

Minesto

NOVA INNOVATION

ORBITAL MARINE POWER

CATAPULT Offshore Renewable Energy

PERPETUUS tidal energy centre

renewableUK

SIMEC ATLANTIS ENERGY

scottish renewables

TOCARDO TIDAL POWER

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Front cover images:
Image, right hand side: Mike Brookes-Roper, courtesty of EMEC
Image, left hand side: Offshore Renewable Energy Catapult

EXECUTIVE SUMMARY

Creating a fit-for-purpose, modern, low-carbon and secure energy system will require ambitious action across the whole of the UK economy. The UK has a global lead in developing offshore renewable energy technologies and pioneering companies from within the UK and across the world have been attracted to the UK's significant marine energy resource (50% of Europe's tidal energy and 35% of its wave energy)[1], world-leading test centre network, energy sector supply chain capability, innovation funding and previous revenue support models.

This paper sets out the role that the UK's marine energy industry can play in our energy system and our economy, its unique attributes and the rationale for government to adopt a coordinated and strategic approach to support the sector's development.

The UK currently stands as the **global leader in marine energy**. Our industry is delivering advances in tidal and wave technologies – with concepts proven, devices breaking records and projects progressing towards commercialisation.

The marine energy sector harnesses not only our ocean resources but our human resources, while delivering economic development opportunities in peripheral economies. Projects can be found in remote regions, such as our Highlands and Islands and western seaboard, where they rely on local skills, services and infrastructure. Developed in a coherent and strategic manner, wave and tidal technologies can deliver a varied and measurable set of socio-economic benefits to communities across the country.

During 2016, an analysis undertaken by the economic development agencies in the South West, Wales and Scotland concluded that some 1,700 people are currently employed in the marine energy sector[2]. Predictions for the UK see the sector supporting a total of 22,600 jobs by 2040. Crucially, **50-60% of the economic benefit of both GVA and jobs is expected to be generated in coastal areas in need of economic regeneration[3].**

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MARINE ENERGY DELIVERING A NEW INDUSTRY


Offshore Renewable Energy Catapult

1 Ocean Energy Race The UK's inside track: https://c.ymcdn.com/sites/renewableuk.site-ym.com/resource/resmgr/publications/OER_inside_track_final_-_onl.pdf

2 Marine Energy: Key steps to maintain a Great British Success Story, HIE, Marine Energy Pembrokeshire and RegenSW. 2016

3 Tidal stream and Wave Energy Cost Reduction and Industrial Benefit Report, ORE Catapult, (2018)

LEADING PROJECTS

Orbital Marine Power

- 2MW FLOATING TURBINES
- 130MWH IN 7 DAYS

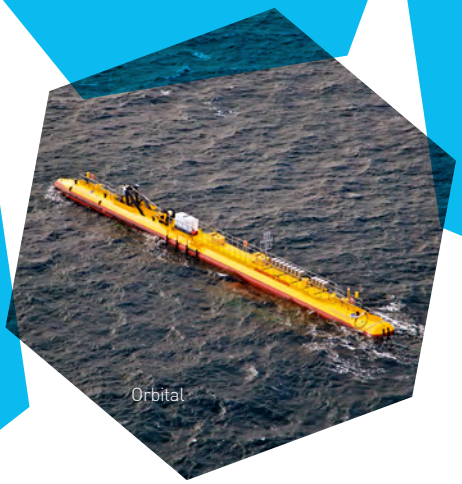
Nova Innovation

Nova Innovation

- 90% UK SUPPLY CHAIN
- WORLD FIRST BATTERY INTEGRATED SYSTEM

MeyGen

- WORLD'S LARGEST TIDAL ARRAY
- 8GWH TO GRID


Orbital

UK MARINE ENERGY 2019

Our tidal stream and wave resources are significant. The UK has a strong maritime history, excellence in marine engineering and successful, global showcase projects. MeyGen, the world's first large scale tidal stream array, has generated over 8GWh of energy to the grid to date – enough to power nearly 5,500 homes. Orbital Marine Power, developers of the 2MW SR2000 floating tidal turbine, generated over 130MWh of electricity in seven days, around 7% of the requirement of the Orkney Islands, where it is based.

The UK hosts the world's leading test centres for marine energy: the European Marine Energy Centre (EMEC) in Orkney and WaveHub in Cornwall. In addition, development sites such as the Perpetuus Tidal Energy Centre on the Isle of Wight and the Morlais tidal demonstration zone in Wales are stimulating activity and investment in various regions across the country.

More wave and tidal energy devices have been deployed in UK waters than in the rest of the world combined[4].

Worldwide, it is forecast that the ocean energy industry will be worth **£76 billion by 2050[5]**. The value of maintaining the UK's global lead in developing these technologies is clear, but to realise these benefits the sector requires policy certainty and a viable route to market in the UK.

Tidal stream and wave technologies have the potential to help us meet carbon targets as well as creating a versatile and secure energy system. However, as well as delivering this energy benefit, as this report sets out, marine energy technologies can deliver a series of sustainable and strategic benefits to the UK.

4 HIE and DBEIS (June 2018) MAXiMAR: maximising the marine economy in the Highlands and Islands. A Science and Innovation Audit Report

5 Highlands and Islands Enterprise, Regen SW and Marine Energy Pembrokeshire: Marine Energy key steps to maintaining a Great British success story (2016)

- DRIVING GROWTH ACROSS THE WHOLE COUNTRY
- DEVELOPING SKILLS
- SUPPORTING BUSINESSES


Colin Keldie, courtesy of EMEC

- INVESTING IN SCIENCE, RESEARCH AND INNOVATION
- UPGRADING INFRASTRUCTURE
- IMPROVING PROCUREMENT
- DELIVERING AFFORDABLE ENERGY AND CLEAN GROWTH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- ENCOURAGING TRADE AND INWARD INVESTMENT
- CULTIVATING WORLD LEADING SECTORS
- CREATING THE RIGHT LOCAL INSTITUTIONS


Colin Keldie, couresy of EMEC


Nova Innovation

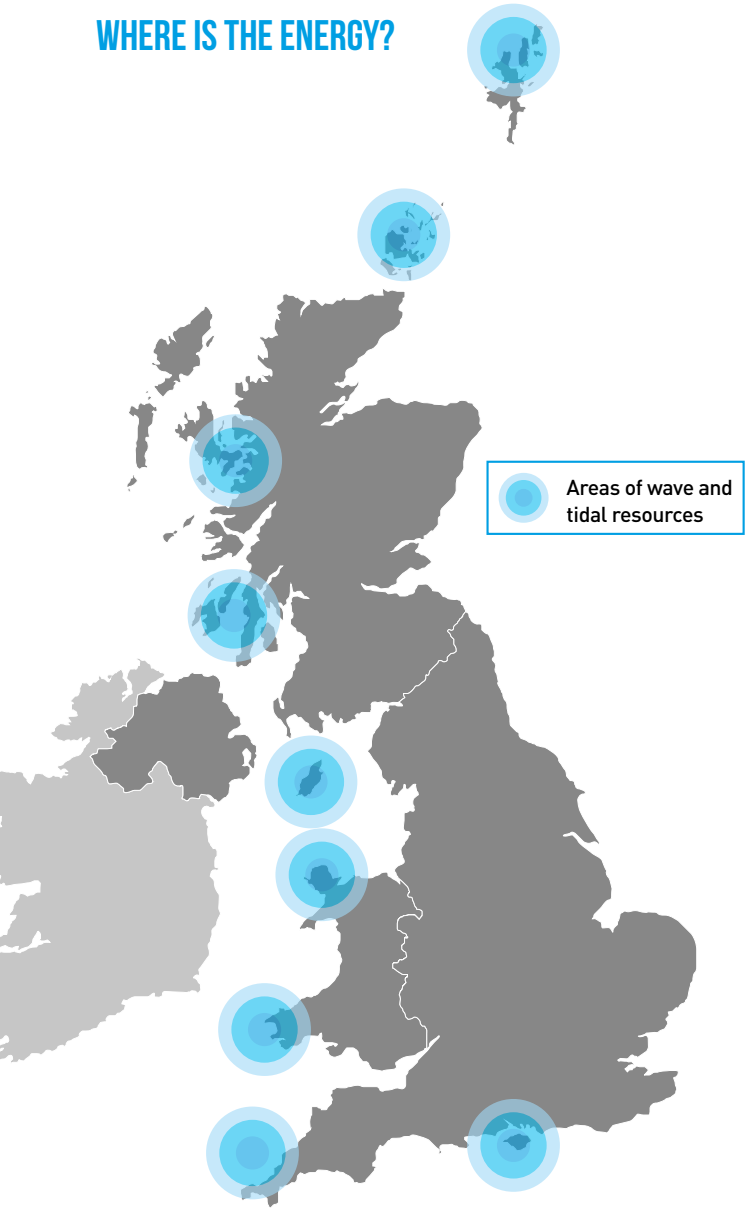

Mike Brookes-Roper, courtesy of EMEC


Colin Keldie, courtesy of EMEC

Currently, the UK, has **1,287MW of leased tidal stream sites and 10MW of operational tidal stream capacity**, including the world's first tidal arrays. There are some 897MW of consented tidal sites in Scotland and another 340MW of consented sites in Welsh and English waters. Based on an industry survey, conducted as part of this report, **some 180MW of tidal energy is already planned post 2025.**

The tidal energy sector in the UK is now on the verge of commercialisation, with the wave sector making strong progress in technology development. There is the potential for strong growth in the sector over the next decade, as the first small-scale arrays become operational. However, **for the UK to capture the economic benefits based on its early sector lead, a clear and accessible route to market is required** to support sustained private sector investment.

WHERE IS THE ENERGY?



The UK is currently home to **22 tidal device developers and 23 wave developers**[6] - Scotland is delivering the world's first tidal arrays, and is home to leading test centres, while the South West of England and Wales are too progressing technology development. Strategic infrastructure is being built nationally to encourage the delivery of marine energy.

MARINE ENERGY – POWERING OUR GRID IN 2019

MeyGen, the world's largest tidal stream array, located just off the northern tip of Scotland, exported a world record 1.4GWh of electricity to the grid in a single month in 2018, which would have powered the equivalent of 5,420 average UK homes during that month[7].

Orbital Marine's SR2000 tidal turbine, a 2MW floating device, produced outstanding performance results whilst deployed at EMEC, including a load factor of more than 38% in the first 24 hours of continuous operation. Over its test programme the SR2000 exceeded projected performance, producing over 3,200MWh of electricity, **more than the total generation of every marine energy device before this date[8].**

Evidence of Success

Following the 'oil shock' in the mid-1970s many countries looked to alternative sources of renewable energy. One clear success story in developing a viable renewable energy industry, is Denmark, a country with a population 11 times smaller than the UK. By establishing a market revenue mechanism to support wind energy development circa the mid-1980's, Denmark delivered an explosion of innovation in wind energy which, by 2016, had resulted in direct employment of 32 thousand people and an export market of €7.3 billion in goods and services. The UK, in comparison, is a net importer of wind energy goods and services, even as home to some of the largest offshore wind development in the world.

6 ORE Catapult, Tidal Stream and Wave Energy Cost Reduction and Industrial Benefit Report. ORE Catapult, May 2018.
7 Marine Energy Council Survey, 2018
8 Marine Energy Council Survey, 2018

UK MARINE ENERGY — THE GLOBAL POTENTIAL

The global market for tidal and wave energy technologies significant, with the International Energy Agency's Energy Technology Perspective[9] forecasting that up to 337GW of marine energy capacity could be deployed across the world by 2050. UK businesses, which currently lead the way in marine energy, could potentially capture £76 billion of the potential market[10].

The UK should seek to maximise this potential through securing the existing supply chain and economic benefits arising from manufacturing, investment and exports in the marine energy sector. Previous studies have shown that **£450 million has already been invested in the UK marine energy supply chain[11]** primarily from the private sector. This will prime the potential for additional GVA benefits through a much larger global market.

Already, the UK marine energy supply chain exports to a number of countries globally, notably Canada, France, Portugal, USA, China, Chile, Japan, South Korea and the Philippines.

Marine energy companies are not only exporting goods and services such as technology, power cables and components but also knowledge capacity in project development, surveying, resource assessment, ecological impact analysis and financial and legal services to a global market.

The UK Government identified renewable energy as a key part of its Industrial Strategy, stating that "**the global shift to cleaner growth, through low-carbon technologies and the efficient use of resources, is one of the greatest industrial opportunities of our time'[12]**. The UK's tidal and wave industry can contribute to maximising the benefits of this opportunity not just through domestic deployment - but through building upon our existing exports to international markets.

The European Marine Energy Centre (EMEC) in Orkney (the world's leading wave and tidal energy test and demonstration centre) has already demonstrated significant export potential. Its services include ready-made, grid-connected berths in some of the harshest marine environments. Testing devices in these conditions allows developers to learn in real conditions, reducing the time, risk and cost of developing new technologies. Since it was established in 2003, **EMEC has exported its knowledge to 18 countries**. In 2017 its consultants provided expertise to China, Ireland, Peru, South Korea and the USA. An economic impact assessment estimates that **EMEC has generated £249.6 million (GVA) for the wider UK economy[13].**

Minesto

Minesto is a tidal technology developer, founded in 2007 as a spin-off from Swedish aerospace manufacturer Saab. Minesto has successfully developed its unique subsea kite technology, called the Deep Green to operate in low flow environments. Minesto UK Ltd has had its headquarters in Wales since 2015. After securing a 10MW agreement for lease in June 2014 Minesto has focussed on verifying the functionality and power production of the Deep Green Technology at utility scale at their Holyhead Deep site off Anglesey. With 23 full time employees in Wales, Minesto has invested £27 million into the Welsh economy to date with a further £170 million expected to 2029.

Bombora

Bombora is a multi-award-winning ocean energy company, incorporated in Wales in 2017 that has developed an innovative and patented wave energy converter called the mWave™. Designed in Perth, Western Australia, the mWave delivers low cost, low impact, renewable electricity and will be tested off the coast of Pembrokeshire in a £15 million project. To date Bombora has invested £2 million of £4.5 million committed in the UK. Critically, Bombora has secured a £10.3 million Welsh European Funding Office grant supporting this project. Bombora has 20 staff based in Pembroke Dock and will continue to strengthen this team as the project progresses and the future project pipeline teams are developed.

9 https://www.iea.org/publications/freepublications/publication/ETP2012_free.pdf

10 https://www.renewableuk.com/news/304396/Wave-and-Tidal-Energy-in-the-UK--Capitalising-on-Capability.htm

11 HIE, Regen SW and Marine Energy Pembrokeshire: Key steps to maintaining a GB Success Story (2016).

12 HM Government Industrial Strategy: Building a Britain fit for the Future. 27th Nov, 2017.

13 EMEC, Internal Study 2018.

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Credit (Colin Keldie)

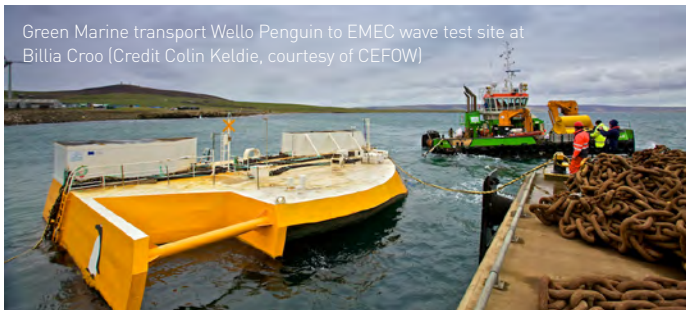
THE BLUE ECONOMY

The Ocean Economy in 2030[14], a major report issued by the Organisation for Economic Cooperation and Development (OECD) in 2016, estimates the gross value added (GVA) of the Blue Economy at more than US$3 trillion by 2030, (at 2010 prices) and at 2.5% of total global GVA. Within this, **marine energy** is notable as an emerging sector, defined by the key role in which cutting-edge science and technology plays in the delivery of projects and technology. There are significant areas of collaboration and overlap between **marine energy development and the development of our existing maritime infrastructure and capacity.** The UK maritime sector contributes £14.5 billion to the UK economy, and directly supports an estimated 186,000 jobs[15].

The UK Industrial Strategy and forthcoming Maritime Sector Deal aim to deliver benefits to the UK and peripheral economies: an aim which is being supported by the ongoing development of the tidal stream and wave energy industries.

The UK marine energy supply chain is currently at the forefront of activity globally. Developed around the world's first demonstration and test sites here in the UK, **vessel operators, offshore contractors, engineering and consultancy services are supporting the growth of the marine energy sector in various regions of the UK.**

SIMEC Atlantis



Green Marine transport Wello Penguin to EMEC wave test site at Billia Croo (Credit Colin Keldie, courtesy of CEFOW)

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14 https://read.oecd-ilibrary.org/economics/the-ocean-economy-in-2030_9789264251724-en#page1
15 Maritime UK, Value of the Maritime Sector https://www.maritimeuk.org/value/

Development of our marine resources will be required if sustainable economies and marine energy are to support and integrate with other forms of infrastructure and economic development. For example, Project Natick, a subsea datacentre, was deployed by Microsoft at EMEC in Orkney in 2018. The project is proof of concept for self-sufficient datacentres, powered by marine energy, which can be deployed in remote locations, reducing data transfer and increasing accessibility and connectivity.

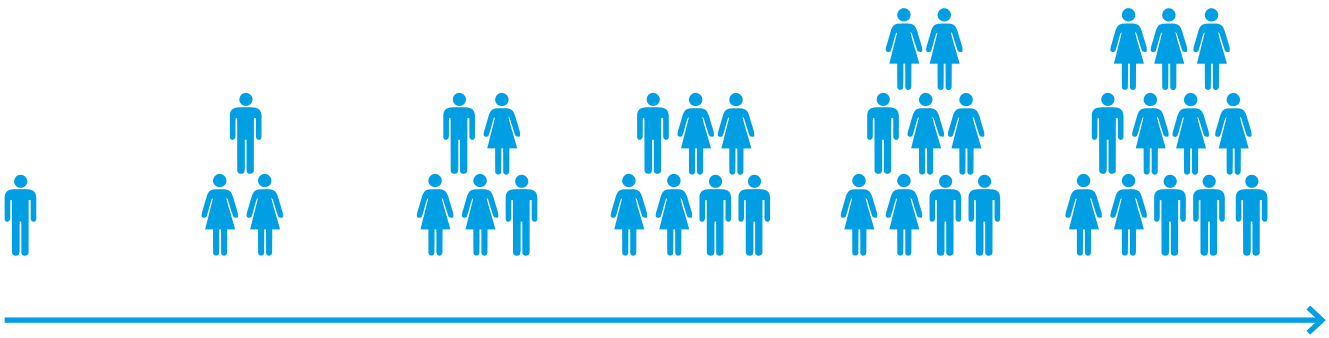
The Swansea Bay City Deal is a further example of marine energy being integral to economic development. The project, including a £1.3 billion investment programme includes significant funding to support the development of a marine energy centre of excellence in Pembroke Dock. The Pembroke Dock Marine project will create a dedicated site which will be used as a base by marine energy developers to progress their devices from innovation to commercialisation.

MARINE ENERGY – DELIVERING FOR THE UK

During 2016, an analysis undertaken by the economic development agencies in the South-West, Wales and Scotland concluded that 1,700 people are currently employed in the marine energy sector. More recently, a report from the ORE Catapult[16] found that tidal energy could generate a net cumulative benefit to the UK of £1.4 billion by 2030 with the potential to create 4,000 jobs, many of which will be in regional economies. The study also reviewed projections to 2050, where it was found the net cumulative benefit to the UK increases to £24 billion (31% of the projected global market) with the potential for some 23,464 new jobs in the tidal stream industry. With wave technology believed to be some ten years behind this, there is still significant potential for job creation here with an additional 26,089 jobs expected in the sector by 2050. Crucially, 50-60% of the economic benefit of both GVA and jobs is expected to be generated in coastal areas in need of economic regeneration.

The report also demonstrates that marine energy employment will grow in distinct maritime and peripheral regions. Employment could come primarily from existing UK industries where they are strong capacity, such as oil & gas, maritime sectors and companies diversifying in to marine energy. There are several supply chain clusters forming in the UK, primarily in regions close to project development. These include Orkney and the Scottish Highlands, the South West of England, Solent/Isle of Wight, West and North Wales and Northern Ireland. Coastal regions in particular see huge benefit from the GVA and jobs the marine energy sector is supplying. A significant benefit of supporting and developing a marine energy sector is the ability to create a sustainable domestic market and supply chain.

DELIVERING JOBS



JOBS GROWTH WITH DEPLOYMENT

16 ORE Catapult, Tidal stream and Wave Energy Cost Reduction and Industrial Benefit Report, ORE Catapult, May 2018

OUR LOW-CARBON POTENTIAL

The UK Government's 2050 carbon targets aim to reduce CO2 emissions by at least 80% of the levels emitted during 1990. Predictions from the Committee on Climate Change suggest the UK may miss its targets for the fourth budget during the period of 2023-27[17].

The ORE Catapult report on marine energy identified that for every kWh of power generated by a tidal stream or wave device, 394g of CO2 is saved compared to the same power generated from a Combined Cycle Gas Turbine (CCGT) powerplant.

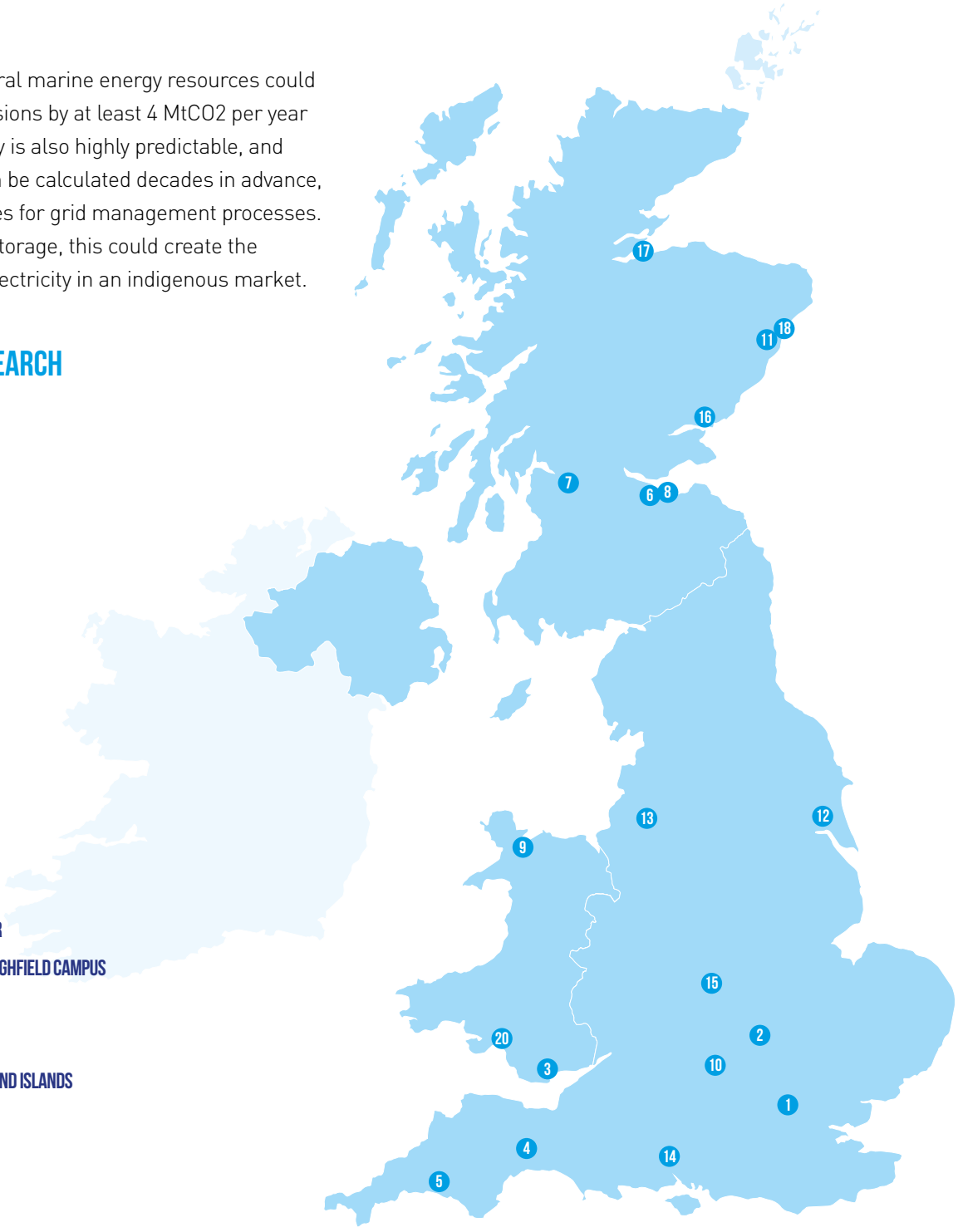
Exploiting the UK's natural marine energy resources could reduce UK carbon emissions by at least 4 MtCO2 per year from 2040[18]. Tidal energy is also highly predictable, and outputs of electricity can be calculated decades in advance, creating huge advantages for grid management processes. Combined with energy storage, this could create the potential for baseload electricity in an indigenous market.

UK MARINE ENERGY RESEARCH

Alongside developing technology and projects, the UK has created and retained world-leading expertise and research facilities aimed at progressing research into tidal stream and wave technologies. Significant funding has been obtained through the Natural Environment Research Council (NERC), the Engineering and Physical Sciences Research Council (EPSRC) and through collaborative European programmes.

MARINE ENERGY RESEARCH UNIVERSITIES

1 IMPERIAL COLLEGE LONDON
2 CRANFIELD UNIVERSITY
3 CARDIFF UNIVERSITY
4 UNIVERSITY OF EXETER
5 UNIVERSITY OF PLYMOUTH
6 HERIOT-WATT UNIVERSITY
7 UNIVERSITY OF STRATHCLYDE
8 THE UNIVERSITY OF EDINBURGH
9 BANGOR UNIVERSITY
10 UNIVERSITY OF OXFORD
11 UNIVERSITY OF ABERDEEN
12 UNIVERSITY OF HULL
13 THE UNIVERSITY OF MANCHESTER
14 UNIVERSITY OF SOUTHAMPTON HIGHFIELD CAMPUS
15 UNIVERSITY OF WARWICK
16 UNIVERSITY OF DUNDEE
17 UNIVERSITY OF THE HIGHLANDS AND ISLANDS
18 ROBERT GORDON UNIVERSITY
19 UNIVERSITY OF OXFORD
20 SWANSEA UNIVERSITY



17 Committee on Climate Change, Report to Parliament-https://www.theccc.org.uk/wp-content/uploads/2017/06/2017-Report-to-Parliament-Meeting-Carbon-Budgets-Closing-the-policy-gap.pdf
18 https://s3-eu-west-1.amazonaws.com/media.newore.catapult/app/uploads/2018/11/19142426/Tidal-Stream-and-Wave-Energy-Cost-Reduction-and-Industrial-Benefit.pdf

This research has driven step-changes in the development, understanding and knowledge capital in relation to marine energy. For example, The SuperGen UK Centre for Marine Energy Research (UKCMER), formed in 2003 has fostered a strong network of Universities, such as Plymouth, Imperial College London, Edinburgh, Exeter, Heriot-Watt, Cardiff and Strathclyde. They demonstrate strong and internationally recognised capability in areas such as resource assessment, design engineering, energy yield modelling, structural analysis and network integration.

Developing device prototypes, their testing and their commercialisation often bring together industry, the supply chain and academia, capitalising on the UK's renowned research expertise in these fields.

The UK's strong university research base has also led to the formation of a number of innovative spin-out companies, such as Aquatera, a marine consultancy in Orkney specialising in marine renewables, and Nautricity, a tidal developer emerging from the University of Strathclyde.
The public sector has played an important role in research and innovation associated with marine energy. Most notable has been the development of Wave Energy Scotland, which was formed by the Scottish Government in 2014. The body developed in response to a series of market challenges and is focusing efforts on innovation and technical solutions. Wave Energy Scotland has funded over 75 projects, bringing together 170 organisations[19].

The European Marine Energy Centre (EMEC)
The European Marine Energy Centre (EMEC) is a UKAS-accredited test and research centre focusing on wave and tidal power development based in the Orkney Islands. The centre provides developers with the opportunity to test full-scale grid-connected prototype tidal and wave devices in unrivalled conditions. EMEC was established by a grouping of public sector organisations following a recommendation by the House of Commons Science and Technology Committee in 2001.

With 13 grid-connected test berths, there have been more marine energy converters deployed at EMEC than at any other single site in the world, with developers attracted from around the globe to prove what is achievable in some of the harshest marine environments.

In EMEC's first 10 years of operation, direct jobs in the marine energy sector in Orkney grew to 250[20].

EMEC Billia Croo east cardinal buoy (Credit Colin Keldie) courtesy of CEFOW) 73


EMEC Integrated Monitoring Pod Deployment (Credit Colin Keldie)


EMEC test support buoy (Credit Colin Keldie)

19 DBEIS and HIE (June 2018) MAXiMAR: Maximising the marine economy in the Highlands and Islands.
20 Press Release: EMEC Celebrates 10th Anniversary

Morlais

Morlais is a tidal stream energy zone off the coast of Anglesey. Designated in 2013, the 45 year lease is held by Menter Mon, a community enterprise agency. The zone has 240MW of capacity and access to both a transmission and distribution networks which are uniquely futureproofed. The Morlais zone has a singular objective – to fully consent and connect for deployment in 2023. With £5.5 million, the project aims to achieve consent by first quarter 2021. The project is actively raising £30 million to connect the project to the seabed with a community of 9 global technology developers are currently committed to deploying at the site.

WaveHub

WaveHub is a wave energy test centre based off the coast of Hayle in Cornwall. Funded originally by the South West Regional Development Agency, the site aims to allow the testing of full scale wave devices off the Cornish coast. Comprised of a subsea converter with a capacity of 20MW, WaveHub can allow up to four device developers to test at one time. It is estimated that when fully operational, Wavehub will have the capacity to provide up to up to £76 million over a period of 10 years in to the regional economy with the potential of 170 direct jobs at the location — with benefits being far larger if a sustainable wave energy industry is formed [21].

ITP Energised

ITP Energised has worked in the marine renewables sector since the early 1990s. The company has worked in a broad range of territories outside the UK including, Denmark, Sweden, Eire, USA, Canada, India, China, Taiwan, Korea and Australia. The projects vary in topic including feasibility studies, FEED studies, device and project development, financial and techonomic modelling, policy development and investor services. Covering several technologies, ITP Energised has been working on combined and innovative technologies to share infrastructure and develop new ideas.

ITP Energised is currently leading a consortium, including Simec Atlantis, to design a 450kW tidal turbine for a project funded by the Chinese Government. The Chinese partners are planning to install the commercial demonstrator late in 2019.

Aquatera

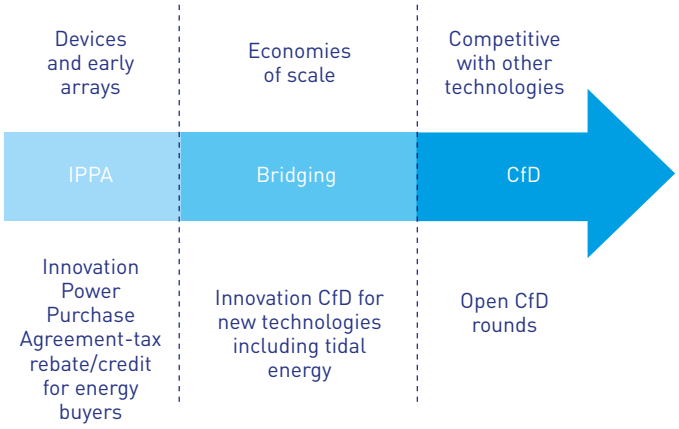
Aquatera was one of the first companies in the UK to specialise in marine energy, completing over 300 projects relating to marine energy since 2000, and has directly supported over 40 different technologies including 20 array projects. This marine energy portfolio has an accumulated value of around £5 million with some £2 million associated with export activities across 25 countries worldwide. Aquatera's expert team have been used through the UK Governments Prosperity Fund to open up export market opportunities for marine energy in Chile, Peru and Indonesia. The company also operates in the Philippines, Singapore, Japan, Taiwan, USA, Columbia, Barbados, Canary Islands, Australia, Norway, Faeroes and Mauritius.

21 https://www.wavehub.co.uk/

SEIZING THE OPPORTUNITY – A ROUTE TO MARKET

This paper has set out the benefit case for a UK marine energy industry, highlighting significant potential for UK technology development and projects. The Offshore Renewable Energy Catapult (OREC) published a new evidence-based assessment that shows the UK's marine energy industries can meet the requirements of the UK Government's 'Triple Test' for determining support for new technologies[22]. The tests are: achieving maximum carbon reduction; showing a clear cost reduction pathway and demonstrating that the UK can be a world-leader in a global market. To deliver this ambition government must ensure that policy enables continued development. The progress of the sector to date has been driven by a coherent package of support provided by government and other stakeholders. This support has provided value for money, with every £1 of public money invested in major marine energy businesses leveraging £7 of private investment. More than 77% of this investment has been spent in the UK supply chain[23]. It is essential that policy continues to underpin a high level of growth in the industry.

The marine energy sector is proposing three interlinked support models, which fit with the current stage of technology development and Government policy, to bring marine energy to a cost competitive position and allow for progression of technology and projects. Full details of this mechanism are given in Appendix 1.



The proposed Innovation Power Purchase Agreement (IPPA), can be used to support technology developers to deliver projects of up to 5MW whilst protecting consumers from costs by providing off-takers a tax rebate when buying marine energy. This would allow marine projects to sell their power over the market rate, with the off-takers reclaiming excess costs against tax, with this cost declining over time.

The Innovation Contract for Difference (iCfD) is a bridging mechanism that enables utility scale projects to through in the current CfD mechanism. This would allow for a new 'pot' within the CfD framework for all new technologies such as wave, tidal stream, and Advanced Combustion Technologies to complete among themselves. This could be funded through the underspend on the CfD budget, an additional iCfD budget or through a tax rebate for energy buyers who are paying the excess costs.

> "Britain excels at research and development but too often we have failed to reap the socio-economic benefits from the commercialisation of our innovations."
> **Rt Hon Theresa May MP, Prime Minister**

By establishing a route to market for marine energy, through the IPPA, it is expected marine projects will be able to deliver energy at a cost of around £150/MWh. With activity in an export market and by developing projects domestically, tidal energy is projected to reach target costs of less than £100MWh after 1GW of deployment. With strategic Government support, the UK can secure the industrial and economic benefits of this emerging industry, whilst maintaining our current lead in the marine energy race.

> "We must never be the protector of incumbency – but instead be constantly looking to create conditions to be open to new competitors and indeed to new industries that may not exist anywhere today but which will shape our lives in the future"
> **Rt Hon Greg Clark MP, Secretary of State for Business, Energy and Industrial Strategy**

22 https://s3-eu-west-1.amazonaws.com/media.newore.catapult/app/uploads/2018/11/19142426/Tidal-Stream-and-Wave-Energy-Cost-Reduction-and-Industrial-Benefit.pdf)
23 Highlands and Islands Enterprise, Regen SW & Marine Energy Pembrokeshire: Marine Energy: Key Steps to maintain a Great British Success Story. (2016

APPENDIX A

Revenue Support Models - Detailed

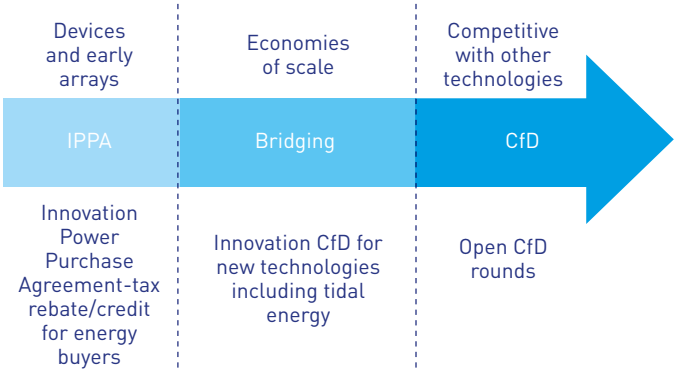
Having established the benefit case for the UK government to invest in the development of the tidal stream energy industry in the UK, the sector would like to propose how that support might be structured. Private capital is needed to invest in projects in the UK, getting device after device into the water, to get costs down and build the capacity for exports. This capital is available if there is a suitable revenue support model to ensure that returns are in place for investors. For that the sector needs revenue support on top of the electricity wholesale price.

Given the aim is to build up the position of a new UK industrial sector it is important that the revenue support is structured to assist technology development as well as project development, but rewards success rather than being a grant funding policy in which experts are employed to pick winners.

In designing the revenue support model, the following criteria were considered:

- early innovation costs must not be loaded onto consumer bills;
- cost exposure for the government must be transparent, controllable and forecastable;
- technology development benefits from the deployment of a number of smaller projects before utility scale projects are delivered; and
- the target end-game is for the technology to be cost competitive with other low-carbon solutions in line with the Offshore Renewable Energy Catapult report.

To meet these requirements, the sector proposes three revenue support models for tidal stream technologies. Technologies will have the opportunity to move from the first to the second to third model, although it is not expected that all will manage this. Some tidal energy technologies have already operated at the first stage and so are looking to go straight to the second stage.



To aid technology developers, we are proposing an Innovation Power Purchase Agreement (IPPA); a tax rebate/credit support system for small projects (up to 5 MW) that enables technologies to demonstrate performance, cost reduction and benefits to the UK economy. The IPPA is constrained in size and does not impact the consumer's electricity bill. It is designed to support technology companies that have perhaps only deployed one device to deploy multiple devices in arrays.

To deliver economies of scale for a proven technology, project developers would be able ramp up the deployment under a bridging revenue support mechanism called an Innovation CfD (iCfD). This uses the existing CfD mechanism, but is limited to new technologies such as wave, tidal stream, Advance Combustion Technology (ACT) and others that BEIS might wish to support. This will lead to larger utility scale projects for tidal stream energy whilst recognising that the technology will not yet be competitive with mainstream low-carbon generating technologies, such as fixed offshore wind. The iCfD will support the development of projects of up to 100MW scale.

Finally, there will be a cost competitive solution – the end game – for when emerging technologies are able to compete directly with other established technologies.

Work by the Offshore Renewable Energy Catapult indicates that 920MW of tidal stream capacity is required to achieve an LCOE of £90/MWh[24]. Assuming all of this is deployed in the UK, we propose that the IPPA is used to support 120MW of deployment and the remaining 800MW is supported by the bridging mechanism, the iCfD. However, expecting projects in other countries the final volume of installations might be less, especially for the iCfD.

Innovation Power Purchase Agreement

The following objectives have been set for the IPPA. Whilst this mechanism could be used for any new generation

24 https://s3-eu-west-1.amazonaws.com/media.newore.catapult/app/uploads/2018/11/19142426/Tidal-Stream-and-Wave-Energy-Cost-Reduction-and-Industrial-Benefit.pdf

technology that aligns with the government's industrial strategy and the three tests on energy innovation from the Clean Growth Fund, the points that follow focus on its use in tidal stream technology development:

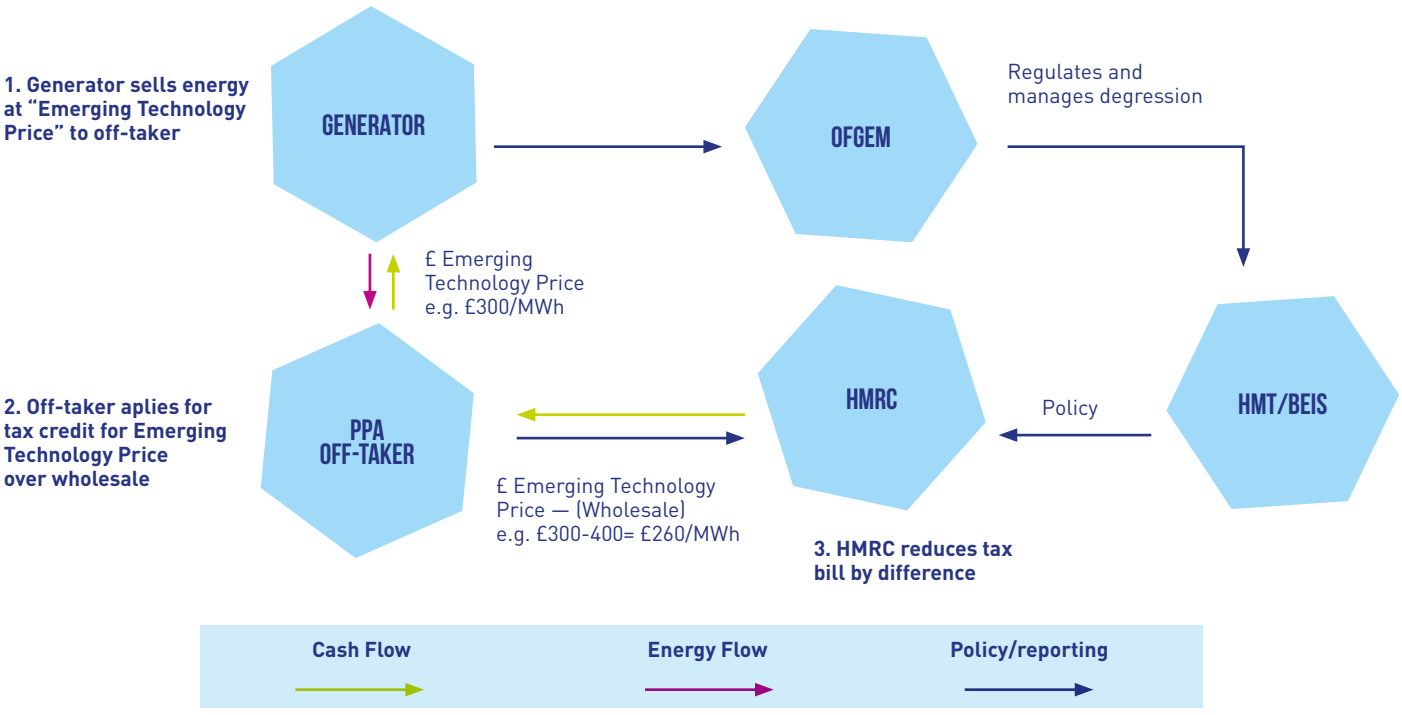
- consumers will not bear the costs of innovation on their energy bills, with costs being covered by a tax rebate;
- it will support new technology development at a scale that allows initial cost reduction and product innovation, before economies of scale are delivered through utility scale deployment;
- it should be available at any time to ensure that the technology development is not held back;
- technologies should have to compete for support for capacity through a mechanism that provides set amounts of capacity at given price support levels;
- support should digress based on capacity deployed at both industry and OEM technology level;
- government should have clarity on, and control over, its exposure to an IPPA programme;
- developers will have to deploy the technology within a given time once they have been allocated capacity for an IPPA; and
- only successful generation should be rewarded and the financial risk is born by the developer.

Funding of IPPA Payments

It is proposed that payments for the IPPA should be financed through tax rebates or credits with 100% of the difference between the additional strike price of tidal stream energy (as determined by government) and the market price being recoverable for the buyer of the power (off-taker).

There are a range of parties that would be interested in being off-takers of electricity from innovative sources of generation such as tidal stream energy. Some of these pay tax such as licenced suppliers and corporates, others do not such as loss-making corporates, local authorities and not-for-profit energy companies. Motivations to provide this support can include the desire to source clean energy and/or to support the UK's industrial development, often at a local level given the inward investment it encourages. Supporters, in principle, of the IPPA include Smartest Energy and Centrica. It is proposed that non-tax payers should be eligible to claim a tax credit from HMRC. However, most of the activity will be from licenced suppliers and corporates rebating off quarterly tax payments. Being quarterly this will limit any impact on their cash positions when they are making their payments on power bought through IPPAs monthly or as agreed in commercial terms.

A generation project and the technology being used will need to gain pre-accreditation to ensure eligibility. They would sign a long-term PPA with a power purchaser similar to those already active in the market for renewable energy with established technologies, supported by a Renewable Energy Guarantees of Origin (REGO)[25] to guarantee the source of energy. The tax return would be completed by the purchaser in their regular return to HMRC or an associated tax credit system.

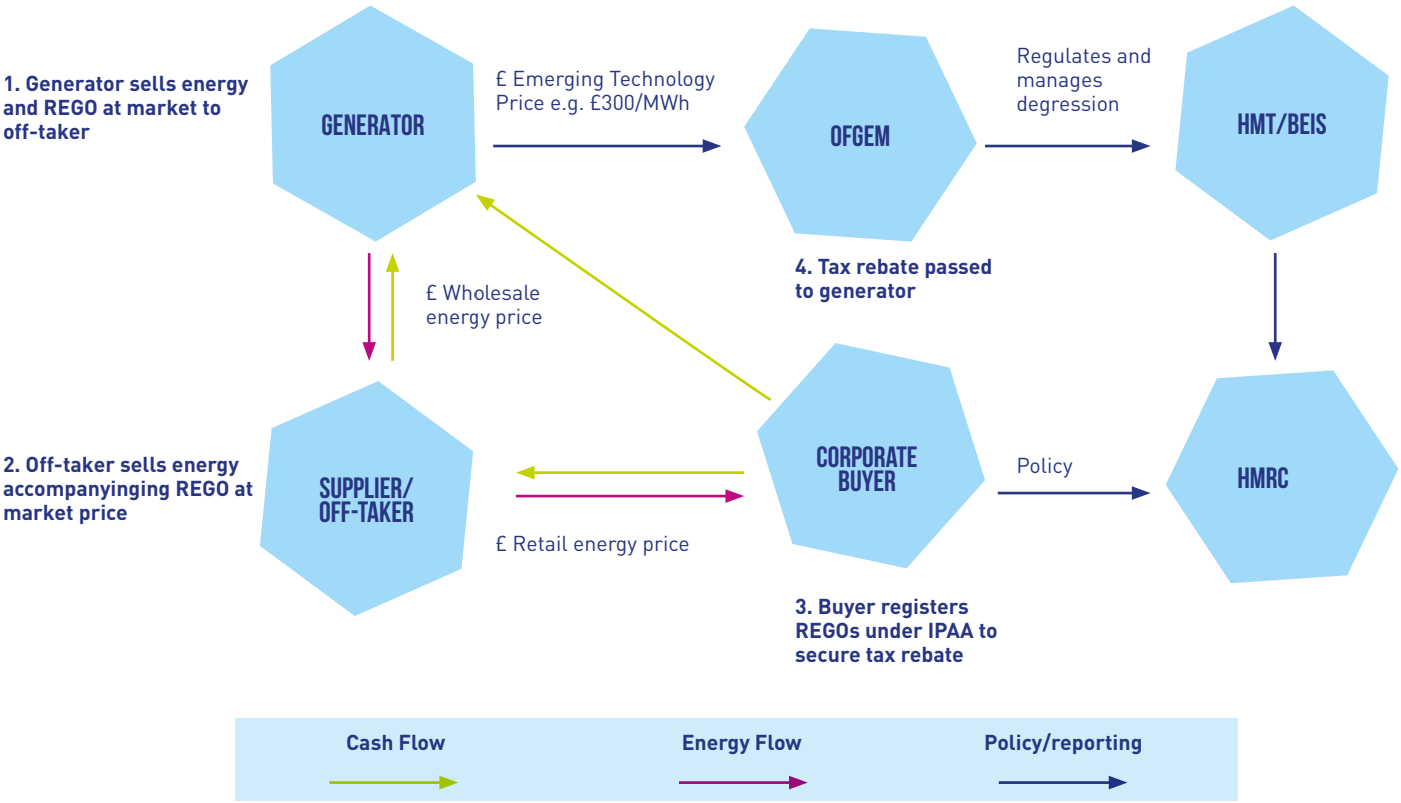


HOW THE IPPA WILL WORK

25 https://www.ofgem.gov.uk/environmental-programmes/rego/about-rego-scheme

Virtual IPPA

Under a corporate virtual IPPA generators would sell their energy to suppliers, and this would be sold to corporates, as happens in the market already. Using REGOs, the origin of the energy could be guaranteed, and this would be used to demonstrate entitlement to IPPA tax-relief. The corporate beneficiaries would then pass on this tax rebate to the generators. This scheme has the advantage of placing the financial risk on the generator.



HOW THE CORPORATE VIRTUAL IPPA WILL WORK

Mechanisms of Support and Management

The following is proposed to manage the government's exposure in supporting the tidal stream energy technology sector through an IPPA.

1. The IPPA programme will open to applications for ten years, with projects starting in that period receiving support for fifteen years from the first power generation. This will provide investor confidence in the development of the UK industry. This commitment by government will need to be grounded in legislation that gives investors the confidence that it cannot be easily revoked.

2. Any new project must submit evidence to Ofgem, or another body providing oversight, demonstrating that it falls within the scope of the scheme. It is proposed that this is done through REGOs as managed by Ofgem building on their existing capacity to manage environmental and social programmes.

3. IPPA allocations will be limited to a maximum capacity of 5MW for a given technology at a given strike price level, an IPPA allowance.

4. Deployments of technologies before the start date of the IPPA programme will not be used to restrict the technologies' access to the IPPA programme.

5. Technology developers will register their working technology solution with Ofgem ensuring that it covers a fully deployable energy generating system, that has been previously deployed and generated grid quality power. It is proposed that the hurdle will require the technology to have been deployed in sea delivering a 10% capacity factor over three months. This should be independently verified and based on metered output. Once registered the solution will only receive IPPA funding for up to a 5MW IPPA allowance

after which the strike price degresses. The 5MW allocation to a technology can be within one project or spread across a number of projects.

6. The technology deployed within each 5MW allowance can be replaced, adjusted and enhanced in order to ensure lessons can be learnt from the deployment. This could include the replacement of a full device, although no additional revenues will be available for such a replacement.

7. Technology enhancements will be expected in order to reduce costs and increase returns, meaning that the vast majority of changes cannot be presented as a new technology solution, including the scaling up of a registered technology. Only if a technology developer produces a radical new solution, approved by Ofgem, will they be able to avoid the degression for their technology.

8. Based on the OREC report a total of 120MW of support should be made available for the tidal stream projects through the IPPA.

9. BEIS will set the initial strike price based on advice from OREC, but it should be in the order of £290/MWh[26]. The strike prices will digress using two mechanisms allowing at least 6 technologies to access each level of IPPA.
a. After every 30MW of industry deployment the sector price digresses by 15%, meaning that after 120MW of deployment strike prices will be at about £150/MWh, similar to the price other technologies were at when they were first deployed in CfD rounds. Projects that straddle a 30MW degression boundary will receive an IPPA allowance split between what is left at the higher rate with the remainder at the lower rate.
b. Each technology will degress by 15% after every 5MW of its deployment, and its IPPA allowance, so that some will move down the industry strike price curve at a faster rate than others.

10. Technologies that have not been able to access an IPPA at one strike price will be able to access the IPPA at the next strike price without having deployed at the previous level.

11. Once these funds have been invested by the government, the net result will be that only technologies and projects that are viable at a revenue support level of £150/MWh or below will go forward to the larger project developer driven projects.

12. Public sector support will be capped based on a maximum load factor of 40% but also based on an overall average of 30%, so managing the cost to government and avoiding energy storage arbitrage.

13. Sites, including Demonstration Zones, will be accredited for an IPPA once an Agreement for Lease (AFL) has been signed with The Crown Estate or Crown Estate Scotland on a first-come first-served basis. Initially there will be a number of sites with this already in place. Priority in the IPPA allowances will go to those that have consent and if this total is over 30MW, then IPPA allowances will be allocated in the order by which technologies can be deployed, which will be independently verified.

14. For new sites once they have an AFL, projects will be held to the following deployment milestones, which if not achieved requires the IPPA allowance to be returned to the pool.
a. Consent after two years, unless requirements such as two-year bird surveys extend this to three years.
b. Suitable grid capacity and accepted grid offer within six months.
c. 10% of total CAPEX invested one year after consent.
d. First deployment within two years of consent, generating power.
e. Full deployment within three years of consent, all devices generating power.

15. If a technology developer has access to a consented site, or sites, for more than 5MW, then it can be accredited to its next 5MW IPPA allowance once one of its devices from its previous accredited allowance has been generating for three months at >15% of its deployed capacity.

16. If a technology developer is obliged to return their IPPA allowance to the pool then it will be taken up by other applicants in order of application, with that technology having to reapply from the back of queue.

17. In order to assist technologies to achieve initial IPPA accreditation (para 5. above) technology developers can apply for a short-term "initial development IPPA": a share of 5MW capacity set aside at the initial IPPA price level (£290/MWh) for deployment at a consented site. The technology then has 2 years to deliver first power to grid and a further two years to achieve the IPPA accreditation threshold and 1 year further operations. After a total of five years, or if the first power milestone is missed, the reserved capacity goes back into the 5MW pot. The development pot is additional to the main IPPA mechanism. This is intended to encourage technology developers to prove their devices in the UK, to the

26 All prices £/MWh are 2012 prices in line with BEIS methodology.

benefit of the UK economy, and allowing UK oversight of IPPA accreditation.

18. Projects will receive payments once projects have generated power with their first device.

19. The base reference price for assessing the level of rebate provided will be an appropriate tradeable index such as the N2EX Day Ahead hourly index with off-takers receiving the difference between this base reference price and strike price for the project.

20. The strike price to which a commissioned project is eligible will be updated annually to reflect CPI over the course of its 15-year eligibility period.

Bridging Mechanism

The bridging mechanism is designed to allow projects of larger than 5MW to be developed, so accessing economics of scale and deployment whilst managing the cost of the programme through some form of competition.
The sector has considered the following criteria to recommend a bridging mechanism for tidal energy, and potentially also other new renewable energy technologies:

- it must be bankable;
- it should use a mechanism that is already in place and is known to work by government and project developers;
- there should be sufficient competition to ensure enough projects of a similar size participate; and
- government exposure should be controllable.

Using these criteria, the sector proposes that the government should create an Innovation CfD (iCfD) in future CfD rounds that is;

- open to a range of new generation technologies such as floating wind, tidal stream, wave and ACT; and
- is limited to projects of up to 100MW with the total capacity in each round for all the innovative technologies being controlled according to budget availability and the government's desire to bring on the new technologies.

This could be funded through three possible sources:

- unspent funds in the £557 million allocated to future CfD rounds;
- funds additional to the £557 million provided to enable technology development in the UK; and
- a tax rebate system for the iCfD whereby the energy buyers can claim a tax rebate in line with the excess costs of the iCfD over a standard CfD.

Costs can be managed through the judicious use of strike prices starting at £150/MWh and can be expected to digress by 7% for every 100MW of tidal energy delivered in line with the Offshore Renewable Energy Catapult report. Costs would reduce more quickly if lessons from deployments outside the UK were used to reduce costs within the UK.

Immediate Support

Given that the IPPA and the iCfD are expected to require detailed assessment and industry consultation the sector requests that in the next CfD round, in April 2019, the ring-fenced minima is restated, solely for this round, in order to allow projects that have stalled to progress.

Multi-Project Sites

It is possible some sites will have a number of projects that are using different technologies on different levels of IPPA and with iCfDs with power going ashore down single cables. The industry will engage with Ofgem on the best way to meter these different projects. Ofgem will need to be comfortable with not being able to inspect meters, on devices or arrays, on the seabed.

Ongoing Support for Smaller Projects

The focus of the new policy is on the development of tidal stream technologies so that they can deliver for utility scale projects in the UK and overseas. However, it is recognised that there will be a lot of export opportunities based on small scale projects around the world, particularly in SE Asia. Following the delivery of the 120MW of IPPA support, small projects will be able to provide power at £151/MWh. Further cost reductions for this export market can be supported either through an extension of the IPPA, or capital grants or both. This is not covered in this paper.

Government Investment

Were the government, in the worst case, to support 120MW of tidal energy capacity using the IPPA as described above and then another 800MW using the iCfD mechanism (these quantities being in line with the Offshore Renewable Energy Catapult report), then there will be the following impact on the government's balance sheet assuming all projects are in the UK:

- £31 million for 5MW of testing capacity (assuming 20% load factor);
- £834 million of tax foregone through the IPPA (assuming a 30% load factor); and
- £1988 million of tax forgone through iCfD (assuming a 30% load factor).

If the industry were to deliver this over twenty years then it would have an average annual cost of £141 million.

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