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Channelling the Energy

A Way Forward for the UK Wave & Tidal Industry Towards 2020

October 2010

RenewableUK previously: BWEA

About RenewableUK

RenewableUK is the trade and professional body for the UK wind and marine renewables industries. Formed in 1978, and with 652 corporate members, RenewableUK is the leading renewable energy trade association in the UK. In 2004, RenewableUK expanded its mission to champion wave and tidal energy and use the Association's experience to guide these technologies along the same path to commercialisation.

Our primary purpose is to promote the use of wind, wave and tidal power in and around the UK. We act as a central point for information for our membership and as a lobbying group to promote wind energy and marine renewables to government, industry, the media and the public. We research and find solutions to current issues and generally act as the forum for the UK wind, waveand tidal industry, and have an annual turnover in excess of four million pounds.

Acknowledgment
This report was prepared by RenewableUK using information derived both from published studies and from industry members. Entec provided support to RenewableUK to help interpret and analyse the results. Where possible the information has been checked against original sources to ensure that it is used in context. Some information provided by members was given in confidence to RenewableUK and was provided to Entec only in aggregated form. Except where stated, Entec has not completed independent checks of the validity of these sources and has interpreted the information in good faith. The opinions and conclusions in this report are those of the contributors and RenewableUK members; they do not necessarily represent the views of Entec.

Kreab Gavin Anderson also contributed to the report, interviewing a range of utility companies and OEMs to obtain their views on the marine sector. These interviews were designed to understand the organisations' involvement in wave and tidal projects to date, their role in funding development, their views on financial incentives and their general perceptions of the future of the UK marine sector. Interviews were undertaken during July and August 2010 and are reported on an unattributable basis.

KREAB & GAVIN ANDERSON WORLDWIDE

Kreab Gavin Anderson is a global public relations and communications consultancy, with particular expertise in the cleantech sector. KGA's consultants are experts in financial communications, corporate positioning, crisis management, public affairs and government relations.

Entec
An AMEC company

Entec is an environmental and engineering consultancy and employs specialists who work for our clients in the private and public sectors on the economics, technology and application of renewable and low carbon energy. Entec are part of AMEC. Entec is pleased to be involved with this work and to help ensure that information valuable in the debate on marine energy is aired. Entec also hopes that the study will promote quality discussion on the key issues.

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1. Executive Summary & Key Conclusions

The UK is currently leading the world in the rapidly developing marine (wave and tidal) energy industry, with 2.4MW installed, a world leading testing infrastructure to support deployment, a high concentration of technology developers and more project leases having been awarded than the rest of the globe combined.[1]

“ In the next five years the UK has a unique opportunity to establish itself as global centre of the future marine energy industry…”

Based on deployment Scenario 3 in The Offshore Valuation,[2] market retention figures published by the Carbon Trust[3] and proportional project distribution figures obtained via a survey of RenewableUK members[4] it is estimated that the UK could secure a marine energy industry worth up to £6.1bn per annum, which would directly employ as many as 19,500 individuals and contribute GVA to the UK economy in the region of £800m per annum by 2035.

The views and opinions of potential future and current investors in the sector highlight a willingness to engage with technology development; however start-up investment costs could prove to be a major hurdle to future UK industry prospects. From analysis of the development of the onshore wind industry it is evident that a coordinated government support framework is essential to establish a world leading renewable energy industry.

In the next five years the UK has a unique opportunity to establish itself as global centre of the future marine energy industry, if it can ensure the delivery of the world first marine energy arrays and provide long term stable market support. In light of this the key actions for varying stages of industry development can be summarised as follows:

1. RenewableUK, 2010. Marine Renewable Energy - State of the Industry 2010
2. Public Interest Research Centre, 2010. The Offshore Valuation. P 54
3. Carbon Trust, 2009. Focus for success - A new approach to commercialising low carbon technologies. P 66
4. Contributors included Aquamarine Power, Atlantis Resource Corporation and Pelamis Wave Power.
5. NASA, 2010. http://esto.nasa.gov/files/TRL_definitions.pdf Viewed - 15/10/2010

First and Next Generation Prototype - Technology Readiness Level (TRL)[5] 1-7 - Up to 1MW

Recent funding schemes have been highly effective but need to be continued over a number of years to bring technology to the point where the industry can move on to the first arrays.

During the next comprehensive spending review period government must ensure the delivery of targeted funding that continues to bridge the technology market gaps in a coordinated manner from the varying UK funding bodies, departments and devolved administrations.

First Wave and Tidal Farms - TRL 8-9 - 2-10MW

UK and Scottish Government should work towards providing a complementary combined grant and revenue package to incentivise utilities and original equipment manufacturers to invest in and deliver the world's first marine energy arrays in the next three to five years.

Capital funding of £251m is the minimum amount required to support this first build, which will halve to roughly £131m if revenue support is provided at a level of 5 ROCs, the revenue portion of this support could alternatively be provided by an interim FiT.

The capital funding could be potentially sourced from the SRO £186m fund, the MRDF £42m and EU funds (e.g. NER 300).

Second Farm and Beyond - TRL 8-9 - 10MW+

Scottish and UK Government must provide sufficient, stable and level revenue support at a level of 5 ROCs for both wave and tidal technologies to ensure continued interest from Utilities and OEMs and until the industry has matured.

The above recommendations provide a coherent support framework that should be executed in a coordinated approach. If implemented correctly they will allow the industry to grow to the scale predicted above.

RenewableUK recommends that to achieve coordination the UK Government and the sector, should investigate and implement a mechanism or forum to continue to develop a long term strategy and delivery processes for the UK marine energy industry.

2. Social And Economic Benefits Of Developing A World Leading Marine Energy Industry

To date the UK has installed 2.4 MW of marine energy and generated over 2,500MWh to the UK grid.

To date the UK has installed 2.4 MW of marine energy and generated over 2,500MWh to the UK grid. The Crown Estate recently awarded development leases for 1.2GW of projects in the Pentland Firth and Orkney waters, which consisted of eight projects ranging in size from 50MW to 200MW and provides the UK with the most developed plans for commercial deployment of marine energy projects. The industry is supported by a host of testing facilities including the National Renewable Energy Centre, the European Marine Energy Centre, Wave Hub and QinetiQ. It was also able to secure in excess of £41m of private investment in the past year alone.[6]

It has been well documented that the development of a successful marine industry could help the UK achieve both its 2020 and 2050 renewable energy and climate change targets whilst also providing security of supply and bringing significant social and economic benefits, the scale of which will depend heavily upon the domestic and export market potential and the proportion of which that is secured by UK plc. [7,8]

For the purpose of this report marine energy refers to energy extracted from wave energy and tidal stream energy.

Resource Analysis

The UK and Europe have a vast marine energy resource which could produce between 15-20% of the current UK electricity demand[9] and 15% of EU electricity demands,[10] representing a substantial domestic and export market (Table 2.1).

	Estimated Market Size (GW)	
	2020	2050
Domestic	1.5 [11]	36 [12]
Export (EU - excluding UK)	2.1 [13]	152 [14]

Table 2.1 - Summary of the Domestic and Export Marine Energy Market Potential[15]

6. RenewableUK, 2010. Marine Renewable Energy - State of the Industry 2010
7. Carbon Trust, 2006. Future Marine Energy.
8. BWEA, 2006. Path to Power.
9. Carbon Trust, 2006. Future Marine Energy.
10. EU-OEA, 2010. Oceans of Energy - 2020 Road Map.
11. RenewableUK, 2010. Marine Renewable Energy - State of the Industry 2010 - Estimated installed capacity 1 - 2GW. 1.5GW is used as a mid range target.
12. Public Interest Research Centre, 2010. The Offshore Valuation. P 54. The offshore valuation represents the most recent deployment scenarios for practically extractable wave and tidal energy in UK waters at the time of print, with contributions from UK Government, Industry and the Crown Estate. Development Scenario 3 states a potential installed capacity of 36.3GW. It is noted that this is higher than any previous practically extractable wave and tidal energy resource estimations for UK waters.
13. EU-OEA , 2010. Oceans of Energy - 2020 Road Map - Target Capacity of 3.6GW, minus 1.5GW for the UK results in a European Market of 2.1GW.
14. EU-OEA , 2010. Oceans of Energy - 2020 Road Map - Target Capacity of 188GW, minus 36GW for the UK results in a European Market of 152GW.
15. RenewableUK believes that additional work will be required to define the global market potential.

From a review of recent studies of the socioeconomic impact of marine energy, it is evident that development of the industry will be capital intensive with commensurate impacts on the economy, resulting in a continuous requirement for labour for construction, installation and decommissioning services together with an ongoing requirement (with a different set of labour skills) to support operations and maintenance.[16, 17, 18]

UK Content

Existing marine energy supply chain studies conclude that marine energy provides employment onshore in manufacturing, offshore in installation and servicing and in shore-side in support activities. It provides opportunities both in industrial areas inland and on the coast and provides links between them.

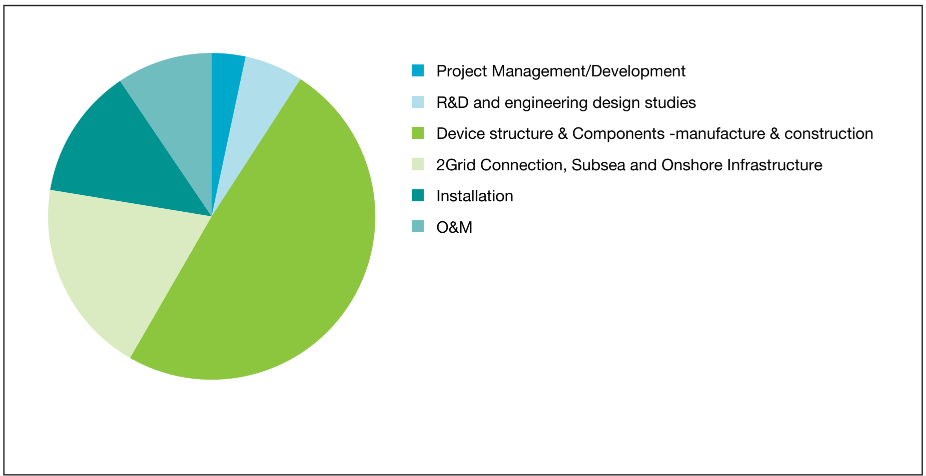
In general terms, impacts are 'additional' and predominately result in new jobs rather than movement of jobs from one industry to another. Whilst it is thought that the existing skills base will be insufficient to deliver the industry growth needed, these skills can and must be developed within the UK to ensure sustainable future employment opportunities.

Overall, there is potential for the UK marine energy suppliers to service the entire supply chain as well as organising its integration. Furthermore having developed such capability it should be possible to service overseas as well as UK marine energy developments.

The economic benefits and job creation generated by the growth of the marine energy industry would also be beneficial to the UK and enable the redeployment of skilled staff from any decline in the oil and gas industries.

Whilst securing 100% of the market is unrealistic, if the correct political, financial and consenting environment were to be established a high percentage could be retained. RenewableUK conducted a survey of leading technology developers to understand the estimated future project cost break-down.[20] It is evident from Figure 2.1 that the three areas of highest economic benefit are in manufacture and construction, installation and grid connection, subsea and onshore infrastructure. This echoes the results of a similar survey conducted by the Forum for Renewable Energy Development Scotland.[21]

Figure 2.1 - Estimated future project cost breakdown - nominal farm capacity 30MW



16. SQW report for Aquamarine Power, 2009. Socio-Economic Impact Assessments of Aquamarine Power's Oyster Projects.
17. ECONorthwest report for Oregon Wave Energy Trust, 2009. Economic Impact of Wave Energy to Oregon's Economy.
18. Sgurr Energy report for FREDS Marine Energy Group, 2009. Supply Chain Report Analysis.
19. Carbon Trust, 2009. Focus for Success, A new approach to commercialising low carbon technologies.
20. Contributors included Aquamarine Power, Atlantis Resource Corporation and Pelamis Wave Power.
21. Sgurr Energy Report for FREDS Marine Energy Group, 2009. Supply Chain Report Analysis.

Figure 2.2 - Potential Domestic and Export Market Share - 2020-2050

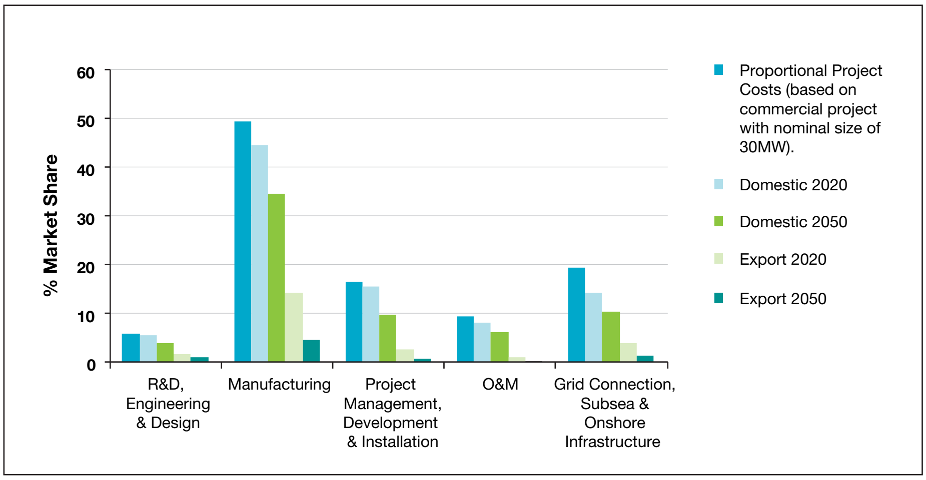


Table 2.2 – Socio-economic impacts from developing a UK Marine Energy Industry

	2020	2035	2050
Annual value to UK	£3.7bn	£6.1bn	£5.9bn
Number of individuals directly employed	10,000	19,500	19,000
UK share of domestic market	80%	71%	65%
UK share of export market	22%	14%	9%
Gross Value Added	£530m	£800m	£770m

Figure 2.2 normalises the estimated project costs of varying sectors of a marine energy project and correlates them to the estimated domestic and export markets share which could be secured by the UK within these sectors in 2020 and 2050.[22]

Based on deployment Scenario 3 in The Offshore Valuation[23] and upon the market retention figures in Figure 2.2, the UK could secure a marine energy industry worth up to £6.1bn per annum, directly employ as many as 19,500 individuals and produce a GVA in the region of £800m per annum by 2035 (Table 2.2). Throughout this analysis it was noted that the date at which these socio-economic benefits are reached will depend heavily upon domestic and global deployment rates, as a faster industry establishment will result in earlier industry maturation.

The following points should be borne in mind when interpreting the data from Table 2.2:

- The annual value is the total capital and operating cost (excluding financing costs and interest charges), spend on goods and services provided domestically.
- Jobs are numbers of Full Time Equivalent (FTE) staff working directly in the marine energy industry. Their spending would also lead to the creation of a substantial number of additional induced jobs in the wider economy. Jobs numbers reflect Carbon Trust estimates for 2040, and are scaled pro-rata to the annual value for the industry in 2020 and 2050.[24] RenewableUK is currently undertaking additional research to provide greater clarity on the sectors these jobs are likely to be created in. This work will also review the current levels of employment, scrutinise existing predictions on future employment levels and provide greater certainty on this issue.
- GVA uses the number of direct jobs multiplied by a typical estimate of GVA to employee ratio, for engineering based industries.
- The decline in the figures from 2035 to 2050 can be attributed to the rate of UK deployment altering from 2.3GW installed per annum in 2035 to 1.3GW per annum in 2050, a function of practically extractable resource limitations.[25]

Commercialising Marine Energy Technology

Whilst the UK is currently leading marine energy technology development, significant work is still required to reach the stage at which projects can be commercially viable. Based upon the UKERC and ETI UK marine energy deployment strategy[26] and correlated to NASA Technology Readiness Levels (TRL),[27] Figure 2.3 provides a basic outline of the anticipated stages of industry development, showing the transition from capital support to revenue support, from prototypes and next generation devices through first farms and beyond.

22. Carbon Trust, 2009. Focus for Success, A new approach to commercialising low carbon technologies. P 66
23. Public Interest Research Centre, 2010. The Offshore Valuation.
24. Carbon Trust, 2009. Focus for success - A new approach to commercialising low carbon technologies. P 68
25. Public Interest Research Centre, 2010. The Offshore Valuation.
26. Energy technology Institute and UK Energy Research Centre, 2010. Marine Energy Technology Roadmap
27. NASA, 2010. http://esto.nasa.gov/files/TRL_definitions.pdf Viewed - 15/10/2010

Figure 2.3 - Stages of Marine Energy Industry Development

1st & Next Generation Prototype	First Wave/Tidal Farms	2nd Farms and Beyond
Market Push: E.g. Capital Grants	Market Push AND Pull: E.g. Capital Grants (Push) E.g. Multiple ROCs (Pull)	Market Pull: E.g. Multiple ROCs

1. First and Next Generation Prototype - TRL 1-7 - Up to 1MW

Capital support is vital to the industry today and devices require continued support through the research and development (R&D) stage. The primary gap today exists when devices are ready for open ocean deployment; at this point capital needs rise rapidly. Device developers are generally small and medium enterprises (SMEs) that do not have the financial backing to fund such projects, and the initial risk exposure is too high for utilities to commit investment or for any manufacturer to underwrite performance. Hence, capital support from government is required to de-risk investment in technology development and stimulate the private sector backing.

RenewableUK believes that Stage 1 of industry development can be split into three specific phases for technology development that can be related to the NASA TRLs as follows:

- Phase 1 - Concept Development and Tank Testing (TRL 1-3)
- Phase 2 - Greater Scale Prototype (TRL 4-5)
- Phase 3 - Full-Scale Grid Connected Prototype (TRL 6-7)

2. First Wave and Tidal Farms - TRL 8-9 - 2-10MW

When marine energy devices become ready for deployment in small arrays, revenue incentives play an important part in making the projects economically viable. However, electricity production from the first wave and tidal farms will be unpredictable, making revenue incentives alone insufficient. For these first steps, upfront capital grant is also required to reduce the amount of capital at risk. Under this scenario, a marine energy project starts to become attractive to utilities. However, to secure investment from utilities, device offerings have to be on a par with alternative options. In particular, device manufacturers have to be able to offer potential utility investors (a) sufficient operating experience to offer guarantees in performance and reliability and (b) involvement of major manufacturers able to underpin these guarantees both technically and financially.

3. Second Farms and Beyond - TRL 8-9 - 10MW+

Following these initial small-scale projects, and with sufficient revenue support, it is likely that marine energy projects could start to move towards attracting debt finance, one of the key requirements in facilitating rapid deployment at larger scales. In turn this will deliver associated cost reductions that would reduce the level of revenue support required.

Over the past five years both the UK industry and Government has taken strides to capitalise upon the UK's unique marine energy potential. However, even with this commitment it has already been suggested that greater Government support will be required to develop robust and affordable technology.[28, 29, 30]

This report will aim to understand how the support framework outlined above could be established in the UK to deliver a world leading marine energy industry over the next five years. This will be achieved by ensuring lessons are learnt from the development of previous renewable energy industries (onshore wind), obtaining an understanding of the investor perspective, reviewing the impact of government intervention to date and providing updated cost figures for technology development and deployment of the first marine energy arrays.

28. Carbon Trust, 2009. Focus for success - A new approach to commercialising low carbon technologies.
29.The Climate Change Commission, 2010. Building a Low Carbon Economy - The UK's innovation Challenge.
30. Bain and Company, October 2008. Employment Opportunities and Challenges in the Context of Rapid Industry Growth.

3. Securing Economic Benefit from Renewable Energy

In developing a policy and financial framework to continue to support the UK marine energy industry it will be important to ensure lessons are learnt from previous renewable energy success stories to secure the greatest return on public investment.

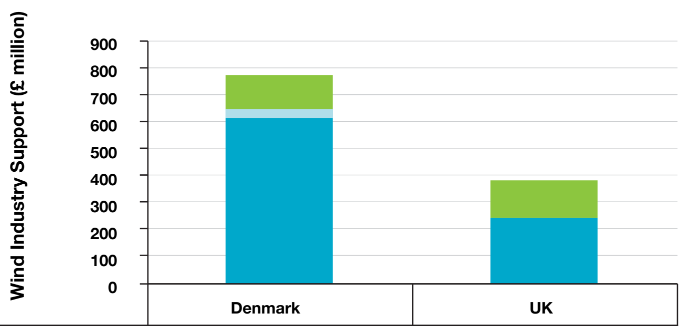
Recent retrospective analysis of the development of both the Danish and British onshore wind industries has identified that disparities in support mechanisms between the two countries was a key factor in determining the variation in the present day market share and correlated economic benefit received from development of this industry.[31, 32]

Development of Onshore Wind

It is particularly interesting to review the total investment which the two Governments provided to support the industries (Figure 3.1). Even though both Governments invested similar sums of money into R&D activities, the Danish Government awarded grants from 1976 to 1981,[33] five years earlier than those which occurred in the UK, providing the Danes with an essential early mover advantage. This was swiftly followed by the establishment of premium revenue incentives[34] and a holistic policy package (Table 3.1).

Since these early initiatives, a total of 20 years consistent market and policy support have laid the foundation for a technological revolution that has resulted in a global export market worth over €5.7bn in 2008. With a 20% share of the global wind turbine market, the Danish wind industry provides employment for 28,000 workers and contributes €1.5bn in GVA to the Danish economy each year.[35, 36]

Figure 3.1 - Comparative Wind Industry Public Support made available in the UK and Denmark[37]



	Denmark	UK
R&D	122	141
Capital Grants	31	0
Production Incentives	615.4	240

31. Aquamarine Power, 2010. Danish wind 1980-2010: lessons for the British marine energy industry.
32. Garrad, A., 2011, Phil. Trans. R. Soc. A, in press.
33. Nielsen, K.H., 2002, Translating Wind Power Policies, PhD thesis, University of Aarhus, Denmark.
34. Musgrove, P., 2009, Wind Power, Cambridge Press, ISBN: 9780521762380
35. Ministry of Foreign Affairs of Denmark, 23rd March 2010. Vestas Maintains its No. 1 Position in the Wind Turbine Market. http://www.investindk.com/visNyhed.asp?artikelID=23741 Viewed - 30/09/2010
36. Denmark: Centre for Politiske Studier, 2009. Wind Energy: The Case of Denmark. http://www.cepos.dk/fileadmin/user_upload/Arkiv/PDF/Wind_energy_-_the_case_of_Denmark.pdf Viewed - 5/10/2010
37. Aquamarine Power, 2010. Danish wind 1980-2010: lessons for the British marine energy industry

Table 3.1 - A comparison of the socioeconomic framework in which wind energy developed in Denmark and the UK between 1980 and 2000 [38]

Political	
Denmark	UK
• £615m spent on production incentives between 1980-2000. • £122m on R&D 1980-2000. • Stable financial support for 20 years: 85% of retail price and later, a premium of £30/MWh spurred domestic growth of wind energy. • Change of government in 2001 altered the support scheme and as a result, stalled domestic growth of wind energy. New support mechanisms vary according to size of turbine and hours of full production.	• £240m spent from 1990-2000 NFFO. • £140m on R&D 1980-2000. • 1989 Electricity Act privatised UK electricity generation. The Non Fossil Fuel Obligation was intended to support the nuclear industry but was later expanded to include renewables. • Policy during first decade (1980-1990) of wind energy was uncertain, NFFO contracts made electricity pricing highly competitive.
Economic	
Denmark	UK
Danish agricultural sector was in decline. Companies such as Vestas, Bonus, Micon moved from traditional industries to a new energy industry.	The UK government supported nuclear and had a strong offshore oil and gas industry. Wind energy was not a priority.
Social	
Denmark	UK
Wind energy continues to achieve a 90% approval rating. Public support was encouraged by allowing anyone within a prescribed vicinity of a wind farm to purchase shares in the development. Structured financial support favoured individuals over power companies. In 2002, 80% of the 6,300 wind turbines in Denmark were owned by wind energy cooperatives or individual farmers.[39]	• Widespread public objection to wind turbines between 1990-1995 due to developments in areas of high potential for conflict, and limited cooperation with local communities.
Technical	
Denmark	UK
• Early R&D support defined three bladed turbines as the design of choice before market pull techniques were employed. • Early support provided the industry with a long term stable framework in which to further develop system reliability and gain a lead over other nations. • Priority access to grid and infrastructure improvements streamlined additional capacity.	• NFFO came too late for the UK manufacturers with only British Wind Energy Group (WEG) still active and due to the price pressures a lot of out of date Danish technology was installed because it was cheaper than anything WEG could provide. Some WEG equipped farms were built but they suffered failures. • NEG Micon bought the British Wind Energy Group in 1998 which effectively ended a domestic wind turbine manufacturing sector.

Current status of Marine Energy Industry

What is clear from the onshore wind example is that a mixture of consistent financial and political drivers must be coordinated to successfully capitalise upon first mover advantage and secure long-term socio-economic benefit. Table 3.2 compares the progress to date that the UK and the USA have made in securing first mover advantage in establishing a marine energy industry.

For the short term it is apparent the UK has established both political and financial support signals for development of a marine energy industry, yet lack of a clear and enduring vision means that the UK runs the risk of only securing minimum long term economic benefit. The USA by contrast has started to realign its energy priorities since the establishment of a new administration and is in the process of developing a long term holistic support plan for marine energy. A recent review of the sector also outlines that many other countries including Canada, Spain, Ireland and Portugal are in the advanced stages of developing favourable political and market support environments.[40]

The Carbon Trust suggests that one of the key actions for the UK to secure long term socio-economic benefits is to minimise costs of the technology through innovation support, in coordination with developing a stable financial framework.[41]

38. Aquamarine Power, 2010. Danish wind 1980-2010: lessons for the British marine energy industry
39. Krohn, S., 2002. Danish Wind Turbines: An Industrial Success Story. Danish Wind Turbine Industry Association. http://www.talentfactory.dk/media(483,1033)/Danish_Wind_Turbine_Industry,_an_industrial_succes_story.pdf Viewed - 30/09/2010
40. Garrad Hassan America, Inc., 2009. Wave Energy Technology Review, Utility Market Initiative.
41. Carbon Trust, 2009. Focus for success - A new approach to commercialising low carbon technologies.

Key Lessons Learnt

Whilst there are analogies to be drawn with the manner in which public support aided development of the onshore wind industry,[42] RenewableUK believes that the following factors will drive a different route to industry development for marine energy:

1. Early wind turbine technology development could be made with modest investment. In contrast the existing wave and tidal energy devices deployed to date possess a rated power output up to 30 times greater than the first prototype wind turbines from the 1970s and are aiming to deploy in some of the worlds harshest marine environments.

2. Consenting a small-scale wind turbine was relatively simple compared to the legislation that wave and tidal energy projects currently face from a developing regulatory framework.

3. Restricted grid access is already causing delays for marine energy projects.[43]

With this in mind the key lessons the UK marine energy industry could learn from the development of onshore wind can be summarised as:[44]

1. First and Next Generation Prototype - TRL 1-7 - Up to 1MW

- Leaving technology development entirely to a market route is likely to be slower than necessary for the UK to secure a significant market share.
- To drive knowledge transfer a mandate should be placed on recipients of substantial sums from a market stimulation programme or some other fiscal instrument to make generic scientific measurements and, as far as possible, to share those measurements within IP constraints.

2. First Wave and Tidal farms - TRL 8-9 - 2-10MW

- Incentives should be provided to encourage industrial investors to enter the sector. Such companies are able to take the longer term view required for marine energy technologies, and will provide more effective support than Venture Capital, which tends to require faster returns than marine energy companies can provide.

3. Second Farms and Beyond - TRL 8-9 - 10MW+

- Provided the technology can demonstrate success at the first farm stage, market incentives will generate a viable industry in due course, if they are sufficiently generous and providing the technology is adequately supported initially until it can demonstrate success.
- Early visualisation of a generous, consistent and long term supported market in the UK will be the single most powerful means of encouraging both a UK industry and a large UK installed capacity.

42.Aquamarine Power, 2010. Danish wind 1980-2010: lessons for the British marine energy industry.

43. RenewableUK, 2010. Marine Renewable Energy - State of the Industry 2010.

44. Garrad, A., 2011, Phil. Trans. R. Soc. A, in press.

Table 3.2 - A comparison of the socio-economic framework in which the current marine energy industry is developing in the UK and the USA

UK	USA
Political	
• Revenue support administered through banded Renewable Obligation Certificates (ROCs). Scotland currently offers the most attractive support levels anywhere in the world.[45] Roughly equating to £170/MWh for tidal energy and £260MWh for wave energy.[46] • £205m committed in R&D and infrastructure 2000-2010 [47] • The Coalition Government have committed to "Introducing Measure to Support Marine Energy".[48] • Decisions from the 2010 comprehensive spending review[49] and renewables obligation banding review[50] provide a key opportunity to establish a delivery plan and secure long term benefits.	• Revenue support via renewable electricity production tax credit. This equates to $11/MWh.[51, 52] • Marine Renewable Energy Promotion Act of 2009 - Requires the Department of Energy (DOE) to establish a program of marine renewable energy research, separated from the Wind and Hydropower program.[53] • R&D spend increased significantly in 2008 and in 2010 $34m was committed by the DOE.
Economic	
UK	USA
• Government indicated intent to significantly cut future public spending.[54] • Already established marine and offshore industry capable of adapting to secure significant section of value chain.[55]	• The USA is starting to deliver a clear policy to drive renewables under the new administration. [56, 57] • Existing manufacturing industry capable of securing economic benefit from developing the sector.
Social	
UK	USA
• Early engagement, public meetings and consultation held in order to manage expectations. • Developing marine planning and licensing system and SEA planned for completion in 2011.[58]	• Varying levels of coordination for marine planning and licensing.[59] • In the process of streamlining federal and state licensing process.[60, 61]
Technical	
UK	USA
• World Leading testing facilities • No current drive toward consensus. • Early support has failed to provide the industry with a long term stable framework in which to further develop system reliability and gain a lead over other nations. • Poor grid access and high associated charges.[62]	• Recently established National Marine Renewable Energy Centres.[63] • Coordinated Water Power Programme currently developing multiyear program planning long term R&D priorities focused on driving consensus. [64]

45. http://www.scotland.gov.uk/Publications/2010/09/06152625/2 Viewed - 13/10/2010
46. Based on a ROC price plus Recycle of £45/MWh and LEC of £37.5/MWh
47. RenewableUK, 2010. Marine Renewable Energy - State of the Industry 2010
48. http://programmeforgovernment.hmg.gov.uk/files/2010/05/coalition-programme.pdf Viewed - 13/10/2010
49. http://www.hm-treasury.gov.uk/d/spending_review_framework_080610.pdf Viewed - 13/10/2010
50. http://www.decc.gov.uk/assets/decc/What%20we%20do/UK%20energy%20supply/Energy%20mix/Renewable%20energy/policy/renew_obs/1_20100331174250_e_@@_RObandingreviewprocess.pdf Viewed - 13/10/2010
51. http://www.irs.gov/pub/irs-pdf/f8835.pdf Viewed - 13/10/2010
52. http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US13F&State=US&ee=1&re=1 Viewed - 13/10/2010
53. http://www.oregonwave.org/resources/legislation/ Viewed - 13/10/2010
54. http://www.hm-treasury.gov.uk/d/press_04_10.pdf Viewed - 13/10/2010
55. RenewableUK, 2010. Rebirth of UK Manufacturing: An Opportunity for a World-class Industry
56. http://www.oregonwave.org/resources/legislation Viewed - 13/10/2010
57. American Clean Energy and Security Act of 2009 (H.R. 2454).
58. http://www.offshore-sea.org.uk/site/scripts/news_article.php?newsID=42 Viewed - 13/10/2010
59. http://www.oregonwave.org/wp-content/uploads/Licensing-and-Permitting-Study.pdf Viewed - 13/10/2010
60. http://www.acore.org/files/pdfs/Renewable_Energy_in_America_Aug2010.pdf Viewed - 13/10/2010
61. http://www.boemre.gov/offshore/RenewableEnergy/PDF/FinalRenewableEnergyRule.pdf Viewed - 13/10/2010
62. RenewableUK, 2010. Marine Renewable Energy - State of the Industry 2010
63. http://www1.eere.energy.gov/windandhydro/news_detail.html?news_id=16248 Viewed - 13/10/2010
64. http://www1.eere.energy.gov/windandhydro/pdfs/48104.pdf Viewed - 13/10/2010

4. Private Sector Investor Perceptions of the UK Marine Energy Industry

As suggested from the review of lessons to be learnt from the development of onshore wind, there are two distinct communities with which the marine energy industry should engage to ensure continued financial support.

Due to differing drivers for interest and investment, it has been suggested that engagement should be sought for the following objectives:

1. The investment community ('angel', venture capital, private equity) with sufficient capital should be encouraged to continue to support technology developers during their prototype development.

2. Industrials (Utilities and Original Equipment Manufacturers) should be encouraged to continue to invest their capital and skills in the marine energy industry throughout the next phase of development, towards the consolidation and growth of the sector, in particular to fund initial array development.[65]

Perceptions of the UK Marine Energy Industry from the Investment Community[66]

Research commissioned by the Department of Energy and Climate Change to understand the appetite of the financial community toward marine energy resulted in 21 institutions taking part in interviews in January and February 2010. The sample consisted of Banks, Corporates, Venture Capitalists and Angel investors. Their key involvements and perceptions are summarised in Table 4.1

Overall 16 organisations had a generally positive view of marine energy, stating that the UK has excellent marine resource, a unique opportunity for a market leading position, strong policy and early stage financial support from government.

The overall negative perceptions focused upon issues relating to the high demand for capital in technology development, the high costs of start-up to commercialisation and the lack of funding between research phase and full scale operation. One of the key conclusions which can be drawn from this survey is that whilst it is evident that these institutions are watching the sector, there are key barriers which are preventing them from investing with confidence.

To try to understand what these barriers are, interviewees were asked what would make investment attractive. The top three responses related to an enhanced, secure and long-term political and financial backing. Table 4.2 provides a summary of these responses. The interviews also highlighted key economic, political, technical and social critical showstoppers which can be viewed in table 4.3.

From the responses provided it is evident that a combination of grant and revenue support with available grid access can help drive activity from the investor community, whereas removal of these incentives and potential environmental opposition are the critical show stoppers.

It can be concluded that whilst there are a number of investors interested in the sector, their key driver for investment is generally short-term financial return; an approach that does not match the long-term development needs of the industry that must be overcome if the industry is to succeed.[67]

65. DECC, 2010. Marine Energy Action Plan Executive Summary.

66. Kreab Gavin Anderson, DECC Wave & Tidal Investor Perspective, 2010 - Presentation at RenewableUK Wave & Tidal 2010.

67. Garrad, A., 2011, Phil. Trans. R. Soc. A, in press.

Table 4.1 - Summary of Investment Community Views of Marine Energy Industry

Banks	• All are involved in renewable investment. • Most invest in proven technology and larger scale opportunities. • Sector currently viewed as small and fragmented.
Venture Capital	• Investment timescales do not match typical fund requirements. • Most are familiar with sector - and viewed it as exciting, promising or interesting. • The most concerning issues are: technology risk, no standout product, economic viability, market fragmentation, scalability and better investment opportunities elsewhere.
Angel Investors	• One actively investing in wave and tidal - others less interested. • Wave is seen as potentially scalable, high risk but with high potential. • Tidal is seen as less risky - but may be effective in smaller-scale applications.

Table 4.2 - Key enablers drive activity from the private sector investment community

Ensure Targeted Funding	• Funding for infrastructure support was suggested to focus on enhancing test sites. • Of 12 respondents 8 believe public sector support increases chances of further investment. • Many considered that increased levels of funding delivered via a number of mechanisms including a dedicated Marine fund or Green bank is required to fill the early stage / VC gap and promote inward investment.
Revenue Support	• Majority supported a RO banding review with a need for increased RO banding levels in England and Wales. • A small minority suggested feed-in tariff for early stage deployment was more appropriate.
Angel Investors	• Ready grid connections and reduced Ofgem charges are needed. • Assistance with project permitting is needed. • The involvement of utilities and major industrials should be promoted. • More clarity around long term leases is needed.

Table 4.3 - Issues Deemed to be Critical Showstoppers by the Private Sector Investment Community

Political	• Lack of funding. • Removal of ROC support.
Economic	• Achieving competitive price for marine energy. • Highly capital intensive. • Low rates of return. • Experience of existing developers - costs exceeding expectations.
Social	• Environmental opposition.
Technical	• Grid connections. • Proving consistent and reliable technology.

Perceptions of the UK Marine Energy Industry from the Industrial Community[68]

Kreab Gavin Anderson was commissioned by RenewableUK in July 2010 to undertake a survey of utilities and original equipment manufacturers (OEMs) to understand their involvement in and attitudes towards the wave and tidal sector. A total of 19 interviews were held in August and September 2010. Respondents included the following OEMs and Utilities

- OEMs - ABB, Fred Olsen, BAE Systems, Bosch Rexroth, Rolls-Royce, Siemens and Voith.
- Utilities - BP, Centrica, EDF, E.ON, EDP, ESBI, Fortum, International Power, RWE Npower Renewables, SSE Renewables, Scottish Power Renewables and Vattenfall.

Current Involvement

17 of the 19 organisations are actively involved in the sector, either as investors or in an advisory capacity. The majority of respondents were generally positive about the potential future opportunities within the sector, although most believe that it will take years to achieve projects of commercial scale.

"Our strategy for marine energy is more a feasibility project to see if there is a business in developing tidal and wave Our strategy is to undertake demonstration projects and then get an idea of what the costs, risks and difficulties are. Once we run a project we have a better view on whether we should have a much bigger involvement."
UTILITY

Table 4.4 - Potential Barriers to Future Progress as Viewed by the Utility and OEM Community

Political	• Need for greater government clarity. • Sector underfunded - level of support / capital grants insufficient. • Confusion over ROCs discrepancies between wave and tidal, England, Wales & Scotland.
Economic	• Relative costs compared to offshore wind. • Competition for internal resources. • High level of cost required for commercialisation. • Future cost of energy.
Social	• Need for costly and extensive environmental monitoring. • Need for improved communications between stakeholders
Technical	• Poor grid access. • Lack of commercial industry participants, e.g. installers and EPC contractors. • Lack of Clarity on Technology risk, resulting from insufficient projects at scale and certainty of reliability.

Ten utilities have already committed funds to the sector - either via direct investment in device developers and/or prototypes or pre-commercial projects - due both to the excellent UK resource and the potential for the industry to become globally relevant. Others are currently less active, due either to limited internal resources, uncertainty about economic viability or the length of time needed for the industry to mature.

"We as a utility are of course users of technology and not developers of technology ourselves. In this ocean area we are trying to follow the market a bit sooner than wind."
UTILITY

"There's a Catch 22 here - the device companies struggle with levels of funding to get to a commercial solution - in rough terms £50-60m. As a consequence the utility companies are quite nervous and want someone like us, who is going to be around in 20 years, to get involved."
OEM

A wide range of issues were cited as being potential barriers to future progress. Answers were given spontaneously, and most were only mentioned by one or two participants (Table 4.4). However, three or more individuals cited their main concerns as being the lack of government clarity and consistency (particularly on support mechanisms), issues relating to technology and reliability, and the high level of funds required for commercialisation.

68. Kreab Gavin Anderson for RenewableUK, 2010. Marine Energy - Utility & Supply Chain Survey.

Inevitably, given the lack of specific information from the Government since the election, several participants expressed concern and confusion over the coalition Government's level of support for the industry and the structure of financial incentives going forwards.

"The main issue is the confusion over the Renewable Obligation Certificate (ROC) system and indecision over what is happening there from a government perspective. Government needs to encourage the industry, not discourage it… potentially investors are hanging back because of the uncertainties. There needs to be a long period for stable investment."
OEM

Clearly, the risk profile of the industry and the high cost of development is a great concern to many participants. Uncertainty is also holding several market players back, with some preferring to observe the experiences and mistakes of others before deciding on an appropriate course of action.

"Grid access and expanding the grid is an issue - it takes time to plan for that - and there are issues around the strength of the grid in areas where resources are insufficient, because of the planning and consenting of electricity projects across the country. It is holding us back."
UTILITY

Pre-Commercial Activities

Interviewees stated that they are involved in a range of pre-commercial activities, extending from providing investment for prototype devices through to obtaining sites and putting in planning applications for arrays. The more advanced players are seeking to operate right across the chain of activities - from obtaining consents, to constructing and commissioning demonstration arrays. Others are looking at more specific activities, such as deploying their prototypes into the water, proving the technology works, obtaining reliability data and generally de-risking projects. It is notable that all companies are keen to demonstrate longer term that the projects are cost effective and can create value.

In terms of funding, all participating utilities are spending their own money and three OEMs are also doing so. Eight organisations have obtained or hope to receive grant funding, either domestically (from the TSB, the ETI, the MRPF and/or Scottish WATERS) or from Europe (both at the EU and regional level). None of the respondents mentioned commercial bank funding or project financing, both being premature, although one utility mentioned that funding was available from development banks.

Through a number of the interviews it was apparent that some of the utility companies are starting to appreciate the large amount of money and other resources they will have to spend in order to get to the point where they can actually make money from the wave and tidal sector.

Methods of Funding

Respondents were asked about the different potential types of funding at different stages of technology development. 11 respondents spontaneously said that grant funding is most appropriate for the current stage of the industry's evolution (**First and Next Generation Prototype - TRL 1-7 - Up to 1MW**). Equity co-investment was mentioned by three participants as being useful, with funding from the ETI, TSB, Carbon Trust and MRPF is all felt to be extremely helpful.

Seven individuals spontaneously went on to comment on the importance of a stable long term revenue support system going forwards, with the majority supporting the ROC regime (although there is an obvious desire to achieve alignment between technologies and territories) and some favouring a feed-in tariff for early stages of deployment (First Wave and Tidal Farms).

"For us we believe in multi-ROCS. Once you get to an array-sized project, ROCs do what we need them to do for us to invest. We know ROCs, we understand them, they are sufficient for us… they're enough to make us take the investment decision to go forward."
Utility

Respondents were generally provided lukewarm responses to the suggestion of loan guarantees (only four mentioned them, all negatively) and tax credits were not particularly favoured, due in part to being perceived as less enduring than the Renewables Obligation (RO). There appeared to be no appetite for mezzanine financing, which was viewed as too expensive, or for capital guarantees.

Due to the evolving nature of the wave and tidal industry, and the fact that it is still essentially at the first and next generation prototype stage TRL 1-7 - Up to 1MW, there was relatively little discussion about commercial bank funding. The consensus focused around the fact that technologies are still being tested so more traditional forms of bank lending simply are not an option because the lenders generally do not yet have a sufficient level of comfort about the ability of companies to be able to repay the money in the future. Three respondents expressed a concern about the apparent funding gap between early stage development and commercialisation. Finally, one utility made a request for either DECC or RenewableUK to assist the industry in producing a guide to finding sources of finance.

"I would almost describe it as a taper. At the early stages of R&D, it's very much grant, up-front capital funding for projects because you know that there's going to be no revenue. As the sector moves to commercialisation you can probably shift to 100% revenue support. Once things have commercialised, investors will take a risk on the capital on the basis that you can get revenue support for the project."
UTILITY

First Wave and Tidal Farms - TRL 8-9 - 2-10MW

When asked a more specific question about funding for first wave and tidal farms, 14 individuals answered the question and all responses were spontaneous. Nine supported grant funding and six mentioned equity investment as being useful. Four expressed support for a combination of grant funding at the outset followed by revenue support as projects move into the commercial stage. Again, the issue of equality of Renewable Obligation Certificate (ROC) regimes across the UK was mentioned.

Loans were felt to be inappropriate, as were mezzanine finance and capital guarantees. As for tax credits, the general view was that these would only benefit the major players. Two individuals added that one of the roles of the proposed Green Investment Bank could be to streamline or coordinate methods of funding.

"For pre-commercial arrays we believe that post-construction incentives are necessary but not sufficient as they do not contribute to getting the arrays installed and commissioned to begin with or address the availability/ performance uncertainty required to support loans and de-risk revenue NPV. They should therefore be supplemented with pre-construction incentives. There are several advantages including a greater potential capital contribution from government / The Crown Estate co-investor as they can share in revenue as opposed to simply writing off a cash injection."
UTILITY

Respondents were asked what other features of funding were important. A significant number of participants (12) took the opportunity to mention the disparity between the ROC regimes in Scotland versus England and Wales. The other issue of major significance (mentioned spontaneously by 10 respondents) is the requirement for clarity on future revenue support mechanisms and consistency of the messages from Government. As one respondent said, "political certainty means funding certainty."

Investment Timetable, ROI and Features of a Successful Global Marine Industry

Respondents were asked about their investment timetable and how long they would be prepared to commit to the sector before expecting to see a return on investment. None of the respondents who answered this question expect to make a return within the next five years as there is an expectation that returns will take between five and ten years.

"This industry has to come out of the embryonic stage to the commercialisation stage within five years, otherwise investors will say they have to go elsewhere. The reality is it will take longer if we do not get the impetus. If you want to accelerate this thing it has got to have the financial climate to be able to drive investment, and that has to be over a five year cycle."
OEM

Most participating utilities and some OEMs take a flexible approach at this stage. Those who are most active believe their development spend can be contained and do not view the initial costs as too onerous yet. However, for some, the level of spend is only acceptable as long as progress can be seen to be made. A smaller number of participants expressed some doubt that the level of returns would be acceptable or commercial projects achievable.

Those individuals who commented on the longer term would expect commercial projects to generate a return over 20-30 years. As the risks diminish and costs reduce, so would the targeted returns. At the commercialisation stage all participants will take a harder view on their return on investment.

To continue investment respondents felt that a successful global marine energy industry would contain the following elements:

- The active involvement of industry majors able to offer commercial contracts with warranties and performance guarantees and increase reliability and durability (12 respondents)
- A healthy supply chain (5)
- A sizeable number of megawatts installed (4). Target numbers ranged from 10-20 GW in the UK, to 50 GW installed globally by 2030.
- Industry consolidation resulting in a smaller number of mature technologies appropriate for a variety of locations (8). 4-5 devices per category is felt to be the optimum number, as this would

- focus available capital but at the same time help maintain a competitive environment.
- Comparative levels of competitiveness with other renewable technologies, particularly offshore wind (4)

Government Non-Fiscal Measures and Industry Action for Encouraging Private Investment

Respondents were asked what non-fiscal measures the Government could provide to increase private investment. In the context of the key political, social and technical drivers considered in Chapter 2, respondents answers focused upon the technical, providing improved grid connectivity and reduced transmission charging (13 respondents), and the social - arranging a fast, transparent consenting and licensing process (12)

"Government can assist in a number of ways, primary among which is the accelerated establishment of Marine Energy Parks. As with National Parks, which are set up to promote heritage objectives and regulate other developments which impact on these objectives, we believe that geographic areas should be set aside as Marine Energy Parks within which marine energy objectives are set and other developments/activities are regulated to minimise the adverse impact on the development of marine energy."
UTILITY

Finally, respondents were asked what the industry could be doing to encourage more active private investment. The most important action was thought to be increasing the level of transparency amongst developers with realistic expectations, credible testing and operations reporting (10 respondents). Two further key actions focused around the involvement of large industrial players (3) and industry collaboration (3). These suggestions are in line with the priorities outlined in points 4 and 5 of the key lessons learnt from the onshore wind industry highlighted in Chapter 2.

"We would be a supporter of standards, for instance looking at how you measure the performance of devices… There are far too many technologies out there and they need to come together. There is not enough finance for everyone."
UTILITY

"Be united. The industry is confused, investors are confused. Government representatives are confused simply because each developer presents their own story as the solution. RenewableUK is doing a good job here - it's a very good start and I admire their efforts. They need to... help unite the industry."
OEM

Conclusions

From reviewing the activities and perceptions of private sector investors it is apparent that many of the views and opinions echo the suggested lessons which should be learnt by the marine energy industry from the development of the onshore wind industry. These suggestions could be translated into specific actions for the three stages of industry development as follows:

1. First and Next Generation Prototype - TRL1-7 - Up to 1MW

- Policy certainty results in investment and the coalition government should identify and clearly articulate how they will support the sector.
- Capital grants are deemed to be the most effective way in which to offer pre-commercial technology support.
- Technology developers need to be more open with information and share their learning experiences.

2. First Wave and Tidal farms - TRL 8-9 - 2-10MW

- A combination of grant and revenue funding will be required to attract industrial investors who are able to take a long term engineering and investment perspective.

3. Second Farms and Beyond - TRL 8-9 - 10MW+

- Increased stable revenue support should be established on a unified basis across the UK as soon as possible to ensure continued investment.

5. Costs for Developing Marine Technology

The previous sections have discussed how Government intervention can impact development and reviewed the perspectives of private investors toward the UK marine energy industry.

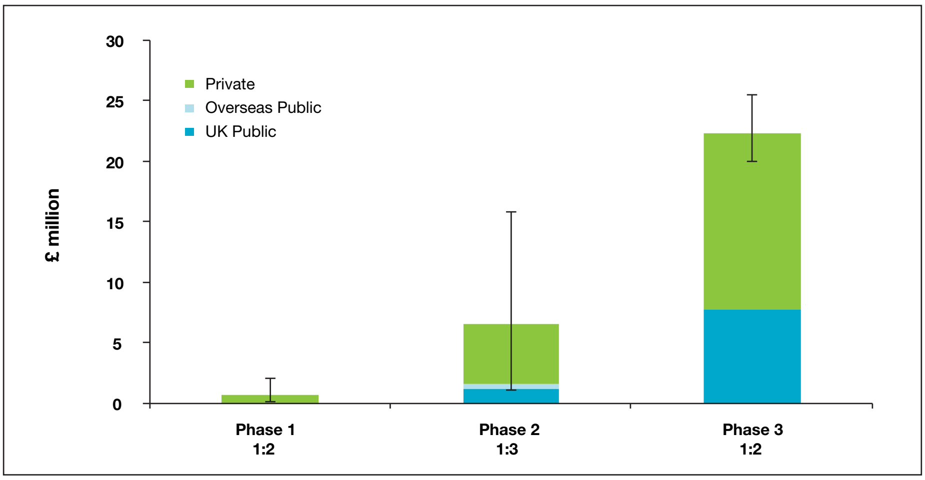
To further aid the development of a coherent policy and financial support framework the following section will examine the effectiveness of government funding to date and present evidence on the cost of technology development for the three stages of industry development

First and Next Generation Prototype - TRL1-7 - Up to 1MW

Marine energy is still an immature technology at a pre-commercial stage of development, with efforts to date concentrating on the demonstration of first generation full-scale grid-connected prototypes.

To understand the estimated cost of developing and proving marine energy devices RenewableUK undertook a survey of technology companies active in the UK.[69] Figure 5.1 depicts the average costs of developing technology from test tank through to first full-scale grid-connected prototype. As stated in Chapter 2, RenewableUK believes that Stage 1 of industry development (First and Next Generation Prototype) can be divided into three specific phases for technology development. In relation to NASA technology readiness levels as follows:[70]

Figure 5.1 - Cost of Stage 1 Industry development, taking a technology from test tank to first full-scale grid-connected prototypes. The ranges apply to the overall cost of each stage and represent the full ranges quoted by the developers. Beneath each bar is the ratio of public to private money.



- Phase 1 - Concept Development and Tank testing (TRL 1-3)
- Phase 2 - Greater-Scale Prototype (TRL 4-5)
- Phase 3 - Full-Scale Grid-Connected Prototype (TRL 6-7)

Whilst we expect the cost of energy to decrease dramatically as installed capacity increase, it is also evident that the costs of developing and proving technology are high. The data collected by RenewableUK suggests that a total average investment of £30 million will be required to take a technology from concept through to construction and installation of the first full-scale grid-connected prototype.[71] This assumes that technology development is sequential and that there is limited need for development iterations during this process.

69. Contributors included - Aquamarine Power, Pulse Tidal, Marine Current Turbines, Pelamis Wave Power, Minesto, Atlantis Resource Corporation and Voith Hydro.

70. NASA, 2010. http://esto.nasa.gov/files/TRL_definitions.pdf Viewed - 15/10/2010

71. N.B. Cost estimates do not take into account additional company overheads (e.g. staff and rates) and are based on deploying only one demonstration per phase.

Members of RenewableUK also provided data relating to the sources of investment, the aggregated proportional split for each phase of development can been seen in Figure 5.3. Angel funding does not exist for any Phase 3 projects and private venture capital continually decreases, whereas the proportion of industry funds and grants increase during the later stages of development. This supports the assumptions made in Chapter 2 and the responses from the private sector investors in Chapter 3, which concluded that industrial investors are required to deliver technologies at scale and that capital grants can stimulate their involvement.

Whilst the UK has invested relatively significant sums on infrastructure and test centres, relatively limited amounts have actually been spent on device R&D to date, with the funds allocated in the last year being broadly equivalent to that spent in the last decade.

Initial work reviewing the delivery of a long term marine energy financial support framework highlighted three funding gaps in the UK's existing support framework, which correlate to the stages of industry development outlined in Chapter 2 (Figure 5.4).[72]

Since the publication of the work from Figure 5.4, the UK and devolved Governments have committed an estimated £51m in Stage 1 of industry development (Figure 5.5).[74, 75, 76, 77, 78]

Figure 5.3 - Sources of funding for marine technology development

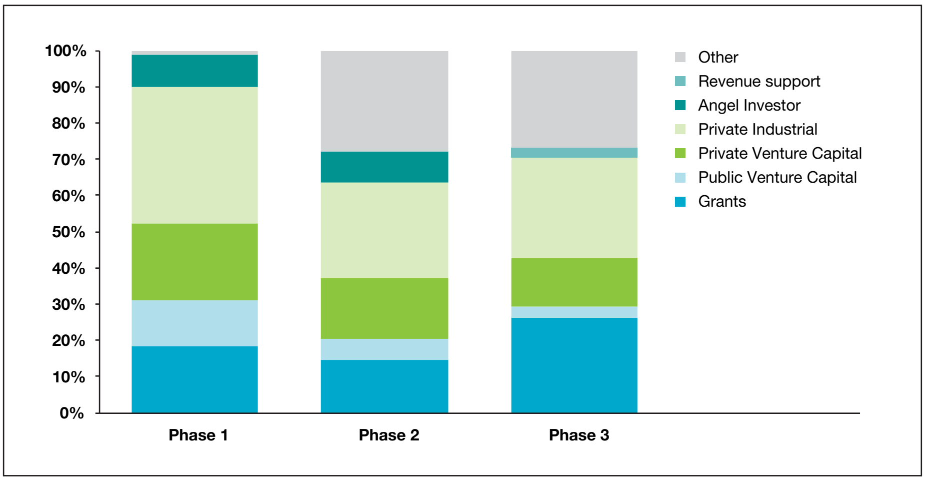
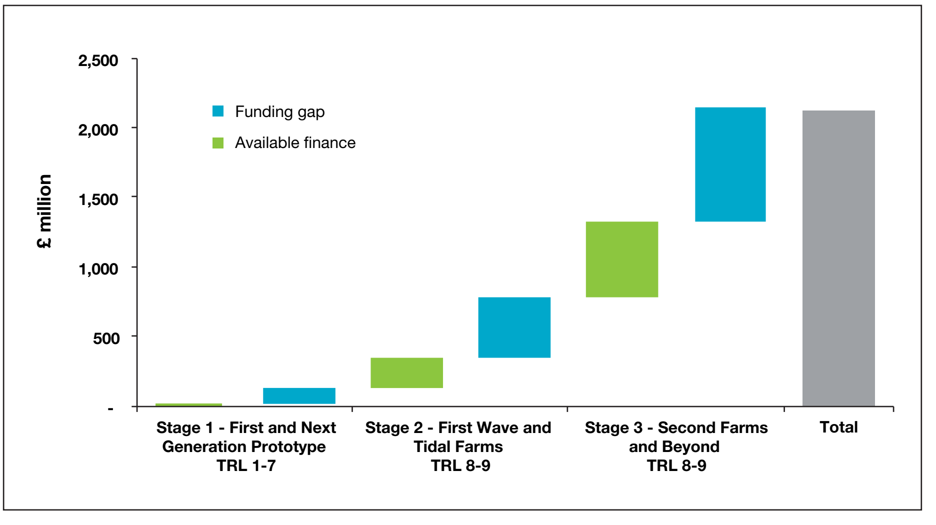


Figure 5.4 –Cumulative support required for the UK to reach early deployment.[73]



72. Carbon Trust, 2009. Focus for success - A new approach to commercialising low carbon technologies.
73. Carbon Trust, 2009. Focus for success - A new approach to commercialising low carbon technologies. P 75. Investment analysis assumes process of selection which starts with 21 devices in the development phase (Stage 1), 13 of which make it to the demonstration phase (Stage 2), then 11 devices enter MRDF (at 10MW scale) operating for five years of which 9 devices go on to operate post-MRDF (at 20MW scale) for a further 10 years (Stage 3) - giving total operating capacity at this stage of 180MW.
74. Marine Renewables Proving Fund (£22m) - http://www.carbontrust.co.uk/emerging-technologies/current-focus-areas/marine-renewables-proving-fund/pages/default.aspx Viewed - 15/10/2010
75. Scottish Enterprise - Wave and Tidal Energy: Research, Development and Demonstration Support fund (£13m) - http://www.scottish-enterprise.com/your-sector/energy/energy-support/energy-funding/energy-grants/Wave-and-Tidal-Energy-Fund.aspx Viewed - 15/10/2010
76. Technology Strategy Board (Round 1 £7m allocated and Round 2 £3m) - http://www.innovateuk.org/content/competition/wave-and-tidal-stream-energy-technologies-reducing.ashx https://ktn.innovateuk.org/web/wave-and-tidal/articles/-/blogs/1430493;jsessionid=06156D025B2104F9BB4FA97C135722E5.9OphEwv4 Viewed - 15/10/2010
77. South West Regional Development Agency (£1.5m) - http://www.press.southwestrda.org.uk/2010/07/29/minister-announces-further-investment-in-marine-renewables-during-wave-hub-visit/ Viewed - 15/10/2010
78. Energy Technology Institute (public proportion £4.6m) - http://www.energytechnologies.co.uk/Home/Technology-Programmes/marine.aspx Viewed - 15/10/2010

This has resulted in at least 21 new projects being initiated, with collaborations between technology developers, world leading academic institutions, utilities and a number of OEMs.

First Wave and Tidal Farm - TRL8-9 - 2-10MW

Once technology developers have proven a device at full scale in open sea environment, the next stage of development is the deployment of the first marine energy arrays.[79] The cost for these projects, in comparison to the deployment of single devices, is an order of magnitude higher. An estimated £432m funding gap has previously been highlighted (Figure 5.4: Stage 2 - First Wave and Tidal Farms - TRL 8-9 -2-10MW),[80] this figure is derived from development of 11 projects at 10MW per project with revenue support of 2 ROCs/MWh and allocation of the existing £42m Marine Renewables Deployment Fund (MRDF).

The costs of a marine energy array can be broken down into cash flow deriving from capital expenditure, revenue and operation and maintenance. Currently in England, Wales and Northern Ireland wave and tidal energy projects receive revenue support of 2 ROCs/MWh. In Scotland the revenue support is 3 ROCs/MWh for tidal and 5 ROCs/MWh for wave.

To understand the estimated Capex and Net Present Value of developing and operating the first wave and tidal farms, RenewableUK surveyed six utilities active in the marine energy sector.[81] The results outlined in Figure 5.6 show how the estimated Capex ifor stage 2 of industry development ranges from £39m for a 5MW project to £58m for a 10MW project.

Figure 5.5 - Investment made into Stage 1 of industry development by central and devolved UK governments 2009 - 2010

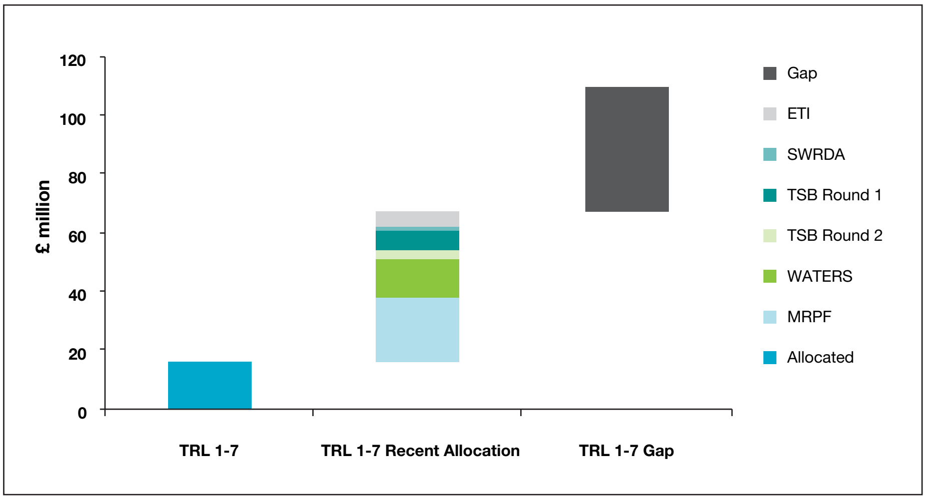
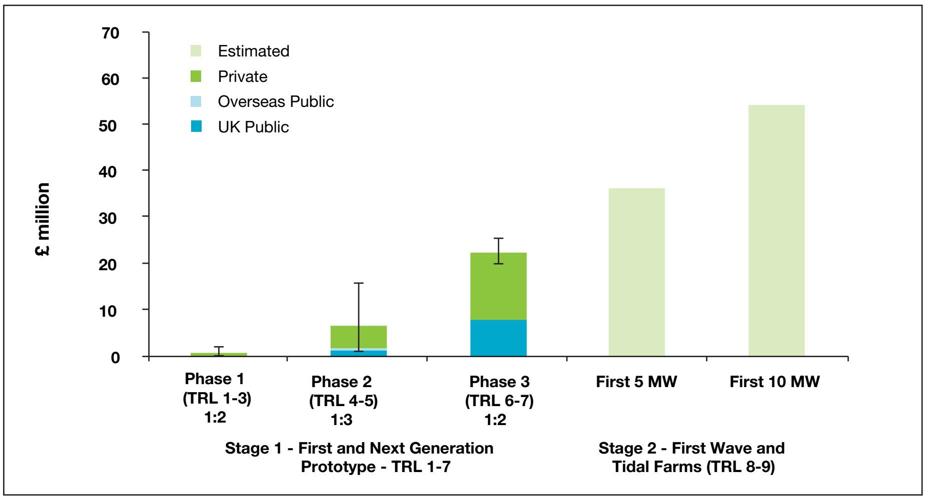


Figure 5.6 - Estimated Capex for First Wave and Tidal Farms.



The survey of the utilities also included analysis of NPV versus the level of ROC support. This was done using a harmonised methodology across all six utilities. Table 5.1 (Wave) and Table 5.2 (Tidal) outline the results.[82]

From this analysis it is apparent that if the levels of banding in England and Wales were to remain at 2 ROCs, the level of capital required to make up the short fall for the first wave and tidal farms is between £27m and £43m. By contrast a wave energy project in Scotland will require capital support in the region of £15m and £23m in order to break even.

79. Hydraulics and Maritime Research Centre, University College Cork, 2003. Ocean Energy Development and Evaluation Protocol.

80. Carbon Trust, 2009. Focus for success - A new approach to commercialising low carbon technologies.

81. Contributors included: SSE Renewables, Scottish Power Renewables, International Power Marine Developments, E.ON, RWE Npower Renewables and EDF*

82. Revenue is derived from sale of electricity via a PPA, ROC prices, ROC buy back and LEC.

Table 5.1 - Net Present Value of a 5MW and a 10MW wave project receiving varying levels of ROC support.

Revenue support	NPV 5MW	NPV 10MW
2 ROCS	-£28m	-£43m
3 ROCS	-£24m	-£36m
4 ROCS	-£20m	-£29m
5 ROCS	-£15m	-£23m

Table 5.2 - Net Present Value of a 5MW and a 10MW tidal project receiving varying levels of ROC support.

Revenue support	NPV 5MW	NPV 10MW
2 ROCS	-£27m	-£41m
3 ROCS	-£23m	-£34m
4 ROCS	-£18m	-£28m
5 ROCS	-£14m	-£21m

These figures are based on the following assumptions which were derived via industry consultation and consensus:

- 10MW sites
- Based on an average of estimates supplied by industry members of Capex and Opex for a 10MW project:
  - Wave Capex is approximately £54m (Range £42m - £82m) and Opex is estimated at £2.2m/y (Range £0.9m/y - £4.2m/y).[84]
  - Tidal Capex is approximately £54m (Range £43m - £84m) and Opex is estimated at £1.9m/y (Range £1.2 m/y - £2.2 m/y).[85]
- In order to take into account economies of scale 5MW figures are based on dividing 10MW figures by a factor of 1.5.
- A two year development cycle with a spend profile of 30% Capex in year -2 and 70% of Capex in year -1 of first power.
- 25 year project life with decommissioning thereafter.
- Calculations are based on notional locations in UK waters.
- Discount rate of 15%.
- Industry-estimated approximate capacity factor used is 30% - (Ranges; Wave 30 - 35% / Tidal 26 - 35%).
- ROCs are assumed to be worth £45/MWh with recycle.
- Base electricity including LECs is worth £37.5/MWh.
- Tax is excluded, and income and costs are assumed to change similarly with inflation.

These assumptions are consistent with other analyses in previous RenewableUK reports and the model was truth tested against RenewableUK's best estimates for costs of offshore wind. It must be emphasised that a first farm at 5-10MW is still at the demonstration level and is not expected to be commercially viable at the present stage of industry development.

Second Farms and Beyond - TRL8-9 - 10MW+

As globally installed capacity increases, costs can be expected to reduce. Previous reports have concluded that each doubling of capacity will result in a reduction of cost of 10% to 15%. Provided that development is continuous and uninterrupted, it is expected that a cost of energy of between £75/MWh and £125/MWh can be reached when 1GW has been installed globally per technology. This is deemed to be competitive with other forms of future low carbon energy generation.[86, 87, 88, 89]

Marine and offshore experience gained from working in the oil and gas industries within the UK can be applied and transferred to the marine industry to promote the reduction of costs, improve energy capture and increase the knowledge base. However, if the industry were to find itself in a development hiatus this learning effect could be reversed as the industry begins to 'forget'. It is essential therefore that industry momentum is maintained.

84. The cost range presented reflects the variety of devices currently under development, each with its own optimal performance and cost characteristics. For example, some devices are optimised for high capital cost and high capacity factor, whereas others are the opposite. Also some devices are optimised for low Capex but higher Opex, whereas others have high Capex with low Opex. This diversity is to be expected and is an indicator of healthy competition to identify the overall optimum configurations.
85. IBID.
86. Carbon Trust, January 2006. Future Marine Energy. Results of the Marine Energy Challenge: Cost Competitiveness and Growth of Wave and Tidal Stream Energy.
87. Ernst & Young, April 2007. Impact of Banding the Renewables Obligation - Costs of Electricity Production.
88. RenewableUK, 2010. Marine Renewable Energy - State of the Industry 2010
89. Energy technology Institute and UK Energy Research Centre, 2010. Marine Energy Technology Roadmap

6. Measures to Support Marine Energy

A generous, supported market in the UK will be the single most powerful means of encouraging both a UK industry and a large UK installed capacity.

From the data presented in Chapter 5 it is apparent that the costs of developing marine energy technology are high. Yet encouragement can be drawn from the fact that the results of Chapter 4 and the key lessons to be learnt highlighted in Chapter 3 suggest that the correct private sector investors are engaged. The UK now has a five year window in which to capitalise upon its established first mover advantage.

During the period of 2009 to 2010 a number of strategic industry and government marine energy coordination reports were published. These documents have already started to outline what may be required to deliver a clear and consistent political and financial support platform.[90, 91] The key areas of consensus lie around following points:

- Ensuring the provision of targeted funding that bridges the technology market gaps in a coordinated manner from the various UK funding bodies, UK government and devolved administrations.
- Confirmation of long term revenue support which is set at a level which provides a strong financial signal to the private sector to invest in marine energy.

The coalition government has clearly stated that it will introduce *"measures to support marine energy"*.[92] This chapter will explore options and make suggestions for delivering a support framework that will allow marine energy projects to reach a point by which they are sustainable on revenue support alone.

The key measures to support the three stages of industry development are considered in turn:

1 - First and Next Generation Prototype - TRL 1-7 - Up to 1MW

Leaving technology development entirely to a market route is likely to be slower than necessary for the UK to secure a significant market share.

In the 2010 Marine Renewable Energy State of the Industry Report,[93] RenewableUK highlighted two reasons as to why developers have not been able to access the MRDF to date: firstly that many developers cannot obtain the funding required to install the first full-scale device and secondly that marine energy device development is challenging, takes a significant period of time and does not allow the opportunity to prove performance onshore before going offshore.

The focused funding provided to industry over the past year has started to tackle the issue of deploying full scale prototypes and has been strongly welcomed. It is expected that a number of devices will advance to the full scale array stage within the next three years.

To continue to address the issues being faced by development challenges, RenewableUK believes that the Government needs to maintain this support to industry through the crucial early years. The TSB call launched in September 2010, focusing upon verifying performance; improving reliability in a real environment; and developing installation, operation and maintenance methodologies, is a good example and will go some way to potentially addressing these issues.

One of the key reasons for the success of the funding allocated over the past year has been communication between funding bodies and improved consultation with industry. Currently however, there are no clear indications that future funding will be made available, creating the risk that

90. DECC, 2010. Marine Energy action Plan Executive Summary.

91. Marine Energy Group, Forum for Renewable Energy Development Scotland, 2009. Marine Energy Road Map.

92. http://programmeforgovernment.hmg.gov.uk/files/2010/05/coalition-programme.pdf Viewed - 13/10/2010

93. RenewableUK, 2010. Marine Renewable Energy - State of the Industry 2010

technology and IP may become stranded, with potentially leading technologies being unable to attract the private finance required to proceed at industrial scale.

One of the key conclusions from Chapter 3 notes that - *To drive knowledge transfer a mandate should be placed on recipients of substantial sums from a market stimulation programme or some other fiscal instrument to make generic scientific measurements and, as far as possible, to share those measurements within IP constraints* - and this should also be borne in mind when allocating future funding.

Recommendations

Recent funding schemes have been highly effective but need to be continued over a number of years to bring technology to the point where the industry can move on to the first arrays.

During the next comprehensive spending review period government must ensure the delivery of targeted funding that continues to bridge the technology market gaps in a coordinated manner from the varying UK funding bodies, departments and devolved administrations.

2 - First Wave and Tidal Farms - TRL 8-9 - 2-10MW

Incentives should be provided to encourage industrial investors to enter the sector. Such companies are able to take the longer term view required for marine power technologies, and will provide more effective support than Venture Capital, which tends to require faster returns than marine energy companies can provide.

The Marine Renewables Deployment Fund (MRDF) was established by the UK Government in 2004 to support the first arrays of devices operating at sea. £42m of the £50m fund provides a combination of capital grant and revenue support for devices. This is limited to a £9m cap per technology/project of which a maximum of £5m can apply as a capital grant based on 25% of eligible capital costs with the remainder being able to be applied as a revenue top up over seven years operation. As a result, from the project owners' perspective to:

a) obtain the maximum revenue support a project would need to be no more than 2-3MW in scale; however to
b) achieve maximum capital support the project would need to cost >£30m.

In practice since these requirements are mutually exclusive, the actual level of support given to a project over the seven years of MRDF support would be much lower than the current £9m cap, meaning that the £42m of MRDF as currently structured would be unlikely to be fully deployed.

Based on the analysis in Chapter 5, table 6.1 outlines the estimated shortfall industry would incur from three scenarios of development. Justification of these scenarios is as follows:

- MRDF Scenario (Four 5MW projects) - Based upon the maximum number of projects the MRDF would be able to support at £9m per project.
- Marine Renewables Proving Fund (MRPF) Scenario (Six 10MW projects) - Based upon developing the six technologies which government has supported to full scale prototype stage via the MRPF.
- Carbon Trust Scenario (Eleven 10MW projects) - Based upon the eleven 10MW projects the Carbon Trust estimate will be required for the UK to secure a significant future market share of the industry.

As Government has already committed to developing 6 full scale prototypes via the MRPF, RenewableUK recommends that at minimum funds should put in place to support these devices deploy initial arrays and advance through Stage 2 of industry development. Failure to do so would result in UK investment benefiting foreign industry development.

It is evident from all of the scenarios in Table 6.1 if high levels of revenue support are not provided to support initial marine energy projects, the level of capital grant required to make up the shortfall will potentially double to a level which may be prohibitive for private investment to overcome.

One of the key recommendations from the MEAP was to retain the current UK-wide MRDF mechanisms or to instigate a similar instrument and to extend its operation to cover new devices reaching demonstration stage in the period 2011-2014. This was also stated in the UK Renewable Energy Strategy published in July 2009 and is an action which RenewableUK strongly supports.[94]

RenewableUK also welcomes Scottish government's recent statement in their Renewables Obligation consultation document that they are minded to allow the provision of capital grants in combination with banded

Table 6.1 - Estimated short fall (net present value) incurred in developing five 5MW marine energy arrays at varying levels of revenue support.

Revenue Support Level	MRDF Scenario (Four 5MW projects)	MRPF Scenario (Six 10MW Projects)	Carbon Trust Scenario (Eleven 10MW Projects)
2 ROCs	-£111m	-£251m	-£459m
3 ROCs	-£94m	-£211m	-£386m
4 ROCs	-£76m	-£171m	-£313m
5 ROCs	-£58m	-£131m	-£240m

94. DECC, 2010. The UK Renewable Energy Strategy, ISBN: 9780101768627. P 143
95. The Scottish Government, 2010. Changes to the Renewables Obligation (Scotland) Order 2010: Statutory Consultation http://www.scotland.gov.uk/Publications/2010/09/06152625/2 Viewed - 15/10/2010

ROC's for marine energy.[95]
In order to have maximum impact on industry development, a change to make MRDF support capital only and banding of the RO to 5 ROCs for wave and tidal technologies across the UK, have been suggested as necessary reforms that would transform the scheme.

An additional alternative option would be to raise the small-scale FiT to 10MW for a limited number of marine energy arrays. The level of FiT support required to assist with such deployments would need to be significant in order to mitigate the high risk and costs associated with deploying such a small array in the offshore environment. This would also have to be coupled with a capital grant mechanism.

Recommendations

UK and Scottish Government should work towards providing a complementary combined grant and revenue package to incentivise utilities and OEMs to invest in and deliver the world's first marine energy arrays in the next three to five years.

Capital funding of £251m is the minimum amount required to support this first build, which will halve to roughly £131m if revenue support is provided at a level of 5 ROCs, the revenue portion of this support could alternatively be provided by an interim FiT.

The capital funding could be potentially sourced from the SRO £186m fund, the MRDF £42m and EU funds (e.g. NER 300).

3 - Second Farms and Beyond – TRL 8-9 – 10MW+

Incentives alone based on energy produced, provided they are sufficiently generous, will provide a viable industry in due course

It is apparent that initially marine energy projects will need at least 5 ROCs for both wave and tidal technology to make them economically viable and to build the UK marine energy industry. This support level can then be reduced in line with increased installed capacity and as the industry learns and becomes more efficient.[96] This should not be seen as a long term enduring support level, rather an enhancement reflecting the initial cost of bringing novel technology to market. In time, the need for support would be expected to decline in line with enhancements in project economics.

Even if increased interim FiT measures were introduced for projects under 10 MW, the long term certainty that an increased revenue incentive at a level of 5 ROCs is still required for project over 10 MW and needs to be confirmed as soon as possible to drive continued utility and OEM investment in current projects.

Recommendations

Scottish and UK Government must provide sufficient, stable and level revenue support at a level of 5 ROCs for both wave and tidal technologies to ensure continued interest from Utilities and OEMs and until the industry has matured.

The above recommendations provide a coherent support framework that should be executed in a coordinated approach. RenewableUK recommends that to achieve coordination and ensure as many as 19,500 direct jobs and a GVA in the region of £800m per is secured by the UK in 2035. The UK Government and the sector should investigate and implement, a mechanism or forum to continue to develop a long-term strategy and delivery processes for the UK marine energy industry.

96. RenewableUK, 2010. Marine Renewable Energy - State of the Industry 2010

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