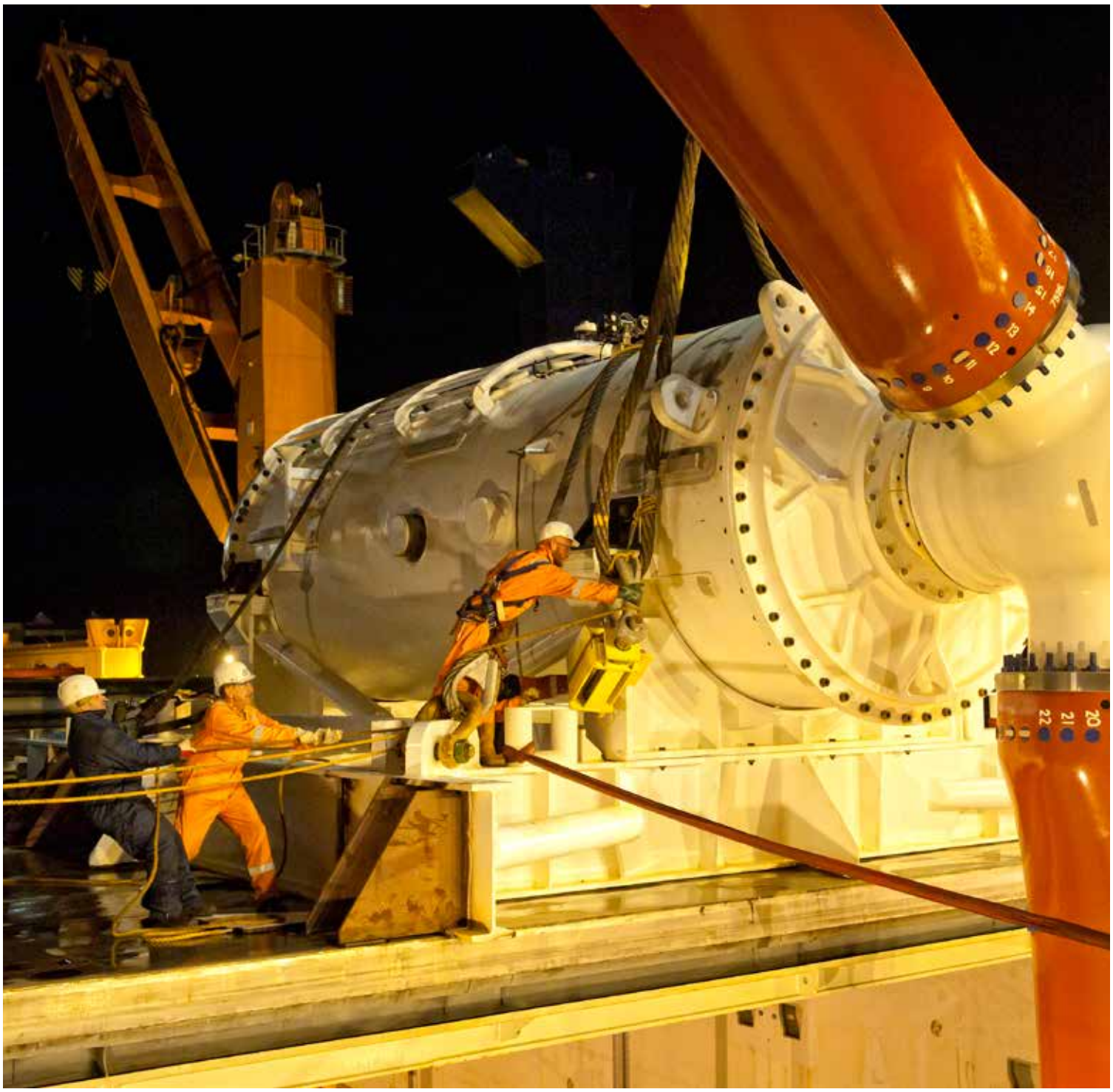
Wave and Tidal Energy in the UK: Capitalising on Capability

A report for the Marine Energy Programme Board

FEBRUARY 2015



Cover photo courtesy EMEC

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A note about the Authors

This industry led paper has been prepared by the Marine Energy Programme Board (MEPB) working groups, co-ordinated by RenewableUK and with extensive input from the marine energy strategy groups of RenewableUK, Scottish Renewables and the Renewable Energy Association. These groups are comprised of world leading experts in wave and tidal energy development including technology developers, utilities, supply chain companies as well as technical and legal consultants. The Crown Estate, South West Marine Energy Park, Pentland Firth and Orkney Waters Marine Energy Park and officials from the Department of Energy and Climate Change (DECC), Department for Innovation and Skills (BIS) and Scottish Government as well as development agencies including Scottish Enterprise (SE) and Highlands and Islands Enterprise (HIE) add to the insights of these groups. This report therefore represents a balanced snapshot of the industry's view of the requirements for continued commercialisation of the wave and tidal sectors. The supply chain capability assessment summarised in section 3 was prepared by BVG Associates, commissioned by RenewableUK and Scottish Renewables, with extensive engagement with the wider supply chain.

Executive Summary

The wave and tidal sectors represent a once in a generation opportunity to secure a new low carbon, indigenous source of electricity which delivers significant economic and industrial growth. The UK is home to some of the best marine energy resource in the world. It has an evolving, dynamic marine energy sector which is already achieving outstanding technology progression with many concepts now proven in real sea conditions.

We have made an enormous amount of progress, but there is still much to do to realise the clear and major 'triple bottom line' case that exists for the UK, and we must increase our efforts over the coming years to reap the following benefits.

The Opportunity

Export Potential	Regional Economic Development	Low Carbon, Secure Electricity Supply
As current market leaders, UK suppliers could capture a large proportion of a global market across over 50 countries	High value jobs will continue to be created close to areas of high energy resource, often in areas where other economic development opportunities are limited	Highly predictable energy from perpetual sources will reduce our dependence on imports of fossil fuels and diversify our renewables generation
Triple Bottom Line		
It has been estimated that the UK could capture a slice of the global marine energy market worth up to **£76 billion**[1] (cumulative, undiscounted) and, separately that this could contribute around **£4 billion** cumulatively to UK GDP by 2050 [2]	There are around 1,700 people working in the UK wave and tidal sectors with nearly **£450 million** spent to date in the UK supply chain. This could grow to over 20,000 skilled jobs in the next decade[3]	Wave and tidal stream energy has the potential to supply 20% of UK electricity avoiding **30 million** tonnes of CO2 emissions each year[4]

UK industry has an international presence in marine engineering, built up through centuries of ship building and offshore operations in industries such as infrastructure, fishing, shipping and oil and gas. Marine energy offers a major opportunity for this expertise and many players in these industries are already benefitting from diversifying into the wave and tidal supply chain.

However, to maintain our global lead and commercialise these industries, sustained and consistent practical and financial support from government at all levels is urgently required.

By implementing the recommendations in this paper, the UK can set its wave and tidal sectors on an accelerated path towards unlocking the long term opportunities indicated above, securing the following medium term outcomes over the next 5-10 years:

- the positioning of the UK as the most attractive location in Europe for both private investment and major European Commission funding available to the marine energy industry;
- the growth of an increasingly attractive investment proposition in tidal energy technology and projects with deep and sustained experience and operational data gathered through the construction of least three pilot tidal arrays. This experience will secure major reductions in the Levelised Cost of Energy (LCoE);
- the reinvigoration of private investment in wave energy in the UK, utilising our leading expertise and world class test and demonstration facilities to bring the world's most advanced wave technologies towards proven reliability and survivability;
- continued growth in the experience of UK companies throughout the supply chain, leading to a sustainable competitive advantage in a growing export market.

Summary Recommendations

The recommendations listed below are set out in more detail in section 5 of this report which places them into context.

Several of these recommendations are directed at 'Government'. By this we mean government in the UK at all levels including the UK, Scottish and Welsh Governments, the Northern Ireland Executive and Local Enterprise Partnerships.

Recommendations for Both Sectors

Action 1: It is essential that Government, along with the MEPB, works to provide a joint, clear and consistent vision of the role wave and tidal energy will play out to 2030 and beyond. This vision must be supported by a UK wide strategy and funding at a suitable intensity to kick-start a transition to a commercial industry over the next 5 – 10 years.

Action 2: The Department for Energy and Climate Change (DECC) should take steps to improve access to revenue support for wave and tidal projects, to better fit their needs in the absence of the Renewables Obligation (RO).

Action 3: Government should assist the UK industry in their efforts to access and make efficient use of European funding sources.

Recommendations for Tidal Energy

Action 4: Government should work together to provide measures to improve returns and/or reduce risk exposure to a level sufficient for financial close to be reached on at least three pilot tidal arrays in UK waters by 2018.

Action 5: Government should together fund a new, sustained and flexible R&D programme for innovation focused on driving down the LCoE from tidal stream energy. The programme should support innovation in devices, components and enabling technologies in areas such as installation and operations and maintenance (O&M).

Recommendations for Wave Energy

Action 6: Government should work together with industry to establish a new and comprehensive *UK wide* programme to accelerate the demonstration of robust, reliable and investable wave technology and related enabling technologies. This should include an R&D programme and in parallel, provide the requisite project support to deliver full scale technologies and pilot wave arrays in UK waters.

1. State of the Industry

Potential: The opportunity presented by wave and tidal energy is substantial. It has been estimated that with the right political and financial support in place, as much as 240GW of marine energy capacity could be installed worldwide by 2050[5]. In the UK, wave and tidal stream technologies have the potential to deliver up to 20% of our electricity demand[6] from low carbon, home-grown and *predictable* sources. The value of maintaining a global lead is clear and the opportunity for UK based businesses to capture some £76 billion[1] of this market by 2050 must not be missed.

From innovation to industry: Tidal energy and wave energy are both emerging technologies and a period of focussed technology demonstration activities, optimisation and cost reduction is required for them to become fully commercial. Where these activities take place will have a big impact on where the short and long term economic benefits will fall. The marine energy sector will leverage the expertise of, and provide a major diversification opportunity for, the existing world leading UK marine and maritime industries. These industries are already worth £17bn a year to the UK economy[7] but need new applications and markets if current levels of employment and contribution to the economy are to be maintained and expanded.

Value already being added: It is thanks to the private sector, bolstered by significant support and testing infrastructure provided by public sector, that the UK has managed to position itself as world leader - both in marine energy systems and project development. An enormous amount of experience and knowledge has been built up by UK companies and academic institutions working in the wave and tidal sectors, both of which are already adding value to the UK economy. A recent survey of marine energy companies working in the UK by RenewableUK found the industry has already invested over **£578 million**[8] developing various technologies with over **77%** of this spent in the UK economy. Respondents to the survey have received a combined figure of around **£70 million** in public support thus leveraging, on average, around **£7** of private money for each **£1** of public funding received.

Overseas companies, utilising British expertise and testing infrastructure, have brought a significant amount of private investment into the UK with around a third of the money spent by survey respondents coming from outside of the UK. Similar research conducted by Scottish Renewables in 2014 showed that to date, the companies surveyed had invested more than **£200 million** into the Scottish economy, and that more than **62%** of the companies' supply chain is Scottish. This shows the importance of the sector to economic development right across the UK[9]. Several overseas companies have relocated or opened subsidiaries in the UK. More projects are under development around the UK than in any other country. This investment is creating skilled jobs, with over **1,700** people employed in the wave and tidal sectors across the UK with over **800** of these in Scotland alone[10].

Industry achievements: This investment has led to landmark achievements in the UK including those listed below:

Examples of Landmark Achievements in the UK in 2014/15

- MeyGen Phase 1a, a 6MW tidal project reached financial close, the first tidal array in the world to do so
- Siemens MCT's Seagen 1.2MW turbine remains the longest operating tidal device having been in Strangford Lough, Northern Ireland since 2008. It has now generated around 10GWh
- Alstom's 1MW tidal device achieved a generation milestone of 1.2GWh at the European Marine Energy Centre (EMEC)
- The two Pelamis Wave Power P2 devices achieved a combined generation milestone of 250MWh at EMEC
- EMEC and Aquatera Ltd completed the Orkney Vessel Trials project which found opportunities for installation costs to be reduced by as much as 70-80%
- The first community owned tidal turbine in the world, made by Nova Innovation was installed in Shetland
- Wales' first full scale tidal turbine was unveiled: Tidal Energy Limited's Delta Stream
- WaveHub in Cornwall announced it is fully booked and the first Seatricity device began being tested at the site
- Carnegie Wave Energy announced plans to establish a UK office with funding to develop a 3MW array at WaveHub, deployment of which could commence as early as 2016
- Aquamarine Power's Oyster 800 wave machine demonstrated survivability over its third full winter at sea.
- The first wave energy convertor connected to a fish farm was achieved by Albatern in Scotland

The UK is now closer than ever to developing commercially viable marine energy. In parallel, markets around the world are also developing rapidly.

Examples of Global Developments in 2014/15

- In France, GDF Suez and EDF secured the rights and funding to develop two pilot tidal energy farms in the 'Raz Blanchard' with a combined capacity of 20MW, due to be operational by 2018
- In Canada, the Fundy Ocean Research Centre for Energy (FORCE) site completed the installation of its four cables establishing Canada's first grid connected test facility
- OpenHydro were awarded a berth for two of their Open-Centre turbines at FORCE with installation due in 2015
- Atlantis were awarded a feed-in tariff to develop an installation of up to 4.5MW of tidal turbines at FORCE. The first turbine is due to be deployed in late 2016
- In Australia, Carnegie Wave Energy opened its two device demonstration wave array off Perth
- The Strategic Initiative for Ocean Energy project launched its Market Deployment Strategy with an ambition for 100GW of ocean energy to be deployed in European waters by 2050

Challenges in 2014: Despite these successes, 2014 was a difficult year for the UK marine energy sector. Pelamis entered administration, while Aquamarine Power announced restructuring involving a significant number of redundancies. Siemens announced that it will not be taking forward its own array project, and at the time of writing, is looking for a buyer for Marine Current Turbines. With limited access to finance and a shortage of sites with access to affordable grid connections, technology progress has been slower than initially anticipated. This, combined with the financial crisis and uncertainties around longer term market visibility, has impacted investor confidence and called into question long term prospects for the development of a market.

Recent developments: In response to recent developments in the wave sector, the Scottish Government announced the establishment of Wave Energy Scotland (WES). WES is a subsidiary of HIE, and will run a research, development and innovation programme to develop key components. It will cover the development of both new concepts and existing 'promising' technology, in order to create a pathway to commercial performance. At the time of writing, the operating structure of WES has not been finalised, nor has its budget been made publicly available.

We endorse the continued hard work of the Islands Delivery Forum on the issue of access to suitable grid connections and other initiatives underway across the UK, which are explored throughout this report.

While all of these steps are to be welcomed, the industry requires co-ordinated, consistent, sustained and targeted support from all UK administrations over coming years.

2. A Pathway to Capturing Market Share for the UK Supply Chain

The UK has the opportunity to lock in its current pioneering position in wave and tidal energy. Instilling confidence in the long term prospects will help to draw in private investment and grow a flourishing, commercial UK market over the next decade. With supply chain requirements in this domestic market met predominantly by UK companies, the experience gained will enable these companies to capture the lion's share of the export market as it grows out to 2050. This approach is a tried and tested method of turning UK resources and skills into a long term global prospect. Some examples of this are provided below.

Danish Wind Energy

The Government of Denmark spent £920 million on wind power development from 1980-2000 to become a global leader in that industry. The Danish wind industry employs 28,000 workers in an export market worth nearly £5 billion per year in 2008 [11]

Rolls Royce's RB211 Engine[12]

Rolls-Royce is another British success story which owes its achievements to significant state support. The development costs of the first RB211 engine bankrupted the company in 1971. However, government intervention in the form of launch aid, and ultimately nationalisation, ensured the company's survival. Between 1971 and 1988, Rolls-Royce received around £862 million from the state. The RB211 became the backbone of the company's success, and it now employs 40,000 people worldwide, with annual sales of £7.4 billion.

Airbus[13]

The long running 'launch aid' subsidy scheme was absolutely critical to the success of Airbus in the UK. Through the scheme, government financed a proportion of upfront R&D costs in return for a defined levy on subsequent product sales. In 1984 BAe was awarded a loan of $370 million to develop the successor to the A300, the A320. This support led to Airbus UK becoming a major force, directly employing around 13,000 staff, indirectly supporting 100,000 jobs in the UK and generating annual revenue of £1 billion.

3. Delivering the Economic Benefits

3.1. Current Status of the UK Supply Chain

In 2014, on behalf of RenewableUK and Scottish Renewables, BVG Associates conducted an assessment of the capability of the UK supply chain for wave and tidal energy[14] . The study looked at those companies already active in the wave and tidal sectors but also opportunities for diversification by suppliers active in other related sectors such as the automotive, oil and gas and offshore wind industries. As part of the study they undertook extensive consultation with the existing and potential supply chain for the sector through 26 one to one interviews, 67 responses to an online survey and discussions with industry groups including the RenewableUK Marine Strategy Group and the MEPB Economic Benefits subgroup.

Results of the research: The capability assessment summarised in the table below considered 12 sub-elements of the supply chain. Each of these was graded red, amber or green for capability, using the following definitions:

Green:

The capability of the UK supply chain is not currently an area of concern. Where problems have been identified, there are reasons to believe that these will be rectified by market pressures. A watching brief should be maintained, recognising that significant investment and supply chain development is still required in some cases in order to deliver sufficient capacity and capability and the right cost.

Amber:

The capability of the UK supply chain is an area of concern. Some proactive intervention is required in order to address market disconnect. This may relate to the lack, or availability, of optimal solutions, with the industry forced to use more expensive components and services.

Red:

The capability of the UK supply chain is an area of significant concern. The issue demands further analysis and strategic action. Again, this may relate to the availability only of non-optimal solutions.

Table 1 Supply chain status summary.

	Supply chain sub-element	Summary actions	Supply chain element
A	Wave / tidal farm design, development, ownership & asset management	Support to make more attractive to project developers and investors.	Development and project management
R	Wave energy devices & subsystems	Focus down onto the leading technologies and accelerate development of those.	Device supply
A	Tidal energy devices & subsystems	Focus on enabling deployment of 2nd and 3rd arrays.	
A	Foundations and mooring systems	Supply chain support and motivation to develop and demonstrate cost effective solutions, particularly for tidal	Balance of plant supply
G	Subsea array and export cables	Support the development of wet-mate and cable protection arrangements for high-flow conditions.	
G	Substation electrical systems	Prioritise development and demonstration support for systems suitable for (first) tidal and (then) wave projects.	
A	Installation ports	Early definition of next array sites to help ports prepare and undertake long-lead developments	Installation and commissioning
A	Foundation and device installation	Supply chain support to develop and demonstrate cost effective installation solutions.	
A	Subsea cable installation	Supply chain support to develop and demonstrate cost effective installation solutions.	
G	Small vessels and equipment	Document the requirements for specialist vessels / equipment for cable installation at tidal sites.	Vessels
A	Larger vessels	Support for development of new vessels for efficient cable, foundation and device installation and retrieval.	
A	Consultancy and R&D services	Support development of test facilities according to industry needs.	Other

3.2. Opportunities for the UK Supply Chain: Domestic and Global

The study shows that the UK supply chain is well placed to support the full scope of supply for wave and tidal energy. Components and services similar to those required by wave and tidal companies are already being offered in the UK for other sectors which currently have much higher demand and it will take time for the wave and tidal industries to ramp up to requiring large volumes. Therefore there is confidence that the UK supply chain will be able to grow at the pace needed to deliver wave and tidal energy, provided the companies involved have sufficient confidence in the market potential to invest in diversification into these new markets.

Wave energy devices and subsystems were the only areas with a high level of concern due to the gap between solutions available and what is needed for early commercial arrays.

With regards to export opportunities, the existence of competitive overseas supply chains must be taken into account when considering the potential for the UK to capture part of this market share, even if not experienced in the sector. Crucially, the report found that export opportunity could be improved with a stronger track record of government facilitating export through robust financial support via export credit and other de-risking and cost-reducing instruments.

Whilst the large and heavy nature of many components may in some (but not all) cases lead to fabrication and final assembly activities being located at an assembly site close to the installation site, opportunities for exports of such components from the UK should not be ruled out. By their nature, marine energy devices are weatherproofed and robust, enabling large assemblies to be transported safely. Offshore wind is one example of an industry where large structures are transported considerable distances. In addition there are large parts of the supply chain where size and weight is not an issue and UK companies could provide a significant proportion of global services. Key opportunities identified for export were advised by interviewees to be:

- device and component/sub-system supply and related Intellectual Property
- system engineering, including design, manufacture and integration
- specialist skills & expertise, including in project development, installation and operation management.

A wide range of target export territories were identified by interviewees. Canada and France were identified most often by interviewees as key targets, followed by Japan, Korea and the USA. Clearly, export to France offers different opportunities to the long-haul markets, but France also has a history of government-policy actively supporting local content, even at the cost of competition.

3.3 Economic Benefit Case Studies

Despite the early stage of wave and tidal energy deployment, the case studies below offer just a few examples of how companies and employees from all corners of the UK and across the supply chain are already benefiting from investment in wave and tidal energy.

3.3.1 South West England: A&P Falmouth


Image courtesy of: Paul Harry falmouthphotos.com


Image courtesy of: Paul Harry falmouthphotos.com

A&P Falmouth have expertise in quality ship repair and conversion and fabrication built up over one hundred and fifty years of experience with the marine, oil, gas and shipping industries. They have used this expertise to develop a strong presence in the renewables industry.

Their maritime heritage combined with their location at Falmouth Docks has made them the natural choice for wave developers deploying devices at FaBTest and WaveHub in Cornwall. A&P built the Fred Olsen Limited BOLT "Lifesaver" deployed at FaBTest in 2012. There were 24 companies involved in the supply chain and 95% of these were local, leading to around £100,000 being spent in the local economy. A&P went on to build Seatricity's first full scale device "Oceanus2" which was deployed from their shipyard in Falmouth to WaveHub in 2014. For this project all 37 companies involved in the supply chain were local, resulting in around £50,000 being spent in the local economy. Their expertise in aluminium working allowed A&P to identify a cost saving of 33% for this device. With the learning curve obtained from this, A&P feel they are in a strong position to manufacture the 60 devices due to make up Seatricity's 10MW WaveHub array. A&P have also provided ongoing operations and maintenance, and facilities to both test programmes. Having completed its testing at FaBTest, the Fred Olsen device is now en route for deployment in Hawaii.

"At A&P we are constantly striving to improve services which will assist in the supply of low cost energy. For example, we are currently configuring our 11kV ring main within the yard at one of our berths which will assist in the ability to energise individual devices and will also be harmonious to the supply requirement at WaveHub."
Paul Weston, A&P Group Renewable Energy Technical Manager

"The proximity of the Falmouth facilities to the FaBTest site, and the support of the Harbour Commissioners and local supply chain has always been a winning formula. When testing prototypes, problems will always present themselves, and having partners to hand that are capable and willing to assist has been key to the success of this stage of the project."
Dr Alan Taylor, the local representative for Fred. Olsen

"A&P's commitment to champion and support our future growth plan matches our own reciprocal commitment to re-invest the benefits of our incremental wave energy programme with partners here in Cornwall. That takes many forms; creating local employment opportunities, regional regeneration and, we hope, placing Cornwall at the hub of a fledgling wave energy revolution with truly global potential."
Andy Bristow, Strategy Director, Seatricity

3.3.2 Wales: Tidal Energy Limited

Image courtesy of Tidal Energy Limited

Tidal Energy Limited (TEL) are set to deploy the first large scale tidal energy device in Ramsey Sound, Wales in early 2015. Named 'Ysbryd y Mor' meaning 'Spirit of the Sea', the DeltaStream 400kW demonstration device, weighing 150 tonnes and with a 16m by 20m frame, was fabricated and assembled by Pembroke Dock based company Mustang Marine Ltd. Mustang Marine was bought out of administration in early 2014 and the contract to build TEL's turbine is thought to have been a big factor in the deal which saved roles for 30 staff.

Considerable Welsh expertise has contributed to the project alongside Mustang Marine. Of 195 contracts placed in the project, over 70 were awarded to companies based in Wales. Around 90% of the total supply chain provision has been sourced in the UK. Additionally, TEL worked with universities across Wales and the UK as part of the project including Cranfield University on the blade design. There is a strong history of engineering in Wales in the manufacturing and oil and gas industries, and now wave and tidal energy development offers a real opportunity for skills and capital diversification. Demonstration zones are being developed off West Anglesey for tidal stream and at South Pembrokeshire for wave and there are plans for tidal lagoons to be built at Swansea Bay and Cardiff. The use of EU funds to support the Ramsey Sound project shows recognition of the opportunity for Wales to benefit from the growth of these sectors.

"European funds invested in the Ramsey Sound project have leveraged further private investment in the area and created new jobs to support the local economy. Not only are we developing highly predictable renewable energy, but by doing so here, we will build up a centre of expertise to create lasting benefits to people and communities in Wales."
Martin Murphy, Managing Director, Tidal Energy Ltd.

3.3.3 Northern Ireland: Minesto


Image courtesy of Minesto

Minesto are developing a kite-like tidal energy generator, designed to extract energy from low velocity currents. They have been testing their ¼ scale prototype in Strangford Lough, Northern Ireland since 2013. Although based in Gothenburg, Sweden, over 45% of the company's costs in developing their technology have been spent in the UK. Five full time staff are employed locally at Portaferry to manage the site and run the test programme. These are skilled personnel with expertise ranging from diving to electrical engineering. Local contractors such as McLaughlin and Harvey were used in the construction and installation of the test site and Northern Ireland based consultants such as Marenco are working on environmental monitoring associated with the project. Minesto also work closely with experts in academia including those at Queens University Belfast on the test site.

At 20-30m deep, Strangford Lough is too shallow for Minesto to deploy a full scale device. Through collaboration with the SEACAMS team at Bangor University in Wales they were able to identify a deep enough site with suitable tidal velocities and have now secured an agreement for lease from The Crown Estate for the site called "Holyhead deep" in Wales. The site could provide up to 10MW of power and UK consultants are helping Minesto to develop plans which could see over £60m spent with UK companies over the next 5 years. Minesto will establish their UK Headquarters in Wales as well as production facilities for the global market. By 2018 Minesto plans to have some 40 direct full time employees plus 30-50 contactors and consultants.

"The political support and excellent tidal velocities have helped the tidal industry to develop in the UK. With the clustering of expertise in this field, the UK was the natural place for us to develop our technology."
Anders Jansson CEO of Minesto

3.3.4 Scotland: Green Marine

Image courtesy of Green Marine

Green Marine provides solutions for the safe installation, removal and maintenance of a wide range of tidal and wave energy devices and gravity bases. The company was set up in 2011 in Orkney in response to the build-up of marine energy activity in the area following the establishment of the European Marine Energy Centre (EMEC). The family company has a history of working in the commercial fishing industry over several generations with ideal expertise to diversify into bespoke vessels and marine operations for wave and tidal energy projects. The number of employees ranges from around 16 to 22 depending on the requirements of the operation, bringing direct employment opportunities to Orkney which now has around 300 people working in the marine energy industry.

Indirect employment is created through the use of the local supply chain, from the local butcher and baker to crane operation and engineering services. This award winning business has opened up opportunities to other local companies involved in the renewables industry by combining their services with those of Green Marine. Having provided services to most of the developers working in Orkney, the team are now exploring opportunities to export their expertise and equipment to projects in other parts of the world such as France and Japan and are regularly involved in talks and visits to these countries to explore upcoming opportunities being generated in this new and exciting industry.

"Before we got involved in some of the projects at EMEC, boats were being called in from the likes of Norway and beyond to do the work. The key thing with Green Marine being readily available to complete the offshore operations is that we can greatly reduce costs for the developer and increase the income for the islands. As one of the few companies with experience providing marine operations to wave and tidal devices we are in an ideal position to win work in the now growing export market."
Jason Schofield, Managing Director, Green Marine

4. Financing the Future

Market confidence: Confidence in the scale of the market for wave and tidal energy, is a fundamental requirement to securing the private investment needed to achieve long term success. The headline market support offered by the current Renewables Obligation (RO) scheme and the newer Contracts for Difference (CfD) has created an attractive market for marine energy projects in the UK. Unfortunately, despite the level of support on offer, it is still very difficult to secure private sector investment for marine energy projects. This is due to of a number of factors:

1. While larger array projects (10-30MW) could be financially viable, it is impossible to raise the necessary finance for them without having first demonstrated smaller array and pilot projects in order to be able to offer the performance guarantees and warranties that would make larger developments investable.
2. Smaller array and pilot projects are generally not financially viable as standalone projects, because of the high fixed costs associated with development, grid, installation and manufacturing.
3. The availability of capital from traditional investors in energy projects – utilities and project developers – is limited and is being stretched by the many other projects and technologies which currently offer similar or higher returns with much lower risk.
4. The risk profile, and limited returns, for new technology (especially in a marine environment) has also dissuaded private and institutional investors and has made debt finance very difficult to obtain.
5. The positive signal of government support for the sector which the high RO and CfD strike price is meant to convey has been diminished by lack of clarity regarding the new CfD regime beyond 2020. Indeed, given the lead time for project development, there is in practice no visibility of the level of support that will be available for new projects.

The closure of the RO scheme in 2017, and the complex and prescriptive nature of the CfD which replaces it, will make it more difficult and onerous for project developers to secure revenue support. This is particularly challenging for small scale, community and test centre projects, as well as for pilot arrays.

Holistic approach – New Financial models: There are a number of development models emerging within both the wave and tidal energy sectors and policy must be flexible enough to support such diversity to ensure competition in the sector.

The co-ordinated financial package that was put together to enable the MeyGen project to reach financial close is a good example of how several sources of finance (grant funding,

Confidence in the scale of the market for wave and tidal energy, is a fundamental requirement to securing the private investment needed to achieve long term success.

co-investment, project finance and a debt facility) from both public and private sources, can be brought together. Significantly, although MeyGen is a relatively small pilot at 6MW, the opportunity that has been created by a relatively small finance package, could unlock an 86MW project backed by several hundred million pounds of private investment.

MeyGen is one example of a private sector led project developer and there are a number of other similar sized projects in the UK pipeline with large scale technology being developed to fit these.

Other approaches that are being developed include the use of demonstration zones such as WaveHub, and new demonstration zones off Pembrokeshire and the Isle of Wight, to channel public investment into infrastructure and supply chain capability to both de-risk projects and reduce project capital expenditure.

For smaller schemes, particularly those using smaller scale devices, an approach to channel regional and municipal investment to create "community" based projects, or to provide energy to coastal businesses and remote locations may be viable. The interest in smaller device schemes has grown as a stepping stone to larger projects and also a significant sub-market in its own right.

The importance of capital support: The common theme across all the early stage projects described above is that access to some form of capital support to reduce exposure and de-risk both public and private investment has been critical.

Once the industry has developed a track record and uncertainty over technology performance and reliability has been removed, it will be possible for projects to be wholly financed on commercial terms. At that stage it will also be possible to reduce the level of market support in line with the expected cost reduction.

Until then however, capital support will be required. We support the 2014 report by the Offshore Renewable Energy Catapult (ORE Catapult), which identified a figure of around £300m to underpin the financial close of three more tidal array demonstration projects in UK waters as drive two or three viable wave technologies through demonstration projects along a path to commercial readiness.

A number of sources could contribute to secure this £300 million and therefore a co-ordinated approach is needed. As well as funding directly from the UK Government and its agencies, and from the ongoing commitment of the Scottish Government,

funding is also likely to be secured from Welsh and other regional funding partners such as Cornwall and the South West.

Bringing down the cost: As the deployment of wave and tidal energy increases, the LCoE will progressively fall, to ultimately become cost competitive with established forms of electricity generation. BVG Associates estimate in their report that tidal energy could reach a point of cost competitiveness with offshore wind with around 2GW installed worldwide and other studies (such as the Strategic Initiative for Ocean Energy project [15]) show both wave and tidal reach this point within 1-2GW installed. The industry is committed to working with government at all levels to achieve this through innovation, experience and economies of scale.

The graphs below demonstrate the levels of cost reduction experienced in the wind and solar sectors:

It is important to note that the costs of continuing to maintain the options over the next 5-10 years are a fraction of the future economic value that could be created.

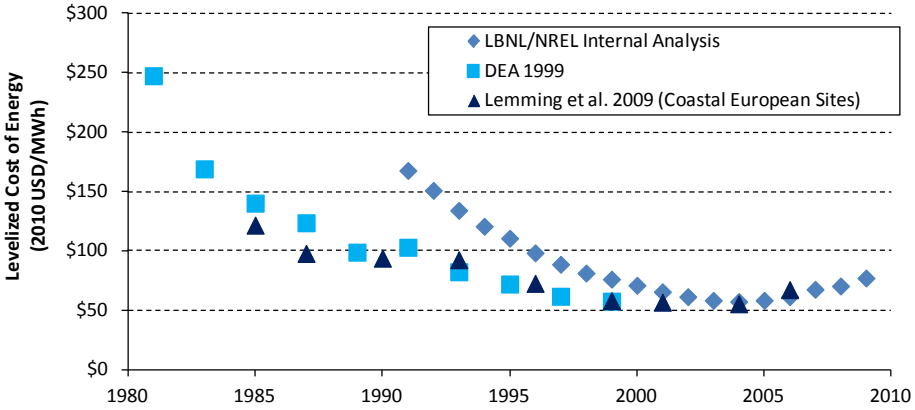

Figure 1: Source IEA Wind Task 26

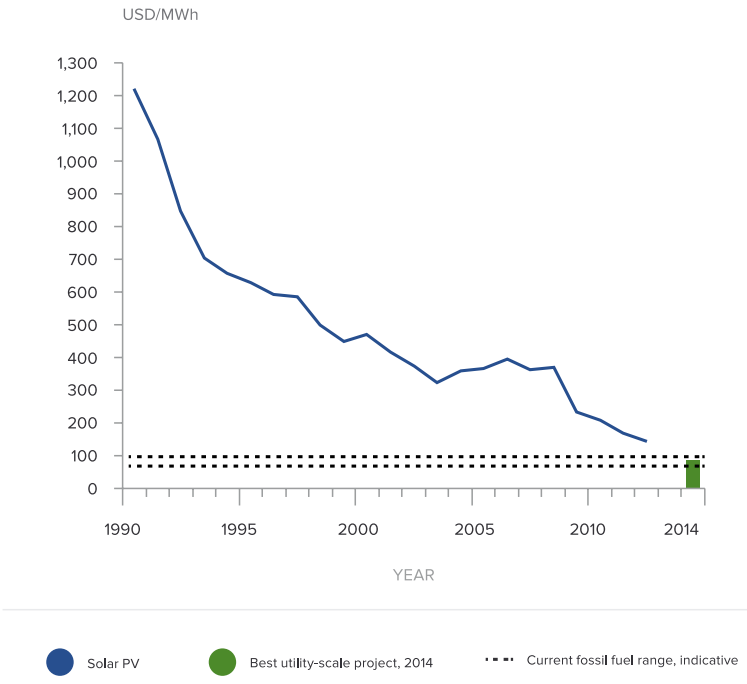

Figure 2: Source New Climate Economy Report 2014

5. Recommendations

Several of these recommendations are directed at 'Government'. By this we mean government in the UK at all levels including the UK, Scottish and Welsh Governments, the Northern Ireland Executive and Local Enterprise Partnerships. We do not suggest that these recommendations will address all issues facing the wave and tidal sectors. For example, it is crucial that measures are brought forward to expand grid capacity in areas of high marine energy resource. However, we believe the following actions would address the industry's most pressing concerns. The recommendations are divided into three categories: those directed across both sectors and separate recommendations for wave and tidal stream.

5.1. Recommendations for Both Sectors

Action 1: It is essential that Government, along with the MEPB, works to provide a joint, clear and consistent vision of the role wave and tidal energy will play out to 2030 and beyond. This vision must be supported by a UK wide strategy and funding at a suitable intensity to kick-start a transition to a commercial industry over the next 5 – 10 years.

Rationale: Governments across the UK have previously stated their desire to ensure the UK is at the forefront of innovation and technology development for the global marine energy sector. However, we strongly believe a new, unified vision for the whole of the UK is now needed. Without a unified approach there is the potential for funding to be spent inefficiently resulting in both duplication of effort and important measures falling between the gaps. A consolidated *UK wide* strategy including the other measures set out in this paper would provide confidence to investors that the UK is the place to do business in wave and tidal.

The ORE Energy Catapult has indicated that **public funding of the order of £300 million will be required over the next 5 years, to kick start a transition to a commercial industry.** This public funding should leverage a similar amount of private investment[16]. The funds could be sourced from across all parts of government and include regional funding already earmarked for the sector as well as any additional funding UK projects are able to secure from European Commission programmes such as Horizon2020. The level of public funding required must be reviewed and refreshed as the industries progress.

It is crucial to note that the support received from Government to date has succeeded in leveraging many times as much investment from private sources, resulting in a wealth of expertise and outstanding technology progression, with many concepts now proven in real sea conditions. A ramp up is now required for wave and tidal energy to grow from R&D through pilot projects (which have the potential to increase the total capacity installed to date dramatically with each project) and transition into fully commercial propositions.

Action 2: The Department for Energy and Climate Change (DECC) should take steps to improve access to revenue support for wave and tidal projects, to better fit their needs in the absence of the Renewables Obligation (RO).

Rationale: With the RO ending in 2017 there is a gap in the availability of revenue support for innovative technologies. It is now clear that the Contracts for Difference (CfD) regime poses challenges for many wave and tidal developments including small scale, community or test centre projects, and pilot arrays. Unless steps are taken to make the CfD more accessible for wave and tidal projects we anticipate that it will not drive the intended level of investment in these technologies. Potential solutions include offering bespoke negotiated CfDs to test centres, allowing their customers to benefit from revenue support and amendments to the Feed-in Tariff regime, which is not currently available to wave and tidal technologies at any scale.

Action 3: Government should assist the UK industry in their efforts to access and make efficient use of European funding sources.
It can do this by:

i. influencing calls to provide more appropriate funding for innovative projects, e.g. by providing the right levels of capital support and flexible terms;

ii. directing enterprise agencies at a national and regional level to assist and facilitate collaborative proposals;

iii. ensuring that, where possible, UK managed European Funding, e.g. European Regional Development Funding (ERDF), and newly created blue economy categories can be leveraged on top of any UK funding; and

iv. giving consideration to participation in cofund[17] bids in 2015 and 2016.

Rationale: The European Commission has already stated its strong support for the development of ocean energy technology as part of its overall blue economy strategy. This has created a significant opportunity for the marine energy sector and it is important that the UK industry is able to maximise the impact that this funding will have.

While we recognise industry and parts of government are already working with the Commission (e.g. through the Ocean Energy Forum) the actions above will help ensure additional investment from both the Commission and private sources can be drawn down by UK projects and companies, amplifying the effect of UK funding. Collaboration between Member States as part of these projects will also help the European market for ocean energy to grow, providing further opportunities to UK businesses with expertise in this field.

5.2 Recommendations for Tidal Energy

Action 4: Government should work together to provide measures to improve returns and/or reduce risk exposure to a level sufficient for financial close to be reached on at least three pilot tidal arrays in UK waters by 2018.

Possible delivery mechanisms for this include:

i. A co-investment funding package including grant, loan and equity finance to cover a proportion of capital costs at a level which will draw in private investment for the remainder (building on the MeyGen model). Supply Chain Plans could form part of the eligibility criteria for such a package. We recommend projects at test centres as well as standalone projects should be eligible.

ii. Access to government guarantees to underwrite a proportion of risk (alongside relevant parts of the supply chain) for set initial periods of installation and operation of tidal array demonstrators. Coverage could be gradually reduced as track records are demonstrated and investors and technology suppliers become more comfortable with the risks involved.

Rationale: The risks inherent in developing a new technology mean it is impossible to raise the necessary finance for large arrays until the industry has demonstrated the performance and reliability of technology in smaller arrays (<10MW). Only then will manufacturers have the track record to be in a position to offer "bankable" performance guarantees and warranties that will unlock the necessary capital finance for larger arrays.

However, the experience over recent years has shown that in the current financial climate, neither industrial investors nor utilities are prepared to take on the cost and risk of first array projects without significant capital support. Without capital support, smaller pilot and demonstration arrays are not economically viable because of the high fixed upfront costs associated with development, grid, infrastructure and installation.

The success of the MeyGen project demonstrates that a co-ordinated approach to the grant funding and co-financing of projects can enable demonstration arrays to reach financial close. Other models may involve the use of regional funds, debt facilities, EU funding, underwriting guarantees, community or municipal co-investment or the use of infrastructure provided by test sites and demonstration zones. A combination of these measures could unlock the balance of investment into projects from private finance and Original Equipment Manufacturers (OEMs).

Action 5: Government should together fund a new, sustained and flexible R&D programme for innovation focused on driving down the LCoE from tidal stream energy. The programme should support innovation in devices, components and enabling technologies in areas such as installation and operations and maintenance (O&M).

Organisations like InnovateUK and the ORE Catapult may be well placed to help deliver this action. We note the current funding for the ORE Catapult expires in 2017 and if it is to play a role in this proposed R&D programme this must be extended.

Rationale: By focusing on projects which drive down the cost of energy, the ultimate aim is to reduce the cost of tidal energy to the tax or bill payer. Whilst several tidal technologies are now proven at a single device level, there remains significant potential to reduce their LCoE through improving reliability and performance and for cost effective second generation technologies to come forward. Installation and O&M can make up a large proportion of the cost of a tidal project and therefore efficiencies in these areas will have a substantial impact on overall cost reduction. Beyond the impact on LCoE, the criteria for accessing the programme and its funds should be kept as open as possible. The introduction of an expert industry panel to assess applications to the programme will ensure the rapidly changing needs of the sector are met and that funds are spent as efficiently as possible.

Developments in enabling technologies may also be beneficial to other industries such as wave and floating offshore wind.

5.3 Recommendations for Wave Energy

Action 6: Government should work together with industry to establish a new and comprehensive *UK wide* programme to accelerate the demonstration of robust, reliable and investable wave technology and related enabling technologies. This should include an R&D programme and in parallel, provide the requisite project support to deliver full scale technologies and pilot wave arrays in UK waters.

This would build on the initiative that has been taken by the Scottish Government to form Wave Energy Scotland (WES) and bring together the R&D capability and resources from all parts of the UK including Wales, Northern Ireland and South West England. The project support funding should be designed to enable the deployment of full scale devices and pilot arrays at demonstration centres such as EMEC, Wave Hub and within the Wave Energy Demonstration Zones.

As with Action 6, organisations like InnovateUK and the ORE Catapult may be well placed to help deliver this action. We note the current funding for the ORE Catapult expires in 2017 and if it is to play a role in this proposed R&D programme this must be extended.

Rationale: It appears to be taking longer for wave energy technology to approach commercial readiness than tidal stream technologies and there have been a number of setbacks along the way. However, the achievements of UK wave technology developers to date have been ground-breaking with many concepts now proven in real sea conditions. Our research and demonstration facilities are world class, and the UK is now at the centre of a global wave energy industry which is attracting developers from around the world.

The fact remains that the greatest resource potential for clean energy from the oceans lies with wave energy, with research suggesting that it could supply as much as 14% of the UK's electricity demand and has a potential global deployment of around 188GW[18] by 2050. The more innovative and less familiar technical solutions required in wave mean there is a greater opportunity for the UK to secure and grow a competitive advantage in the supply chain and capture a large part of this huge export opportunity. The Scottish Government's announcement that it will create and fund WES, the Welsh Government's commitment of significant regional funding and the increased investment planned in Cornwall and the south west are all very positive for the industry. These steps reflect the significant public and political support that exists for wave energy and an appreciation of the economic benefits which can be captured in parts of the UK with high resource.

Implementation of this action will cement the UK's position as a leading centre for wave energy technology development, and enable the industry to make the critical steps towards commercial deployment.

6. Conclusion

Supply chain research presented here and the expertise within the MEPB both indicate that a prerequisite for investment in wave and tidal energy is investors' confidence in the growth of a market of significant scale.

The supply chain companies interviewed by BVG Associates identified the following as influential factors in their decision when looking at whether to expand their investment in wave and tidal energy capability in the UK:

- UK Government signals of support
- UK market growth predictability
- Attractive strike price
- World market predictability
- Funding for demonstration sites
- R&D funding (grants or co-funding)
- Infrastructure grants (including for grid), and
- UK content targets.

Whilst some of these factors are beyond any government's control, the recommendations provided in this report will improve confidence in the market and drive investment. With these actions implemented we believe a thriving marine energy industry, which delivers economic growth and job creation across the UK as well as clean, reliable energy, can be maintained and expanded. In return, the MEPB members and the wider industry will work with all stakeholders to develop pathways to cost competitive technology whilst adding value to the UK economy.

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Notes