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MARINE ENERGY

Key Steps to maintain a Great British Success Story

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Iomairt na Gàidhealtachd 's nan Eilean

Cable laying in the Pentland Firth, MeyGen project (courtesy of Atlantis Resources Ltd)

THE UK – A MARITIME NATION

For centuries we have led the world in innovation and exploration of the marine environment.

In the last 40 years we have become a global leader in deep ocean oil and gas exploration – creating thousands of skilled jobs and £billions of exports for the British economy.

Now we are the world leader in a new industry – marine energy – with firms across the UK at the forefront of wave and tidal power innovation and deployment.

Already we have seen more than £half a billion new, mainly private, investment flow into the sector; and with the UK's first commercial scale tidal power plants on track to come on-stream this summer, marine energy is already an exciting and dynamic part of the UK economy.

Across the country, this fledgling industry already supports 1700 jobs, with a home-grown supply chain stretching from Cornwall to Orkney and beyond.

The prospects are tantalising. It is a sunrise industry, just reaching commercialisation, but worldwide it is forecast the ocean energy industry will be worth £76 billion by 2050.

This could contribute around £4 billion cumulatively to UK GDP by 2050, with the potential to create over 20,000 jobs by the next decade.

Looking at this timescale, the rationale for supporting new technologies through the CfD budget is to help the UK nurture longer term low carbon generating capacity in order to achieve binding low carbon targets. A variety of low carbon generating capacity will be required by 2050, and the choice for Britain is between taking a leadership position in this new energy field, or leaving it to others.

The UK already has a clear lead in this exciting new sector. Our innovators have taken the best ideas from our universities and laboratories and are now proving them at various scales in our seas.

The industry now needs a clear signal from government to convert this early lead into a world-beating export-led industry.

Front Cover image: Atlantis device under test at EMEC, Orkney (courtesy of Atlantis Resources Ltd)

Scotrenewables SR2000 at Harland & Wollff, Belfast (courtesy of Scotrenewables)

1. A UK-WIDE INDUSTRY

The UK marine energy industry is already making a positive impact in every part of the UK.

It is now more than a decade since the European Marine Energy Centre (EMEC) was established in Orkney and in that period UK has become a global centre of excellence in marine energy.

There are around now 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.

Through policy frameworks and technology support programmes established by DECC, BIS, the Scottish Government and it's agencies, to innovation programmes sponsored by universities and their funding councils, no other nation has greater 'strength in depth' than team GB.

This 'innovation ecosystem' has drawn significant investment and industrial interest from within the UK and overseas, with some of the world's leading businesses taking a stake.

Firms include ABB, Andritz Hydro, Siemens, SSE, Alstom, Global Energy Group, Fred Olsen, Total and DCNS amongst others have all made investments in the sector, and the roll-call of companies which have been to EMEC reads like a 'Who's who' of marine energy innovation.

So far, every £1 of public money invested in major marine energy businesses has leveraged £7 of private investment, and more than 77 percent of this investment has been spent in the UK supply chain.

Recent successes include:

- The MeyGen project, the largest tidal stream energy project in the world, is due to go live this year in the Pentland Firth, with plans to grow out to 398MW in the next decade.
- At EMEC, the Scotrenewables SR2000 and Sustainable Marine Energy's (SME) PLAT-O will be the 26th and 27th marine devices to connect to the grid and commence testing later this summer, whilst the test centre is installing a hydrogen production facility at its tidal site, and is a key partner in the EU-funded pilot project 'Building Innovative Green Hydrogen' to look at the energy innovations of the future.
- WaveHub in Cornwall has a number of developers planning to deploy array projects over the next five years and has attracted inward investors from Australia, Scandinavia, America and Europe. The first major installation starts this summer, backed by Finish utility Fortum and €17million Horizon 2020 funding. This will lead to the world's first wave energy array this decade.
- Harland and Wolff in Belfast has manufactured and delivered its first SR2000 2MW floating tidal turbine the world's largest – to Orkney-based Scotrenewables.
- The 120MW Morlais site in Anglesey has just completed an ITT and will be offering berths for lease by the end of the summer.
- In Northern Ireland the 100MW Fair Head site has begun its consenting process.
- In Shetland, Nova Innovation are currently installing 3 community scale turbines (100kW) with a UK supply chain content of over 80%.
- Tidal Energy Ltd deployed Deltastream off the coast of Wales in December 2015 – the country's first foray into tidal power. They continue to monitor marine mammal interactions and will be refitting the device with a removable nacelle in August this year.
- Swedish firm Minesto has ordered tidal turbines from Schottel Hydro for their 10MW tidal scheme in Holyhead Deep off the Welsh coast.
- Development of the world's largest wave energy demonstration zone (90km^2) is scheduled to start this year in South Pembrokeshire with support from the Welsh Government.
- The Port of Millford Haven is due to welcome three technology developers to the region in the coming months after the prioritising of €100.3 million EU structural funds by the Welsh Government for marine energy. To date this funding has been matched with over fifty percent private investment, suggesting the minimum spend in Wales by 2020 could be €150 million.

Atlantis turbine shaft assembly (courtesy of Atlantis Resources Ltd)

2. THE MEYGEN SCHEME - LEADING THE WORLD

Phase 1A of the MeyGen tidal array is the first stage of the 398MW MeyGen tidal energy Project. Located in the Inner Sound of the Pentland Firth, it is the world's first multi-turbine tidal stream energy project.

Once complete, Phase 1A will have a capacity of 6MW, comprising a single Atlantis turbine and three Andritz Hydro Hammerfest turbines. Phase 1B, consisting of a further 6MW, is due to commence in 2017, with the major bulk of the 74MW Phase 1C due to be in place by 2018-19.

Atlantis has entered into a partnership agreement with infrastructure fund Equitix, which intends to meet at least 25% of the future equity funding requirement of Atlantis's Scottish projects, including MeyGen Phase 1C. In the next two years alone, parent company Atlantis anticipates committed capital investment of almost £500 million pounds for construction of the company's UK portfolio (including the £51million already committed for construction of MeyGen Phase 1A). This investment will be sourced from a combination of debt, equity and grants.

This investment will depend upon a clear signal of commitment from the UK Government.

Already the £51 million Phase 1A scheme is creating significant jobs and investment.

The project, which has been supported by DECC (£10 million), the Crown Estate (£10 million) and the Scottish Government (£23 million), already supports 120 jobs and boasts a supply chain including major industrials such as ABB, SSE, Global Energy Group and James Fisher Marine Services.

A number of these firms have brought expertise gained in the North Sea oil and gas sector. Marine energy offers a clear transition for many of these firms to bring tried and tested experience and equipment into this emerging global industry.

In addition, Atlantis has secured EU funding (NER 300) of almost £16 million for a further 10MW scheme in the Sound of Islay, and almost £13 million of grant funding from the same programme for MeyGen Phase 1B.

Atlantis foundation, Nigg Energy Park (courtesy of Calum Davidson)

3. THE FIRST 100 AND BEYOND – THE NET BENEFITS OF DEPLOYMENT

Compared with a mature sector, such as onshore wind and solar, 100MW is a modest deployment target.

But for a new industrial sector, the first 100MW moves a technology from proof of concept to commercial reality.

Unlike the offshore wind sector, which would require a new player to secure an initial order of 100 - 150 turbines to create a UK based manufacturing facility, initial modest orders of 5-10 turbines per annum for the marine sector would be sufficient to create that UK capability.

Voith tubine foundation, Arnish (courtesy of Calum Davidson)

This step requires a level of grant support, but equally important is a market mechanism to 'pull through' investment – based on energy production.

Using the current CfD model, it is calculated that 100MW of support for marine energy would have a gross cost of around £60 million per annum – or 18 pence per UK household per month.

However this could potentially unlock £100s of millions of inward investment and solidify the UK's global leading in marine energy.

Crucially, ocean energy is high on the EU agenda. Pilot to early commercial-scale projects will receive significant funding – in the order of €30 to €100 million in the next five years. If the UK does not have a revenue support mechanism, then UK projects will not be able to leverage these significant EU funds to attract further inward investment.

A new study estimates economic impacts based on assumed deployment of 105MW by 2020, with a further 600MW forecast up to 2030. This activity would bring the following total net benefits to the UK economy:

- **Capex (705MW): £2,785 million**
- **O&M (across 25 years): £1,170 million**
- **UK employment: 36,700 FTE job years (Capex and O&M)**
- **UK GVA: £2,165 million**

By 2020 alone, the boost to the UK economy would amount to 5,250 FTE job years and GVA of £310 million.

Installation of TEL's DeltaStream device, Pembrokeshire (courtesy of Marine Energy Pembrokeshire)

4. EMEC AND WAVEHUB - INTERNATIONAL CENTRES OF EXCELLENCE

Both WaveHub in Cornwall and the European Marine Energy Centre (EMEC) in Orkney are global centres of excellence in ocean energy research and demonstration.

EMEC

Founded over ten years ago with European, UK and Scottish support, EMEC has established itself as the focal point for research, development and full-scale testing of ocean energy prototypes. EMEC has research links with 238 universities and other organisations in the UK and internationally; and in the last twelve years, a total of 25 full scale wave and tidal machines have gone through their paces.

Using around £39 million of public support, EMEC has had an economic impact far beyond its own shores, acting as a magnet for investment and job creation. **A recent study estimates EMEC has generated a GVA to the UK economy of £194 million with the creation 3,801 full time equivalent job years** – equating to 149 full-time jobs in the Orkney economy.

To quote the European Ocean Energy's Industrial Vision Paper, 2013:

" ….strategic investment in practical support and facilities will also accelerate innovation. The best example of this is the European Marine Energy Centre. Co-investment from Europe, the Scottish and UK governments has created a self-financing hub for learning and technical advancement – and leveraged millions in private finance into the sector and the local economy."

It remains the only centre of its kind to offer grid-connected wave and tidal berths and is now actively exporting its knowledge and expertise to enable the establishment of marine developments across the globe, including Japan, China, USA and Singapore.

Scotrenewables SR2000 and SME's PLATO, tidal turbines at Hatson, Orkney (courtesy of EMEC)

WAVEHUB

WaveHub in Cornwall, the world's largest grid connected array test facility, sits alongside a growing ecosystem of leading facilities in the south west, including the Falmouth Bay Test Facility, the COAST wave tank and Plymouth Marine Building, the Dynamic Mooring Centre, the South West Mooring Test Facility, the National Composites Centre in Bristol and the North Devon Demonstration Zone

Seatricity's Oceanus 2 device being installed at WaveHub (courtesy of RegenSW)

Together these facilities have generated over £170 million investment within the last decade, creating more than 400 marine energy jobs in the region.

Wave Hub has attracted a number of international developers planning to deploy array projects at the Cornish site over the next five years. The first of these projects will start installation of a first device this summer and will then build out a wave energy array (the first full scale wave array in the world) by 2018. A second international developer has actively begun work to deploy a larger project in 2017, and a third significant project is expected to come on stream in 2018. By 2025 the South West aims to see the first full commercial scale wave farms, which will form the basis for further larger commercial projects out to 2030 and beyond. Beyond 2030, there is potential to develop 1.2 GW of wave energy off Cornwall, and more if this is linked to larger projects in the Celtic Sea and across to south Wales.

Other regional highlights in the South West of England include the opening of the new Marine Renewable Energy Business Park at Hayle, which has been part funded by DECC, several successful EU investment fund calls for marine energy, the establishment of two marine based Enterprise Zones including the transition of 'Oceangate' the former Plymouth South Yard dockyard for the private sector.

In March 2016 the Chancellor announced a further £15m to support the creation of a Cornish MarineHub Enterprise Zone, and the intention to transfer ownership of WaveHub from BIS ownership to Cornwall Council, giving the local authority and Cornish community an even greater stake in the future development of marine energy.

Looking ahead, the UK Government needs to address the suitability of the CfD mechanism in providing appropriate support for small scale developments and test centres.

5. A GLOBAL OPPORTUNITY

There is a growing global market for ocean energy. The International Energy Authority's Ocean energy Systems Vision for International Deployment of Ocean Energy estimates that up to 337GW of marine energy could be installed worldwide by 2050.

In Europe alone it is estimated there are 270 gigawatts of exploitable wave energy resource.

Installed Capacity	337 GW
Electricity Generation	810 TWh
Direct Jobs	299,555
Investment	$1.87 TRILLION
Carbon Savings	0.8 BILLION tonnes of CO2

Source: OES Global Ocean Energy Deployment Vision, 2050

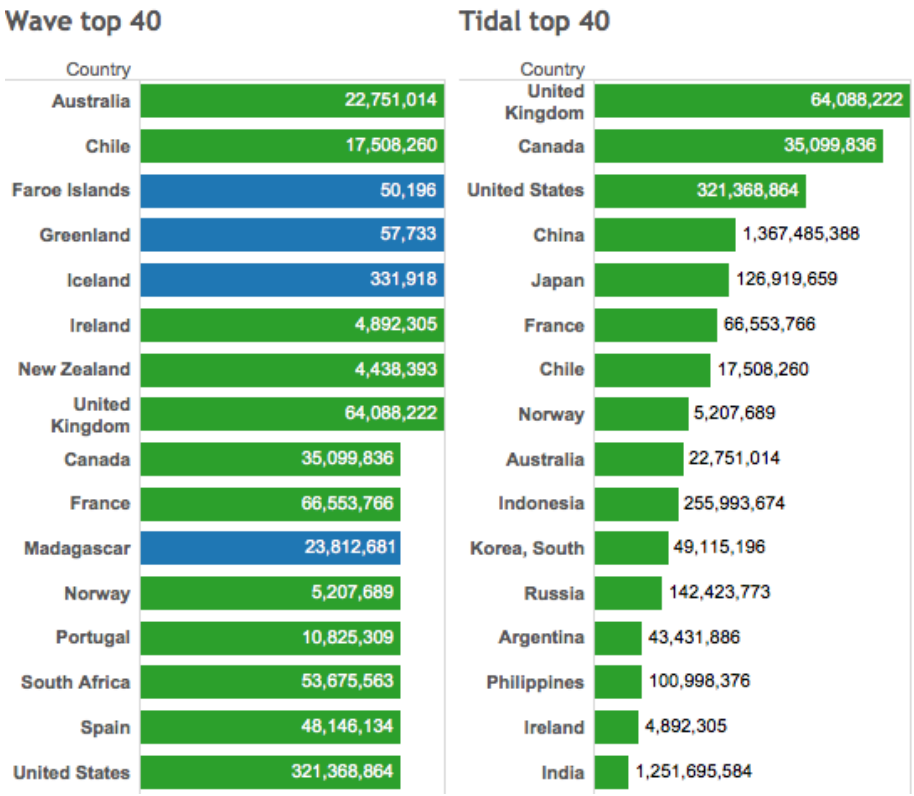
It has been estimated the UK could capture a slice of the global marine energy market worth up to £76 billion, and the UK could capture at least £4 billion of that opportunity, with the potential for over 20,000 jobs by next decade.

A significant body of research has been undertaken by the UK, demonstrating export opportunities for indigenous technologies, with potential to provide utility-scale electricity in Chile, the USA and Australia and to develop niche applications in dozens of other maritime nations.

The US Department of Energy is also taking an increasing interest in the sector, and has mapped the energy potential of wave and tidal energy around its coast – calculated at 898–1,229 TWh/year for wave energy and 222–334 TWh/year for tidal stream.

A GLOBAL MARKET

RANKING OF COUNTRIES BY OPPORTUNITY (POPULATION)



NOTE: Figure shows ranking of countries with potential for marine energy based on quality and accessibility of resource (figures show population, colour coding relates to quality and quantity of available data with green indicating more data available.)

However competitor nations, including France, Ireland and Canada are now putting in place measures to capture this growing economic opportunity.

COMPETITOR AMBITIONS

France is providing support by backing specific projects with upfront capital grants and revenue support. Earlier this year Ségolène Royal, France's Energy and Environment Minister, inaugurated the second DCNS/OpenHydro tidal turbine for the EDF Paimpol-Brehat tidal-turbine demonstration farm project. DCNS has now tabled plans to build a tidal turbine factory in Cherbourg.

France has a target of 100MW of marine energy to be delivered by 2023 and projects such as Raz Blanchard are fully supported. These projects are being delivered by French companies.

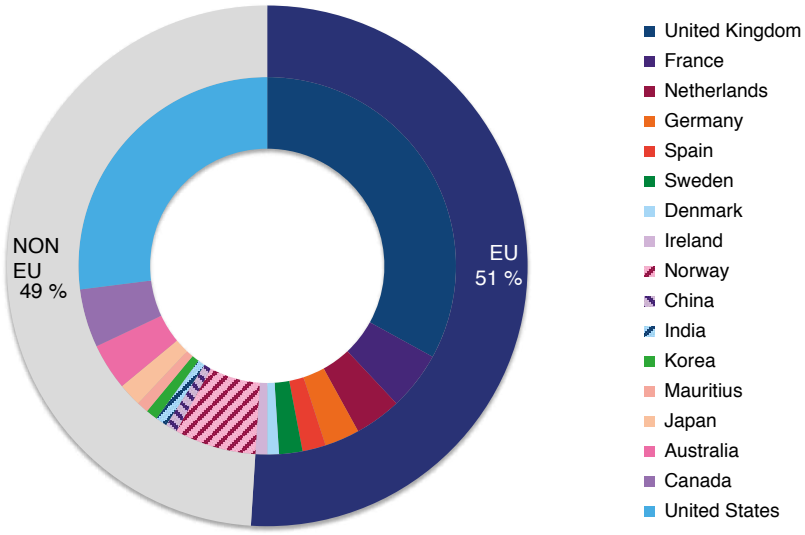
The country's commitment to offshore energy is increasing. They have recently announced an additional 6GW of fixed offshore wind contracts will be awarded by 2023 in addition to the 3GW that should be functioning by then. In addition they have committed to issue a call for tenders for the commercial development of tidal and floating offshore wind.

This will place France in the vanguard of offshore energy within a decade.

Canada is providing support to FORCE and Fundy Tidal with the technology being provided by non-UK European companies. Indeed, French company DCNS has installed two 2MW tidal turbines in Nova Scotia.

As the graphic below shows, the UK is a leading player in the tidal industry; however it is an increasingly busy marketplace with a number of nations rapidly developing their capabilities.

There is the real prospect that, without appropriate forms of support in the immediate future, the UK could sacrifice its technology lead to other competitor nations.



Distribution of tidal companies in the world. Source: EMEC 2014a

DENMARK AND FRANCE - A LESSON LEARNT

In the early 1980s and 90s the UK and Demark spent equivalent amounts on early wind R&D. However it was the Danish Government which provided the market support mechanism which allowed small manufacturers such as Vestas develop into global players.

The Danish wind industry now employs 28,000 workers in an export market worth nearly £5 billion per year (2008 figures).

Similarly, the UK was global leader in nuclear energy technology in the post-war period until nuclear fission R&D expenditure was wound down in the 1980s and 90s.

UK Chancellor George Osborne remarked to the UK Energy Select Committee that is was a source of regret that the UK no longer had the capability to build its own nuclear power fleet.

The actions required to support the UK industry are modest and specific, but without them the industry will falter, and a UK success story will go on to prosper overseas.

6. THE NEXT STEP COMMERCIALISATION

Success will not come without public support.

Most of the world's greatest innovations – solar panels, jet engines, the internet, nuclear power, the iPhone – have their genesis in long-reaching public funding.

The UK has a strong track record in supporting R&D for wave and tidal energy technologies – which have helped the country establish its current global lead.

The UK network of accredited test centres at WaveHub and EMEC, the BIS-funded UK Offshore Renewable Energy Catapult, and Scottish Government funded Wave Energy Scotland together provide the R&D framework to bring technologies from the laboratory to first full-scale prototype and beyond.

Although wave energy remains at the advanced R&D stage, tidal energy has made great strides and the first commercial projects have already begun – both in the UK and overseas.

Grant funding is helpful to de-risk technology development and encourage the embryonic supply chain to invest in R&D, but strong market pull is needed to create the necessary momentum for this technology journey and the confidence for the private sector
to invest.

Significant investment is waiting in the wings and a clear signal is now required that market support will be in place.

The previous government pledged 100MW of CfDs at £305 per MWh to the UK marine energy industry. This was strong and positive pledge of support for a rapidly-maturing technology, and in line with agreed government/industry routemaps.

To have a market, there needs to be a potential for earning revenues and this has to date been based on the 100MW minimum for marine energy.

The sector now needs a clear signal of continued support from the UK Government – this could come through confirming the 100MW ring-fence for marine energy within the Levy Control Framework, or some other market support mechanism tailored to early stage technology.

Two key measures – the ability for marine projects to access CfD revenues pre and post 2021 and the continuation of a minima capacity and strike price for wave and tidal energy – would give a green light to £100s of millions of private sector investment and would unlock the potential of more than €100 million pledged EU support.

Early array projects will be the most expensive, and it is feasible to create a sliding scale of support to reflect the cost reductions which will be realised as learning rates increase and new technologies are proven and incorporated into projects.

It is accepted the future strike price will reduce as a mechanism to drive down costs, and provided this is done in a clear long-term way, it will provide market visibility for private investors.

For any investment in either technology or project development the sector needs certainty around a future market at this stage. In the absence of this certainty little or no private investment will flow.

A PATH TO COST REDUCTION

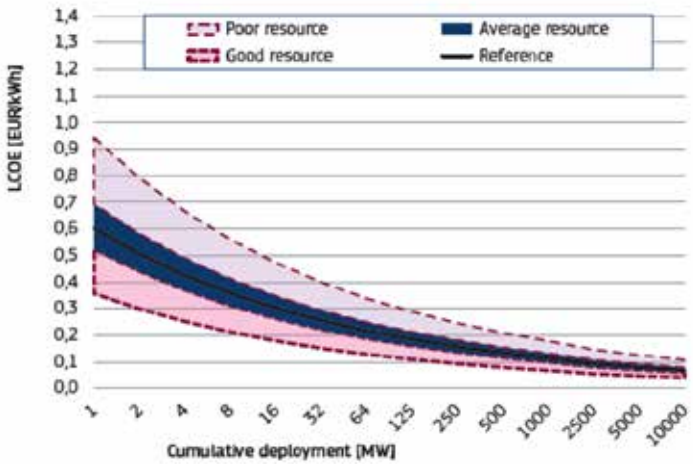
It is anticipated the future build out of marine energy in UK waters will be modest in the near term.

Already we have seen a clear divergence between wave and tidal technologies, and we expect this to continue into the medium term, with small wave arrays being deployed by the early 2020s, and tidal being deployed at larger scale by the mid-2020s.

We will not see a rapid uptake in deployment until the later years of the decade. This follows the trajectories of other renewable technologies – namely wind and solar – where deployment has increased exponentially once technologies have become established and costs have come down.

In a similar fashion, as the deployment of wave and tidal energy increases, the levelised cost of electricity (LCOE) will come down. BVG Associates estimate tidal energy could become cost competitive with other forms of energy once 2GW has been installed worldwide, and other studies suggest wave and tidal will reach competitive levels with around 1-2GW installed.

This analysis is also supported by the EU's 2014 Joint Research Committee which states that reference tidal technologies could achieve commercial competitiveness once approximately 1.5–5 GW of cumulative capacity have been installed, in line with the findings of SI Ocean (SI Ocean 2013b). Lower LCOE could be achieved in the best-case scenario, in which the technology is installed in high resource areas with high operational capacity factors and low capital expenditure.



LCOE predictions for tidal arrays. Source: JRC based on ERTI 2014

Fred Olsen's Bolt device on tow to FAB Test (courtesy of RegenSW)

7. CONCLUSION

The UK-led wave and tidal energy sector is already having a significant and positive impact on our economy, bringing innovation, inward investment and new skilled jobs into geographical areas affected by downturns in more traditional economic activities – including fishing, shipbuilding and, more recently oil and gas.

This net positive economic benefit comes as a result of more than a decade of visionary support from the UK, Welsh and Scottish governments.

We are now seeing the first commercial schemes being built in UK waters – creating real jobs and new investment; whilst at the same time competitor nations such as France and Canada are closing in on the UK's early lead using technologies developed and tested in the UK but being built in Normandy and Nova Scotia.

The sector now needs a clear signal of continued support from the UK Government – this could come through confirming the 100MW ring-fence for marine energy within the Levy Control Framework, or some other market support mechanism tailored to early stage technology.

In return, this would unlock a wave of investment and economic activity – including near term capital investment of almost £500 million pounds for construction of Atlantis's Scottish portfolio – and will help consolidate the UK's global lead in this fast growing sunrise sector.

If we fail to support the industry now, competitor nations will overtake the UK's early lead, and we will forsake the future benefits a global marine energy market will bring.

Now is the time to be bold, and to support of one of our best success stories.

APPENDIX SOURCES OF INFORMATION

A Report for Highlands and Islands Enterprise by Steve Westbrook, Economist with Lucy Parsons, Stewart & Parsons, BVG Associates and Solution Management Ltd

UK Marine Industries Alliance, A Strategy for Growth for the UK Marine Industries 2011

The Carbon Trust Green Growth Paper 2011

Technology Innovation Needs Assesment for Marine Energy 2012

Direct and indirect jobs from high growthscenario in RenewableUK
“Working for a Greener Britain and Northern Ireland 2013”

UK Marine Energy Programme Board

http://www.ons.gov.uk/peoplepopul tionandcommunity/birthsdeathsandmariages/families bulletins/familiesanhouseholds/2015-11-05

EMEC Economic Impact Assessment, HIE, Steve Westbrook, 2016

IEA Blue map HiRen – 188GW wave / 52GW tidal by 2050

Direct and indirect jobs from high growth scenario in RenewableUK
“Working for a Greener Britain and Northern Ireland 2013”

http://energy.gov/eere/water/marine-and-hydrokinetic-resource-assessment-and-chara terization

https://setis.ec.europa.eu/sites/default/files/reports/2014-JRC-Ocean-Energy-Status-R port.pdf

The Danish Wind industry 1980-2010 lessons for the British Marine Energy Industry

http://www.publications.parliament.uk/pa/ld201012/ldselect/ldsctech/221/22105.htm

A Report for Scottish Enterprise, International Markets and Niches for Marine Energy, April 2016

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