Tyndall Centre
for Climate Change Research

Tidal stream energy in the UK: Stakeholder perceptions study

A research report by The Tyndall Centre University of Manchester

Carly McLachlan

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Contents

Technical Summary

This report presents the views of a range of stakeholders from the tidal stream energy sector on the barriers and opportunities that the sector faces and which organisations have the responsibility and ability to act on these. Approximately 20 individuals from a range of organisations were interviewed including: trade associations, academic research projects, testing facilities, regional and national government, utilities, funding bodies, regulators, and technology developers. The report identifies areas of consensus and disagreement within the industry. Key findings from the project are summarised below.

Degree of progress: There was a widely held view that the industry is very much 'on the cusp' of significant development. Grid connection by companies such as Marine Current Turbines and OpenHydro as well as the licensing of the Pentland Firth gave a clear backdrop of optimism and confidence to the sector.

Funding: It was widely agreed that the current economic climate made attracting investment difficult for the sector. In addition, the profile of costs in the sector (i.e. high levels of investment to deploy, test and prove a device) makes attracting private investment challenging. The discrepancy in Renewable Obligation Certificates (ROCs) banding between Scotland and the rest of the UK and between wave and tidal devices was much discussed by respondents. Whilst it was broadly (although not exclusively) agreed that the discrepancy within the UK should be redressed, the appropriateness of the difference between wave and tidal was contested.

Testing facilities : Testing facilities in the UK were seen as being world class. However, there were concerns expressed over the cost of accessing these facilities and some developers 'jumping' stages of testing.

Grid: As with many renewables, connecting to the grid was widely seen as a potentially major barrier. Concerns over availability of connection and the cost of that connection were discussed. There were calls for the Government to underwrite grid connection for the industry, giving tidal developments guaranteed and prioritised grid connection when they required it. An alternative suggestion was for developers to form consortia to apply collectively for grid connection in certain areas. Whilst seen as a significant barrier, many respondents stressed that transmission companies were now much more engaged with the sector and a sense of optimism that the issue could be dealt with satisfactorily was evident across the range of stakeholders.

Overpromising: Many respondents from technology developers to Government officials felt that the sector had previously been guilty of 'overpromising' what it could deliver in terms of the speed of technology development and deployment. There was some concern that if claims continued not to be met, government support, private investment and public enthusiasm may wane.

Scotland: The more favourable ROC regime, the early undertaking of an SEA, the significance of marine energy as a part of Scotland's energy needs and political will, were seen by a range of stakeholders to have given Scotland a significant advantage over the rest of the UK. For some interviewees the wealth of marine energy resource in Scotland made this an entirely reasonable situation, for others there was a strong sense that steps must be taken so that the rest of the UK is not 'left behind'.

International Position: Whilst the UK Government and UK stakeholders generally saw the UK as being the 'world leader' in tidal stream and marine energy more generally, this position was felt by many respondents to more 'at threat' from international competition than it had ever been before. China, Portugal, France, Canada, Spain, Korea were noted among the key competitors. Deployment of arrays of devices was seen as a key step in protecting the UK position as was establishing a UK based supply chain to service the world market.

Environmental Impact: The degree to which the precautionary principle should be applied was contested and it was argued by many respondents that some of the environmental monitoring costs would need to be covered by the public purse. Whilst some presented the technologies as 'benign' others stressed that impacts were unavoidable and that the concern must be how best to deal with these.

Networks: The level of design convergence in the tidal sector compared to wave energy led some respondents to argue that collaboration between developers was particularly challenging as they had to distinguish themselves on the detail of operation. However, there was enthusiasm across a number of organisations for collaboration on areas such as: baseline environmental data collection, environmental monitoring, establishing standards and a publicly funded deployment vessel.

Responsibility and Key Actions: Whilst it was widely agreed that the industry had to prove the reliability and efficiency of the devices in real conditions over extended periods of time in order to move to wider scale deployment and commercialisation, the focus of responsibility was presented differently. For some respondents, it was up to developers to prove the reliability and value of the industry to UKPLC, for others the Government had to commit to increased levels of funding in order to allow them to do this. Whilst these two issues are clearly related, the alternative framings imply different policy responses.

1. Introduction

During the rise and fall of the tides that occur twice daily, water flows in and out of estuaries carrying energy with it.[1] These currents can be magnified in particular tidal stream 'hotspots' by features such as headlands, inlets, straits or by the contours of the seabed which work to force the water through narrow channels.[2] Both the speed of the flow and the area of that flow that is intercepted determine the amount of energy that is possible to extract. The concept of tidal stream energy is often presented as 'similar to wind energy' but due to the higher density of water than air, extraction over smaller areas and at lower speeds can yield the same amount of power.[3]

The European Marine Energy Centre (EMEC) classifies the various tidal stream devices under four headings: horizontal axis, vertical axis, oscillating and venturi. A horizontal axis turbine works in a similar fashion to a wind energy turbine, extracting energy from the tidal stream as a wind turbine would from moving air. The vertical turbine operates in much the same way as the horizontal turbine but is mounted vertically. Oscillating devices are hydrofoils attached to an oscillating arm. As the current flows on either side of the hydrofoil this results in movement of the arm. This in turn drives fluid in a hydraulic system. The venturi approach uses a duct to concentrate the flow past the turbine. This flow of water can either be used to directly drive the turbine or the induced pressure difference in the system can drive an air turbine.[4]

As will be discussed in this report, tidal stream energy is often coupled with wave energy, with the two being referred to as 'marine energy'. Tidal barrages are also sometimes included in this term. The Government's Marine Energy Action Plan (MAP) used the term to refer to tidal stream, wave energy and tidal barrage. In the MAP, 1-2GW of installed marine energy capacity by 2020 is presented as a challenging but achievable goal. The British Wind Energy Association's (now RenewableUK) *Path to Power* report stated that 15-20% of UK's electricity could be provided by marine power (wave and tidal stream only) in the first main commercial phase of deployment. Although marine energy is only expected to contribute 3% of renewable electricity in 2020, it is argued in the MAP that given the challenging nature the UK's target of 15% renewable electricity in 2020 "every few terawatt hours of generation will be important".[5]

Although it is a smaller overall resource than wave energy, tidal energy has the benefit of being 'predictably intermittent'. This will allow the output from tidal devices to form part of the system's 'baseload', making it more attractive in this regard than many other renewable energy options (e.g. wind energy).[6] The Carbon Trust believes that the tidal stream sector could contribute 7% of the UK's electricity needs.[7]

The MAP states that total UK practicable tidal stream resource level is thought to be approximately 17TWh/year which is equivalent to approximately 4 million households (the practicable resource level for wave energy relates to approximately 11 million households). The calculations used in the MAP for tidal stream are based on their most conservative assumptions. Other methodologies lead to a higher figure but the MAP argues that even with the conservative approach, the resource level is high enough to warrant significant attention

[1] Carbon Trust, 2006, Future Marine Energy.
[2] European Marine Energy Test Centre (EMEC), 2010, Tidal Devices, http://www.emec.org.uk/tidal_devices.asp
[3] Carbon Trust, 2006, Future Marine Energy.
[4] European Marine Energy Test Centre (EMEC), 2010, Tidal Devices, http://www.emec.org.uk/tidal_devices.asp
[5] DECC, 2010, Marine Energy Action Plan, Executive summary and recommendations, p18.
[6] DECC, 2010, Marine Energy Action Plan, Executive summary and recommendations.
[7] Interview with Carbon Trust Representative

and interest. The full extent of energy that can be exploited depends on various factors such as turbine interactions, device spacing and cumulative impacts. As more devices are deployed in real sea conditions it is thought that a better understanding of the practicable resource will be developed.[8]

The diagram below characterises the development stages of tidal stream (and wave) energy devices.

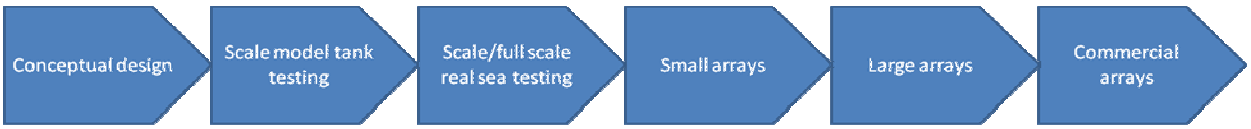

Figure 1 Deployment stages adapted from BWEA's Path to Power[9]

[8] DECC, 2010, Marine Energy Action Plan, Executive Summary and Recommendations.
[9] British Wind Energy Association, 2006, Path to power, available at http://www.bwea.com/pdf/pathtopower/PathtoPower_low.pdf

2. Aims of the study

This study sought the views of a range of tidal stream stakeholders to assess the various barriers and opportunities that the sector faces. Respondents were asked about: the current state of the industry, its prospects for growth, the challenges and opportunities it faces and which organisations have the responsibility and power to take effective action to manage these.

In the Renewable Energy Strategy (RES), the Government announced its intention to produce a Marine Energy Action Plan (MAP).[10] On the 15th March 2010, the Executive Summary and Recommendations of the MAP were launched. The MAP outlines a vision for marine energy out to 2030 (wave, tidal stream and tidal barrage), with reference to 2020 and identifies the actions required by both the public sector and industry to realise that vision. The MAP is organised around various work streams including: Finance & Funding; Technology Roadmapping; Infrastructure, Supply Chain and Skills and Environment, Planning and Consenting. DECC plans to publish a more detailed document in the first quarter of 2011 which will be subject to public consultation. The plan aims to set out a consensus view on achieving the levels of wave and tidal deployment in the RES identifying the barriers, opportunities and challenges that the sector faces. It is conceived of as a 'practical guide on how the environmental and economic benefits of marine energy can be realised'.[11]

Like the MAP, this study aims to identify barriers and actions required by a range of stakeholders but here the focus here is specifically upon tidal stream. However, the study does not set out to provide a definitive or single route map for the industry. Instead, it offers a snapshot of different views on the sector's current position and future potential but does not seek to comment on the validity of these views. It is hoped that this report will offer a useful input to the public consultation phase of the plan. In addition, whilst the MAP was spoken of very favourably by respondents, this study offered an opportunity for respondents to be more openly critical of Government's role and suggest alternative actions that it could or should take. Comments on the report are welcomed and should be sent to c.mclachlan@manchester.ac.uk.

The study was funded by the UK Research Councils (RCUK) through the Tyndall Centre for Climate Change's Transition Funding period.

[10] DECC, 2009, The UK Renewable Energy Strategy, HM Government, July 2009.
[11] DECC, 2010, Marine Energy Action Plan website, http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/explained/wave_tidal/funding/marine_action_/marine_action_.aspx

3. Method

The project was scoped through: attendance at industry events, industry press, media alerts, membership of the North West Tidal Energy Group, publications from Marine Energy Group and The British Wind Energy Association (now RenewableUK), government publications and academic publications. These various sources were used to develop an initial 'topic guide' for interviews covering a range of issues that have previously been identified as potential opportunities and barriers for the industry.[12] A trade body for the sector gave comments on a draft version of the topic guide and suggested some potential interviewees. Potential interviewees were also identified through this scoping process. In addition, a 'snowballing' approach was taken where respondents' suggestions for additional interviewees were contacted.

Approximately twenty one-to-one telephone interviews were conducted with stakeholders from a broad range of organisations between October 2009 and February 2010. These included: trade associations, academics, testing facility operators, regional and national government representatives, utilities, funding bodies, regulators, and technology developers. Interviews were recorded and transcribed and quotes from them are used throughout this report for illustration.

[12] See Appendix 1 for a copy of the topic guide

4. Results

Respondents were asked about a number of different issues for the industry which were identified as potential barriers and opportunities from the scoping stage of the project including: the current state of the industry, the potential of tidal energy, funding, knowledge networks, testing facilities, grid, licensing, consenting & environmental impact, public opinion and support, progress, the grouping of wave and tidal energy, intra-UK differences, international competition and who had the responsibility and capability to take actions to aid the development of the industry. A summary of the responses to each of these areas will now be presented included semi-anonymised quotes for illustration.[13] This will be followed by a more general discussion in the Key Actions and Conclusions.

Current state of the industry

Some general framing questions were asked in order to get an account of the role of the interviewee and their general views on the sector. Respondents were asked to 'characterise the current state' of the tidal stream industry. There were two main ways in which respondents spoke about the industry. Some focused upon those at the leading edge of the sector, those at the 'tip of the spear' as one respondent explained it. There was much discussion about the notion of being on the cusp of fairly significant progress and development in the industry. As these developers are at the point of getting their devices in the water and proving their reliability etc, respondents discussed issues of deployment and the need to make the step to projects that deployed arrays of devices.

> *"...it's now beginning to enter a phase where actually we're starting to – we'll start to see a transition from that sort of more R&D focus through to a deployment and generation focus. I think we've literally – literally been at the last year got to that cusp where things will start to shift across." Government 1*

A number of respondents identified a move away from early stage R&D as a positive sign of the level of development in the industry.

> *"...they're really at that kind of development stage. It's not the stage where you know some guy in his back shed; I mean there are these people – there are these people pottering around doing things but it's – but there's much – it's much bigger than that now" Regulator 1*

However, other respondents discussed the industry in a broader sense, talking about early stage research and development and spoke of the industry very much being in its 'infancy'. Some respondents discussed the stratified nature of the sector directly.

However, regardless of these foci, respondents spoke of an industry with a 'long way to go' and in need of support. The optimism over the potential speed of development in the industry varied. For some, leasing of the Pentland Firth, devices being deployed at EMEC and Strangford Lough and DECC's scoping SEA (a full SEA has since been announced[14])

[13] Individual names and organisations have not been listed - quotes are identified by organisational type

[14] Only once there is an SEA in place will Crown Estates open leasing rounds for areas of seabed – however they will consider specific applications up to 10MW or 20 devices on a case-by-case basis outwith particular leasing rounds

indicated that the industry was well placed. Others felt that the degree of technology development that was still required offered a less optimistic backdrop for the sector.

This question included the term 'industry' and this was picked up for further discussion by a number of respondents. There was a sense that the tidal stream sector (both in the UK and globally) cannot yet be described as an industry and a number of respondents laid out the requirements of an industry – which often mapped to the barriers that they felt tidal stream would need to overcome. This view is demonstrated in the quotes below.

> *"Basically there isn't an industry. With wind power there probably is one. Although it is still at a very early stage. You know when you talk about industry you talk about all the components which means that there is the supply of capital, there is the supply chain, there is infrastructure in place, there is product flowing and there are revenue flows. So all that has got to be there before we say we have an industry. We are really a long way from having an industry." Academic 1*

> *"Using that word 'industry' I think is perhaps a little bit generous. I am not quite sure what the definition of an industry is but maybe people, maybe fledgling industry maybe that's a ... to reflect the technology. It is my view that tidal stream technology is at an embryonic developmental state. Quite a bit pre commercial. Very much as the technology demonstration stage." Testing Facility 1*

Consolidation

Whilst wave and tidal are often grouped together there was a sense that the greater consolidation of tidal stream devices (around three blade horizontal axis turbines) demonstrated that tidal energy technology is more advanced than wave energy technology. Some respondents also believed that the similarity of this design concept to wind turbines potentially made the sector more attractive to investors.

> *"Yeah I mean I – I guess we, certainly we're of the opinion that tidal stream is – is further developed than wave energy in the sense that, there's a lot more design convergence...." Funding Body 1*

> *"The consolidation in tidal may help to bring in investors – people think they are like wind turbines and we understand them!" Testing Facility 1*

Some stated that the industry remained too diverse currently and that further consolidation was required if the industry was to realise its potential.

> *"... I think you know, there has to be a lot of consolidation in the industry. You know, there are just too many players as far as technology companies are concerned; say 140 at latest count." Utility 1*

In terms of consolidation, it was expected a number of 'evolutionary niches' may emerge that would relate to the conditions under which types of tidal stream energy could be extracted (e.g. speed of flow etc).

Current state of sector in Scotland

The more favourable ROC regime, the early undertaking of an SEA, the significance of tidal energy as a part of Scotland's energy needs and political will were all seen to have given Scotland a significant advantage over the rest of the UK and therefore the 'current state' in Scotland was seen more favourably than for the rest of the UK by many respondents. This will

be discussed in more detail in the *International competition* and *Intra-national differences* sections.

Potential of the Industry

Respondents were purposely asked generally about 'the potential' for the tidal stream sector. some respondents sought clarification on what 'sort' of potential this referred to (e.g. jobs, GW, GDP). However, mostly the term was taken to mean the potential level of electricity that could be supplied from the sector. This potential was most frequently referenced back to the Carbon Trust's Future Marine Energy report[15], which gave a potential figure of 15-20% of UK electricity being supplied by wave and tidal stream technologies. Others took a more qualitative approach using terms ranging from: 'huge' and 'enormous' to 'a fairly small part of the whole energy mix'. A representative from the Carbon Trust explained their position on the potential of the tidal sector.

> *"We think that wave and tidal stream can deliver up to 20% of the UK's electricity and we, we believe that around a third of that will come from tidal stream, so something of the order of 7% of the UK's electricity could ultimately be derived from tidal stream. In terms of a timescale, those numbers are obviously sort of for a fully developed industry. We very much think that we'll be in a position to undertake mass rollout of tidal stream technology by 2020, [...] we think by 2020, we will have sufficient confidence in the technology and sufficient understanding about its impacts and benefits to be able to timetable the mass rollout for that." Funding Body 1*

The distinction between what is 'possible' and what is 'likely' given the various factors that will effect the scale and speed of deployment was noted by many of the respondents.

> *"I think it's an aspirational headline figure [15-20% of UK electricity supply]. I mean there will be so many factors that come into the question[...] Again it's difficult to sort of – to give a 'this is where we think it will be, you know, sort of a, you know, X Gigawatt in the water by 2020 because you need to factor in what will the financial support mechanisms be? What will the prevailing economic climate be? Will companies be able to get equity and then project finance? Will there be constraints because of grid capacity?" Government 1*

As noted in the MAP in relation to the 'potential' for the sector, it was stressed that it is necessary only to establish that the resource is significant enough to warrant investment and then 'get on with' deploying devices. Getting a precise figure on the 'potential' for the industry was not important at this stage to some respondents. There were also respondents who felt that previous official estimates (such as the Carbon Trust) were too conservative. This was either felt to be because the devices would be more efficient at extracting energy than had previously been thought or because previous studies on potential had focussed only on high energy areas but that as the technology developed it would be possible to extract from lower energy areas thus adding to the overall potential.

> *"I would expect that as we crack the technology and as we understand more about it the machines will get bigger and they will probably be able to move in to some of the slower moving currents. Just as wind, you don't have to have wind turbines on the top of the windiest mountains you can move them in to some of the lowlands as long as you have got a good steady resource - you can harvest it. If that actually happens we will have a greater energy potential than we currently suspect." Testing Facility 2*

[15] Carbon Trust, 2006, Future Marine Energy available at http://www.oceanrenewable.com/wp-content/uploads/2007/03/futuremarineenergy.pdf

Some respondents stressed that although longer term targets (2030) are commonly cited, urgent action is required if these targets are to be met.

Barriers

After the initial framing questions on the current state and potential for the industry, respondents were asked to identify the barriers that they saw for the sector. This question was initially unprompted, allowing the respondents own framing of the important issues. This was then followed up with prompted topics from the topic guide.

There was a widespread sense that none of the potential barriers that the industry faced were insurmountable. A commonly expressed view was that funding was the key to all barriers – essentially all of the barriers could be overcome if there was the right amount of money available at the right time. For example one technology developer stressed that all barriers essentially come down to cost and that, particularly in terms of Government funding budgets there is not the required magnitude of funding available.

> *"...one of the barriers we have, and it's a really serious one to commercialisation, is a lack of reality in the thinking about what it takes to develop the technology and it does concern me because people don't think long enough term." Device Developer 2*

Other respondents stressed the barrier of technology demonstration. Whilst this is clearly not independent of the financial barrier, it does to some extent place the responsibility differently as it is up to developers to 'prove' their industry's potential.

> *"Yeah I mean what I think the absolutely critical barrier is proving that we have reliable technologies The key critically is getting kit into the water at a proper scale and just showing you can run it consistently in what's actually a really harsh environment. And you know I think that has to be the over-riding priority in terms of the barriers." Government 1*

Funding

Availability, accessibility, flexibility and appropriateness of funding were discussed at length by many respondents. Discussions covered both research and development focussed funding (technology-push) and electricity market mechanisms aimed at incentivising greater penetrations of renewable energy (market-pull). This sections will initially discuss views expressed on the Renewable Obligation Certificate market-pull mechanism before moving on to the technology-push grant funding as well as the attractiveness of the industry for commercial investors.

ROCs

Since 2002, the Renewables Obligation (RO) has been the primary policy mechanism to encourage the deployment of renewable energy. Under the RO, electricity suppliers must produce a specified and increasing proportion of their electricity from renewable sources or pay a buy-out price. Since the introduction of the RO, the level of RO-eligible renewable electricity generation in the UK has increased from less than 2% in 2001 to around 4.4% in 2006. Under the Energy Act (2008), 'banded' Renewables Obligation Certificates were introduced in England and Wales. Previously all renewables obligation eligible projects received 1 ROC per MWh of electricity produced. Under the banded system, different technologies will be awarded different rates of ROC per MWh. Wave and tidal projects will be awarded 2 ROCs per MWh, hydro energy and onshore wind will remain at 1 ROC per MWh. However, in Scotland, under devolved powers, wave energy projects have been banded at 5 ROC per MWh and tidal energy projects have been banded at 3 ROC per MWh. Stakeholders

had a great deal to say on both the difference between Scotland and the rest of the UK and between wave and tidal energy.

There was much support for the concept of banding marine energy ROCs although disagreement remained over the 'right' level of banding. A widely held view was that Scotland was leaving the rest of the UK behind and the rest of the UK must match the higher banding levels of Scotland if there is to be significant development of tidal energy within non-Scottish waters. A ROC banding review has been scheduled by DECC for Autumn 2010. Whilst many stakeholders felt that this review was very likely to both reinstate parity between wave and tidal and to increase banding in the rest of the UK to the Scottish level, this was not universally agreed. In particular, the representative from DECC stressed that any alterations would be based on economic analysis (as opposed to more emotive/ political arguments about being 'left behind' by Scotland which other stakeholders made). In addition, some stakeholders felt that is was entirely understandable that Scotland had a different policy structure to the rest of the UK. This was argued to be reasonable for a number of reasons including: the level of resource in Scotland, the labour market in Scotland (particularly the importance of the oil industry), the significance of marine energy as a proportion of Scottish energy demand and an explicit political desire to attract the marine energy industry to Scotland.

Whilst some respondents were supportive of Scotland pursuing a marine energy agenda independent of the actions of the rest of the UK, a Government representative and UK level trade bodies argued that Scotland may fair better as part of the UK in terms of attracting investment due to an increased resource, increased domestic demand, bringing in a wider pool of skills and more funding being available through the UK Government.

The majority of respondents felt that the difference in banding between wave and tidal in Scotland was not appropriate. Although some stakeholders thought that there was no obvious reasoning behind a different band for wave and tidal, one testing facility representative , said that it was very understandable as the devices are based on different physics. A few respondents suggested that perhaps it was due to the tidal turbines being seen as 'like wind turbines' and therefore a more familiar and mature option.

> *"Nobody has yet convinced me why waves should be – should cost more than tidal. I think that's just a lack of understanding on whoever it was advised them on that. Possibly – well it's a bit like wind power. How difficult can it be? [Laughter]. I suspect that's what the discussion went like." Academic 2*

Others explained that the difference was due to earlier work for the Marine Supply Obligation which found that tidal energy was essentially cheaper than wave energy. When the Scottish Government introduced banded ROCs they used this earlier study to demonstrate the costs of marine energy and argue that state aid rules would not be contravened. The earlier report was referred to by many stakeholders as being out of date. Others argued that tidal developers had perhaps been more optimistic in the information and assumptions that they offered to that study and that this had been to their detriment.

There was much positive discussion of DECC's review of the ROC banding. Respondents were divided on the level of reform they wanted to see. Some argued the most important element of the ROC system is that it offers a *long-term* and *stable* signal to investors and therefore any changes to the regime risked destabilisation. However, two trade bodies argued that due to the relatively small section of the ROC market related to marine energy there was

more flexibility available than in the wind sector without destabilising the market. A couple of respondents argued that as no ROCs have yet been earned through tidal energy, a change at this stage would have little impact. Some respondents also expressed a preference for feed-in tariffs; however, even those in favour of this as an alternative to ROCs, stressed that it was now best to work with the ROC mechanism rather than face the delays that would be involved in trying to change any legislation.

Two respondents stressed that the debate of levels of ROCs was really a distraction from the key issues in the industry. For trade association respondent, mirroring a lack of concern for finding the precise potential for tidal energy, there should not be a delay on trying to find the 'right' level between wave and tidal at this stage. They should both be given five ROCs and changes should be made once more is known about their comparative performance 'in the field'. One funding body argued that the sector had yet to prove its reliability and value to UKPLC, and so this must be the priority before lobbying over the right level of market pull mechanism which they saw as being of importance over the longer term. This stands counter to the importance of the long term signal that other respondents stressed was needed to attract funders well before ROCs could actually be earned.

Technology-push

There are a range of technology-push funding sources that can be applied for in relation to tidal energy projects. These different sources are aimed at different stages of technological development, with funding being available from early stage R&D to deploying devices in real sea conditions. Relevant funding bodies include; the Research Councils, The Technology Strategy Board (TSB), The Energy Technologies Institute (ETI), The Carbon Trust, UK Government, the Devolved Administrations and regional government agencies. [16] Across all of the interviews there was a sense that the current economic climate has made it very challenging to attract private investment to the tidal industry. Funding body representatives in particular talked about the need to achieve the 'right level' of public and private investment for the sector, noting that in the current economic climate this may fall more heavily on the public sector.

> *"[...] it needs to be a sensible blend of public money and private money,[...] what determines a sensible blend is the level of risk that the private community are prepared to take. When times are good in the financial market then perhaps they will take more risk and need less public money to ...temper ...the risk I guess." Funding Body 1*

The profile of costs over the development chain was identified as a particular issue for marine energy. A great deal of cost must be incurred before a viable 'product' is demonstrated due to

[16] For a full account of the different sources of funding available and the stages of technological development that they relate to see:
Forum for Renewable Development in Scotland (FREDS), 2009, Marine Energy Group Roadmap for the Sector, available at, www.scotland.gov.uk/Publications/2009/08/14094700/0
British Wind Energy Association, 2006, Path to power, available at www.bwea.com/pdf/pathtopower/PathtoPower_low.pdf,
UKERC, 2008, Marine Renewable Energy Technology Roadmap, available at http://ukerc.rl.ac.uk/Roadmaps/Marine/Tech_roadmap_summary%20HJMWMM.pdf

the cost of deploying test devices. Many respondents noted the restrictions that the Government had to work under in terms of funding the industry in relation to state aid rules. However, some respondents were frustrated that the Government did not try to test the flexibility of these rules and argued that as the issues of climate change and energy security are so urgent and serious that these rules should be relaxed or abandoned altogether, rather than seeing the current policy framework as 'un-changeable'.

> *"...the UK has decided that this needs to be funded at least to a significant degree by private money as well as public money and private money is obviously particularly hard to come by right at the moment. In the old days we would have simply commissioned this as a government project and made it happen now we are all willing to be tied down by state aid rules and the requirements of the market. I think we have a financing challenge that we have allowed to build up.[...] it does appear that we are trying to tackle the largest threat that humanity has seen for a number of aeons and we are doing it, we are quite happy to be hide bound by you can only have 50% of it from the state - which seems a bit peculiar if we are that keen!" Testing Facility 2*

The amount of technology push funding was generally thought to be too low. In particular, two respondents stated that the marine energy sector received less funding than Scottish Opera. There were also concerns about how arduous the procedures for applying for funding were and the timelines for spending the money allocated. The Marine Energy Group (MEG) part of the Scottish Government's Forum for Renewable Energy Development in Scotland, have supported a 'use it or lose it' (UIOLI) approach so that funding is not tied up by a developer without leading to developments in the field whilst other developers find that there is no new money to apply for. However, one technology developer stressed that the very nature of these projects, with unexpected requirements emerging as the projects develop, means that such inflexibility on spending timescale is potentially very damaging and that funds must be flexible enough to respond to the changing pressures that projects face. This lack of consensus on the UIOLI approach was mirrored by a trade association representative who stated that it received a mixed reception from the industry.

The Carbon Trust recently announced the results of its Marine Renewables Proving Fund competition which supports the building and deploying marine energy devices through providing up to 60% of the capital costs.[17] There was widespread praise from interviewees across the sector that Government and The Carbon Trust had acted swiftly to offer this funding call which was seen to facilitate developers in getting to the point where they could apply to the Marine Renewables Deployment Fund (MRDF) which offers support for arrays and commercial scale projects. The MRDF was widely felt to be too advanced for the sector at this stage and therefore the introduction of the MRPF was very much welcomed. Earlier stage research and development funding through the Energy Technologies Institute (ETI) was generally felt to be ill-suited to tidal developers due difficulties over maintaining the intellectual property of the projects and devices within the developer companies. One respondent called for more transparency on the ETI selection panel membership and the selection process.

[17] Carbon Trust, 2010, *Marine energy ready for mass deployment by 2020* www.carbontrust.co.uk/news/news/press-centre2010/2010/Pages/marine-energy-ready-for-mass-deployment.aspx, 2nd February 2010.

Networks and collaboration

As noted in innovation systems theory, technologies are thought to develop more successfully and rapidly if knowledge can be shared and disseminated throughout the sector.[18,19,20] However, given the competitive nature of the sector and the importance of Intellectual Property to the value of device developers, some respondents were sceptical of any networks being developed. As one device developer explains below.

> *"...we've raised €52 million in our company and, and you know it's – the IP and the technology that has developed is not something that our shareholders are going to be thankful for us to give away too easily. You know it sounds great in principle but I cannot see it working in a – in a commercial world. We are competing." Device Developer 1*

However, other respondents were enthusiastic about the possibility of sharing knowledge and working collaboratively in certain areas.

> *"Up to this point that has been a real issue – it's a bit cloak and dagger, no one really wants to explain exactly what is going on but in the last couple of meetings, we're starting to see a shift change towards a share... you know people are realising, I actually don't need to do everything here. They have found their area that they are honing but there is a whole load of work that is required that companies don't want to do but needs to be done." Trade Association 1*

The areas for potential collaboration which had the most agreement centred on: environmental baseline data collection, environmental monitoring and the development of standards. Work on standards and baseline data collection already underway at EMEC offers the opportunity to see how collaborative approaches could work in the sector. These activities, are aimed at reducing the costs of deployment for individual device developers. A few respondents also argued that public funding should be made available to purchase a deployment vessel for exclusive use of the marine energy sector (in order to avoid direct competition with other offshore installations and offer more flexibility for device developers). There was widespread agreement that if some costs were common to all developers then these should be covered by the public purse.

One academic interviewed, felt that as the industry had moved closer to 'commercialisation' with the involvement of utilities etc, good levels of collaboration and knowledge sharing with the academic community had declined.

> *"...we see UK developers making quite profound mistakes of judgement because they were actually unaware of what the bank of knowledge within the research base was and its – I think there's a growing gap between the research capability and the developmental capability [...] what's happened is you've now got the utilities funding projects and suddenly– the fact that there*

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[18] Foxon et al, 2005, UK Innovation systems for new and renewable energy technologies: drivers, barriers and systems failures, Energy Policy, 33, 16.

[19] Edquist, C., 2001. Innovation policy—a systemic approach. In: Archibugi, D., Lundvall, B.-A. (Eds.), The Globalizing Learning Economy, Oxford University Press, Oxford.

[20] Johnson, A., Jacobsson, S., 2001. Inducement and blocking mechanisms in the development of a new industry: the case of renewable energy technology in Sweden. In: Coombs, R, et al. (Eds.), Technology and the Market: Demand, Users and Innovation.

might be sort of subtle solutions lurking away in a laboratory somewhere tends to have been sidelined to a certain extent and I think we have to reconnect the R & D to the development because that link if not – if it's not broken it has weakened in the last couple of years." Academic 2

Testing Facilities

Testing facilities were thought to be of high quality in the UK and were widely seen as being world leading. In particular, the recent funding awarded by the Department for Energy and Climate Change which will allow development of nursery sites at EMEC and a rotary test rig at NaREC through the Renewable Energy Strategy was praised for offering responsive testing facilities that met the needs of the sector as they emerged and evolved. Some stakeholders from the South West and North West of England felt that there may be potential for test sites to be established in those regions.

A number of respondents spoke of the importance of test facilities actually being used. One respondent raised concerns, that developers were applying for Pentland Firth Leases before utilising all of the testing facilities available. The ferocity of the Pentland resource was argued to make pre-testing particularly important. For others the pressure of both the cost of using the facilities and the deployment and testing milestones that developers may have to commit to in order to attract investment led to the 'jumping' of beneficial testing stages.

Interviewee: "The problem is not so much around infrastructure it is around SMEs being able to afford to use the infrastructure there [...] even EMEC being dedicated test facility - they all come at a price and their affordability is, I think, an issue. Which leads to them not being used which then leads to engineering failures in the field that could have been avoided if budgets had allowed those things to be evaluated. They have no choice, having to forge ahead in a way that from a straight technical point of view is imprudent but from a commercial point of view you know overrides that requirement."

Interviewer : "Would the solution be more public money?"

Interviewee: "Yes potentially, also perhaps the sector not over selling itself... particular companies putting themselves in situations with their investors where they are obligated to meet certain milestones at any price almost. [...] Maybe they got the funding on a certain business case and then that they are sort of locked in to that obligation. That is difficult to renegotiate and that can lead to bad research outcomes." Testing Facility 1

A number of respondents spoke of avoidable errors having occurred during real sea testing and this potentially having a negative impact in the industry as a whole due to negative media attention and destabilising investor confidence. Some respondents argued that there would only be government funding for the testing of a finite number of devices and that this number would also be limited by the number of testing 'berths' at the various testing centres. Therefore, those who managed to prove their devices in the early rounds of testing in real sea conditions would drive concept and design consolidation in the industry.

Grid

The issues faced by the tidal, wave and wind energy industries in terms of grid relate to the mismatch between the location of the highest energy resources and the areas of high density

energy demand. Therefore there may be many projects in these areas seeking to connect to a network that is weak and already near capacity. In particular there was a concern voiced by a number of respondents that they already planned wind energy projects would take all available capacity gained from grid upgrades and the decommissioning of traditional large scale plants. The connection 'time lag' is already proving to be something of a problem in the wind energy sector with some projects looking at connection dates up to 10 years away. In addition, if a connection is secured, there is the issue of the cost of that connection and the ongoing network charges that they will have to pay.[21]

'Grid' was identified by all respondents as a potentially significant barrier for the industry. Particular areas of concern focussed on issues of: timing, cost and responsibility to cover improvements, priority of connection for tidal energy and the level of strategic planning of grid upgrades. The difficulty in managing the timing and cost of grid upgrades is captured by two respondents below.

> *"You need someone to underwrite that [upgrade of the grid] which isn't happening at the moment. They're not going to upgrade the line until there's applications in to do it but no-one can afford an application without the; well no-one can get the investment to put in an application until there's a good connection. So it's a bit chicken and egg." Trade Association 2*

> *"...do you strengthen the grid to where the tidal power is before there's a tidal power industry or do you put the tidal power in there and hope somebody's going to strengthen the grid and do you have to pay for it all?" Academic 2*

Some felt that the government should underwrite the required grid upgrades. Below, a developer argues that the developers simply cannot stand the financial burden and likened it to asking the motor industry to pay for the development of roads.

> *"if you go to Germany and you look what they did, how did they get wind moving? If you wanted to put a wind turbine on the grid you immediately got priority to go on the grid and the grid had to accept you and the grid I believe even had to make sure you got a hook up at a sensible price. Now what they're doing to renewable energy is saying, oh, well you'll have to pay for the grid and you'll have to pay for the grid reinforcement and all the rest of it. And very quickly this sort of, you know… Here's the analogy okay, if you understand this. Question – were the car industry asked to pay for the cost of the roads?" Device Developer 2*

> *I was thinking about a policy commitment from government to create some sort of assurance that when necessary the grid capacity will be made available and a strategy for how that is paid for." Testing Facility 1*

The representative from the Department of Energy and Climate Change (DECC) stressed that reinforcement of the grid is central to their current work and that the tidal sector will benefit from the other improvements they are making. There were calls from some members of the sector for a more strategic approach to marine energy connection specifically. The major upgrading currently focussed on offshore wind was widely thought to be of benefit to marine

[21] British Wind Energy Association, 2006, Path to power, p13 available at http://www.bwea.com/pdf/pathtopower/PathtoPower_low.pdf

energy. However, there were calls for ring fencing of specific marine energy capacity so that it wasn't absorbed by other energy technologies.

> *"When National Grid is upgrading the grid they need to create spare capacity for the installation of marine renewables where there is the potential. [...] in the short term maybe there is the potential to work with what is already there but in the long term, there are major upgrades that are required and marine renewables need to be taken in to context when those upgrades are made. Otherwise you know if 10, 15 years time it will come to a case of you know more upgrades will be needed." Trade Association 1*

Others stressed that the onus had to be on developers to make applications and then the required upgrades could be provided once a project had a successful application.

> *"But the key aspect for the transmission companies is that it's all very well developers sharing their kind of project developments and timelines with them but given the rules that the transmission companies have to adhere to they do actually need an application in to trigger that." Government 2*

> *"If you have got the demonstration out there working and delivering then it might again persuade the electricity companies or the grid companies to do something about it. I think they have to see the market before they are going to act." Trade Association 3*

Despite these challenges there was a good deal of enthusiasm and optimism surrounding discussions about grid in the interviews. This was due to active involvement of the transmission companies with the sector and the increasing level of involvement of utilities in tidal energy. Utilities were seen as being more experienced in working with transmission companies and so understood their pressures and needs more and could utilise existing relationships. This was definitely an area that respondents felt there had been a lot of progress in in terms of attitudes and collaboration. Whilst this may have seemed a major 'barrier' previously it is now more generally being discussed as a 'challenge' but one that can and to some extent is already being dealt with. The announcement of the RES was thought to have encouraged transmission companies to consider planning for wave and tidal energy more seriously and urgently. In particular the Marine Energy Group and trade associations noted a much stronger and active involvement from transmission companies in their activities and working groups etc.

Licensing, consenting and environmental impact

When asked about planning and leasing many respondents gave a strong call for a Strategic Environmental Assessment (SEA) to be undertaken for the rest of the UK, to complement the SEA already in place in Scotland. Since the interviews were conducted, an SEA for England and Wales has been announced and is due to be completed by Spring 2011. There was some frustration with the 'delay' in committing to a SEA and DECC's approach of having a 'scoping study' before commissioning the full assessment. Many actors across the sector felt that both an SEA and more information on when and where and future licensing rounds would happen were required in order to reduce the level of risk enough to attract investors.

In relation to leases, whilst there was much support for the Crown Estates Pentland Firth leasing round, there was some concern that there had been delays to the original timetable of

this process. Again this was felt to undermine the attractiveness of the industry for investors. Many respondents argued that a delay of several months has deep financial implications for the developers as they have to cover costs during this time and explain and justify deviation from the project plan to the investors. Below a respondent expresses their concerns over the delays in consenting.

> *"... Government can trundle along month upon month it does not matter a jot. They don't have to account for their monthly costs. They don't have to pay, worry about paying the bills, the civil servants get paid, the decision makers can take all the time they want. We burn to death right, and what's more, if you're looking at it as an investor are they investing in the technology or are they investing in the Whitehall two step? And that, you know that is a real issue. [...] it's very easy to separate it and say one of the silos is consent, one of the silos is access to capital but the behaviour in the silo of consent has a direct impact on both the costs and access to capital and making those links is really important" Device Developer 2*

However, many respondents spoke in very positive terms about the level of collaboration and communication with consenting and regulatory actors. For example, concerns have been expressed over the impact of marine spatial planning on the deployment of marine energy technologies, particularly in relation to the potential operation of 'exclusion zones'. However, the Renewable Energy Association (REA) and Natural England have worked together on the potential for marine energy devices to operate in Marine Conservation Zones (MCZs).[22] A REA representative explains this collaboration below.

> *"...they [the Government] are talking about up to 30% of English and Welsh waters being Marine Conservation Zones. Now we are not sure, whether... what can happen in these zones so that is a big question mark. In order to overcome that, the REA is working very closely with Natural England. We have produced a joint statement about marine devices in MCZs and the fact that they are not necessarily precluded - they can co-exist." Renewable Energy Association representative*

The key issue discussed in relation to planning was the monitoring and management of environmental impacts. The level of precaution and the associated costs frustrates one developer:

> *"... civil servants will say well the precautionary principle says if you don't know the impact of something you're about to do then don't do it because you take the precautionary approach. It's don't do something about which you don't understand which of course mitigates massively against any new technology despite the work that is done and the very, very high likelihood that something will be benign." Device Developer 2*

Although also critical of an overly cautious approach to minimising environmental impact, an academic stressed that whilst it is understandable that developers present their devices as being 'benign', there will be an impact and this must be dealt with openly and honestly.

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[22] Natural England and the Renewable Energy Association, Joint Statement on Marine Renewable Energy Installations and Nature Conservation http://www.r-e-a.net/document-library/policy/0909Natural%20England%20and%20REA%20joint%20statement%20final.pdf

"There are two different ways of delivering a message and I can totally understand why the developers say this, they want, they genuinely want to develop benign devices and they will do what they can within the financial limits that they have to do that, I am absolutely certain of that. But they are going to have to accept there there will be some effect. The question is not whether there will be an effect but whether that effect will be significant or important and there is different types of significance or importance. There is purely biological aspect to that. So whether the effect is going to be strong enough to effect the population of these animals but there is also a significant human sort of social effect in that people will misinterpret or will interpret the effects in ways that are incorrect biologically." Academic 1

There was widespread use of the term 'deploy and monitor', although clearly what this means in practice may different substantially (i.e. how precautionary and how expansive deployment could be). One respondent argued that the conditions placed upon the Marine Current Turbines (MCT) turbine in Strangford Lough that require that the turbine be switched off if marine mammals are sighted in the immediate vicinity, undermines the potential to develop knowledge. The respondent argued for an 'adaptive management' approach but noted that this is financially risky. Essentially the aim of an adaptive management approach would be based on deploying the devices, monitoring the impacts and making any necessary changes to minimise those impacts. However, it would be possible that sometimes the device would have to be removed if the remaining impacts were deemed 'unacceptable'. This was thought to be a difficult process for both The Crown Estate and developers/investors. The level of environmental monitoring required for the MCT turbine in Strangford Lough was discussed by many interviewees with a general view that the costs associated had been tremendously high. Although some respondents thought that the results from the MCT trial would help to ease the way for other developers, MCT themselves stressed that other devices could not be assumed to behave as theirs had and so other developers would have to face this cost as well.

Public opinion and support

Some respondents felt that tidal energy had very little public recognition and therefore public 'opinion' was fairly nonexistent. Others believed that, generally, public opinion was fairly positive, but in quite an abstract sense. There were also references to marine energy technologies being favoured by the public over wind energy due to their 'lower visual impact'. The Marine Current Turbines development at Strangford Lough was noted by a number of respondents as a good example of consultation and engagement practice. EMEC was also argued to have received widespread local public support.

"Perfect example of how you do something like that - MCT from the beginning engaged the local community, they had someone from the local community supervising the project, undertaking the impact assessments and it is actually, I believe there are actually postcards with the MCT turbine on it now -you can buys in the shops!" Trade Association 1

There was some deviation between respondents as some stressed the fragility of this support. A sense of support being the industry's to lose was often coupled with the importance of proving that environmental impacts were 'acceptable'. The respondent who was concerned about the use of the term 'benign' explains how an open and honest approach to environmental impacts is required if public support is to be developed/maintained.

"...we will just have to live with them [...] certain negative effects which we just will have to accept but the important thing from my perspective, and what I keep plugging on about, is that we have to be upfront about them and we have to be honest with ourselves about them and we have to make a firm decision to go in a certain direction even though there might be an effect. We can't just sweep it under the carpet and hope that it will go away because it won't go away and the public won't forgive us for that." Academic 1

After discussion of the barriers, respondents were asked some broader questions about the position of the tidal sector. The areas discussed included: the degree of 'progress in the sector, the suitability of the wave and tidal grouping and the intra and international competition in the industry. These areas were identified in the scoping study as potential areas of diverse opinion and so this study sought to gather more detail of reasons for these differing views.

Progress

The Forum for Renewable Development in Scotland's Marine Energy Group produced a roadmap for the sector in 2009. In this document they identified a lack of progress since their 2004 report. Therefore in this study respondents were asked directly if they felt that there was a sense of progress in the industry. Design consolidation, deployment of devices and a move away from early stage R&D were seen as demonstrating progress. One issue noted by many respondents across the different stakeholders was the marine sector's history of 'overpromising'. The over-promising was argued to relate to underestimation of costs, salesmanship and the need to commit to certain milestones in order to get investment.

The general economic slow-down is clearly implicated in the difficulty that some developers are having in attracting funding. However, there is certainly a buzz about the industry, a sense of being on the cusp of potential step changes in the deployment of devices. This relates to the first commercial leasing round in the Pentland Firth and the connection to the grid by Marine Current Turbines' and OpenHydro. In addition, the Carbon Trust's Marine Renewables Proving Fund (MRPF) was widely seen as significantly easing the difficulty in financing getting kit 'in the water'. Moving from R&D or early demonstration to pre-commercial full scale trials was identified by interviewees (and in previous studies) as a key barrier and a stage at which a some developers struggle to progress.[23] For some these recent developments have helped to overcome the impacts of previous 'over-promising' (by delivering on previous projections albeit belatedly). However, one respondent stressed that more emergent challenges were being encountered as devices are deployed (e.g. turbulence issues) so future developments may also not progress at the expected rate.

There is a sense that environmental monitoring has the impact of slowing progress. However this tended to be seen as both unavoidable and fairly reasonable. The environmental impact data collection is seen as being critical for the future development of the industry – it will not stop its progression now but it must be dealt with in order for longer term development. As noted under the discussion on grid, recent exchanges and collaborative working with

[23] e.g. Foxon et al, 2005, UK Innovation systems for new and renewable energy technologies: drivers, barriers and systems failures, Energy Policy, 33, 16.

transmission companies are seen as an example of significant progress on a substantial barrier.

Wave and Tidal Grouping

As noted earlier, wave and tidal energy are often grouped together under the term 'marine energy'. For example this grouping can be found in policy documents, trade association memberships and industry events. Respondents were asked about the appropriateness of grouping wave and tidal technologies; the differences between the two were felt to be stark, as one respondents explains:

"the only similarity is that they have water involved" Device Developer 1

Whilst it was obviously agreed that the technology and physics of wave and tidal devices were significantly different, the desirability of the grouping was contested. There were a number of common problems identified that were thought to justify them being dealt with together: the difficulty of working in the offshore environment, regulation, environmental issues and infrastructure. In addition, one trade body argued that there was a certain 'strength in numbers' that should be embraced. Important differences identified included: the relative convergence of design concepts in the tidal sector, the difference in location of deployment and the difference in environmental impacts. It was noted that there have already been some dedicated events.[24] Many respondents argued that the technologies would need to split more eventually but that it was too early to do this now. There was also a sense that the success or otherwise of one sector may lead to a purposeful split from those within the industries as either wave or tidal developers seek to present themselves as more successful or less risky (etc) than the other.

Intra-UK differences

Whilst many respondents talked about the UK as being a world leader, others stressed that it is Scotland that is the world leader in marine energy. The more favourable ROC regime, the early undertaking of an SEA, the significance of marine energy as a part of Scotland's energy needs and political will were all identified by various respondents as having given Scotland a significant advantage over the rest of the UK. For some interviewees the different resource profile of Scotland made this an entirely reasonable situation, for others there was a strong sense that steps must be taken so that the rest of the UK is not 'left behind'.

> *"It is a ridiculous situation. I don't understand why England and Wales is lagging behind the Scottish Exec in those decisions. It seems to create a very unlevel playing field and it is very obvious what the results of that are going to be if this is taken forward over for the subsequent years. Nobody would [...] in a tidal context nobody would install, plan a project in England and Wales on the basis of being able to get better ROCs in Scotland." Testing Facility 1*

> *"Scotland has quite a lot of renewable energy potential, it has a relatively small population, it already has a good amount of renewable energy - hydro. It has got a lot of capital assets sitting there which it can actually used whereas I think if you put that in a UK context it is... it is not a big*

[24] e.g. Tidal Today's International Tidal Energy Summit, www.tidaltoday.com

a part of the UK energy need as it would be for Scotland. I think it makes a lot of sense that there is a difference north and south of the border." Academic 1

Some respondents argued that Scotland itself may suffer if the rest of the UK did not keep pace with marine energy developments, either due a lack of funding or domestic market.

"...the trouble is that Scotland doesn't have the same financial capital reserves to drive all this forward" Academic 1

The current system, including testing facilities set up by regional rather than central organisations, was argued by some to be indicative of not having joined up enough policy in the UK. A more strategic approach was felt to be essential if a UK lead was to be maintained/developed. One respondent argued that the administrations may co-ordinate more if they face more competition from other countries in the future.

International Competition

As well as providing indigenous low carbon energy for the UK, respondents spoke of the potential for UKPLC of a world-leading marine energy industry developing in the UK. Respondents all agreed that the UK, or for some specifically Scotland, has a world leading position in terms of technology deployment, development and R&D base. However, this was generally felt to be a rather fragile position and less extensive or dominant than it may previously have been. One respondent, based outside the UK, stressed that whilst the UK had had the potential to establish dominance from some years, its failure to do so meant that it risked being 'overtaken' by other countries. The need to not be complacent and keep the policy and infrastructure regime 'right' was stressed by one testing facility respondent, using the example of Pelamis (a Scotland based wave energy developer) deploying in Portugal to show how quickly a leading position can be threatened by a change in policy and institutional settings in other countries.

International competitors mentioned by respondents included: France, Spain, Portugal, Canada, Korea and China. The density of population near the tidal resource was thought to make projects particularly attractive in some of these countries. Given China's political system, there was a sense that they could catch up or overtake very quickly. Failure to establish a dominant world leading position was argued to be particularly related to a failure to move to a point of deploying arrays and achieving wider single device deployment. There was a certain sense of frustration articulated in relation to this question as what had been felt to be a substantial lead had not received the level of funding and streamlined consenting required to really consolidate the UK's position.

Many respondents spoke of having to 'buy back' the technology from other countries if the UK did not capitalise on its position and establish itself as the the world leader as the sector commercialised. The failure to develop a domestic wind energy industry was widely cited as an example of what could happen to the marine sector if it was not adequately supported. One utility representative argued that whilst there is a need for government to invest "millions, maybe even hundreds of millions in the fullness of time", this was seen to be reasonable as "it

can be shown that that sort of investment now is going to bring billions of pounds back to the country in the future when they have an industry going and they have exports going as well" (Utility 1). Some respondents recoiled from the idea of international 'competition' and saw developments in other countries as opportunities for UK developers to deploy and for wider collaboration.

5. Key actions

After discussion of the key barriers, interviewees were asked about what key actions they thought needed to be taken and who had the responsibility or power to carry these out. Although some respondents had a very clear idea of particular actions required by particular organisations, others stressed the complexity and interdependency of the actions that needed to be taken. As an interviewee explains below.

> *But you know the thing is … there are so many things that need to be done by so many people [...] it's almost like an infinitely long list … which, each part of which is slightly important to someone." Government 1*

Many of the actions that interviewees identified were felt to already be underway. For example the need to bring in other sectors and develop a UK supply chain using existing expertise was to some extent felt to be being managed as one respondent explains below.

> *So what we are seeing now is that in the Marine Action Plan and also in [trade body working group] we are starting to undertake this gap analysis to highlight where areas that people feel that work needs to be done but they are not particularly interested in doing it themselves. So what that will do, hopefully, is bring in external companies, large engineering companies where they can take on individual generic.... power take-off or wet connector, foundation, these types of things [...] it will make their deployment a lot easier, a lot cheaper." Trade Association 1*

Development of standards, environmental baseline data collection and the ROC banding review were all seen as positive and essential actions that were 'underway'. Grid, whilst widely seen as a key potential barrier was also felt to be 'in-hand' to some extent due to: the active involvement transmission companies with the marine sector, the importance of marine energy identified in the Renewable Energy Strategy and the involvement of the utilities in projects. However, responsibility for this issue was seen differently by respondents as some argued for more strategic planning of grid capacity, underwriting and guarantees from government whilst others stressed that the responsibility lay with developers, who needed to get projects underway before transmission companies could commit resources to upgrades.

Sensitivity over Intellectual Property (IP) issues were thought to have previously made industry players fairly secretive and uncooperative; however, there was a sense that many issues could be dealt with more effectively if organisations worked together. Openness from developers and funding from government were felt to be required if collaborative progress is to be made on: baseline environmental data collection, environmental monitoring, establishing standards and a public funded deployment vessel. Again a shift toward more collaboration between different organisations was already felt to be happening by some actors. In addition to the development of these knowledge networks, one academic stressed the need for device developers and their utilities partners to re-engage with the academic research community.

The level of funding was argued by some respondents to not be high enough to really drive the industry forward on the sort of timescales identified in the RES (i.e. an 'important contribution by 2020 and mass roll out beyond that). Whilst through MAP, the Government have expressed a willingness to 'continue' to fund marine energy through existing bodies, some respondents stressed that a continuation of current funding levels is simply not high enough to develop a rapid movement to commercialisation. The profile of costs for the industry and the cost 'barrier'

of full scale deployment led some respondents to call for increased state funding and the need to reconsider the appropriateness of state aid rules that limit the ratio of public to private funding for projects. As noted under the barrier section, some respondents placed more responsibility with developers to 'prove' their devices rather than with government to increase funding or underwrite grid improvements.

In relation to consenting and planning, there were some calls for there to be a less precautionary approach in relation to environmental impacts. Although the term 'deploy and monitor' was used widely the extent of deployment that this could consist of was conceived of differently. For example, whether projects should be deployed and then alterations made if necessary or if deployment and monitoring of a few projects was required to be successfully carried out before a further round of projects should be deployed. In addition, there were calls for leasing rounds and timetables to be set more 'realistically' with device developers stressing the difficulty in managing costs and investor confidence if delays occurred.

The table below summarises the key actions that stake holders identified. It should be noted that this is not by any means a definitive list but those that the respondents suggested in the interviews. The list includes the range of suggestions made rather than a list of action points agreed by all respondents.

Table 1 Key actions suggested by interviewees

ISSUE/BARRIER	ACTION	ACTORS INVOLVED	STATUS
Develop a UK supply chain	Working collaboratively to identify opportunities for other industries to enter the tidal sector	Collaboration by device developers and other actors, representation by trade associations	Underway
ROC banding	Some calls for increase in tidal banding and parity between UK nations - DECC ROC review	DECC and all other actors feeding in the ROC review	Underway

Standards	Development of standards	EMEC working with device developers - potential need for further government funding	Underway and identified as a targeted funding area in the MAP
Grid	Agreeing priority, cost and timing issues	Transmission companies, device developers, utilities, government	Positive signs of communication and engagement between actors but many issues still unresolved
Networks and collaboration	Continue increase in collaborative activity through facilities such as EMEC and through trade associations. Industry and academy to enhance knowledge sharing	Device developers, trade associations, testing facilities, academics	Positive signs on collaboration on non-core activities. Still some skepticism given competition and sensitivities over IP. DECC facilitating process of developing sector wide sharing of environmental data and information
Industry vessel	Publicly funded vessel available for charter by device developers	Government (for funding)	No plans for this to be done yet. MAP suggests sector considers opportunities for using decommissioned vessels
Funding	Concerns over levels of government funding and calls to make it more 'realistic'	Government	MAP expresses intention to ‘continue’ funding, also stresses need to access EU funding
State Aid rules	Consider more relaxed application or abandonment of state aid rules	Government	currently seen as a firm requirement

Environmental impacts - levels of precaution	Apply less caution and operate more ambitious deploy and monitor approach (tempering risk with importance of climate change and energy security)	Crown Estates, Government, environmental stakeholders	Current approach widely referred to as 'deploy and monitor' - issue here is with what level of deployment and timescales this refers to. 'Representative Strategic Co-ordination Group' will be set up to consider deploy and monitor approaches as well as other environmental issues
Prove devices	Deployment and monitoring: reliability, output and impact	Device developers (although some also argue more public funding needed to achieve this)	Some devices already deployed and Pentland Firth projects underway

6. Conclusions

This report has presented the views of a range of stakeholders from the tidal stream energy sector on the barriers and opportunities that the sector faces and the key actions that need to be taken to act on these. Approximately 20 individuals from a range of organisations were interviewed including: trade associations, academic research projects, testing facilities, regional and national government, utilities, funding bodies, regulators, and technology developers. Key conclusions are now identified that relate to: the UK's 'world leading position', funding, environmental impacts, public support, grid, use of test facilities, overpromising and responsibility for the next steps for the industry.

The UK's world leading position in the tidal (and wave) sector was agreed by interviewees and there was a generally very positive and optimistic tone to assessments of the industry's current position. Deployment of full scale devices, connection to the grid, technology convergence, leasing of the Pentland Firth and a move away from fundamental R&D activities were all seen to demonstrate that the industry was 'on the cusp' of major developments and moving towards commercialisation. However, there were notes of caution. In particular, the fragility of the UK's world leading position as other countries were seen to have 'caught up' on what was once a dominant position. The potential for the UK to be 'over-taken' in terms of developing tidal and wave energy was noted by numerous respondents. China, Portugal, Canada, France, Spain, Korea and other nations were noted among the key competitors. Deployment of arrays of devices was seen as a key step in protecting the UK position as well as establishing a UK based supply chain to service the world market. Although the potential for tidal energy for the UK energy mix was broadly seen primarily as a post 2020 contribution, a number of stakeholders stressed the urgency of action required if these longer term targets are to be met.

The current level of funding was argued by many respondents not to reflect the scale of costs required to move to commercialisation. However, there was widespread support for both DECC's Renewable Obligation Certificate (ROC) banding review and the Carbon Trust's Marine Renewables Proving Fund. The profile of costs in the sector (i.e. high levels of investment to deploy, test and prove a device) also made attracting private investment challenging. Some respondents argued that public money needed to be used to leverage in these funds, others called for an easing or abandonment of state aid rules, allowing more publicly funded projects to be commissioned. In relation to planning and consenting there were calls for a more 'realistic' and rigid timetabling approach as developers expressed concern over managing the cost and investor confidence implications of delays to project timescales .

The discrepancy in ROC banding between Scotland and the rest of the UK and between wave and tidal devices was much discussed by respondents. Whilst it was broadly (although not exclusively) agreed that the discrepancy within the UK should be redressed, the difference between wave and tidal was a source of more controversy. The more favourable ROC regime, the early undertaking of a Strategic Environmental Assessment, the significance of tidal energy as a part of Scotland's energy needs and political will, were all seen to have given Scotland a significant advantage over the rest of the UK. For some interviewees this an entirely reasonable situation, for others there was a strong sense that steps must be taken so that the rest of the UK is not 'left behind'.

Whilst some presented the technologies as 'benign' others stressed that impacts were unavoidable and that the concern must be how best to deal with these. There was widespread use of the term 'deploy and monitor', although clearly what this means in practice may differ substantially (i.e. how precautionary and how expansive deployment could be). Concerns were raised over the sustainability of the environmental monitoring costs that projects have faced.

There was widespread agreement for environmental monitoring and baseline data collection costs to be covered by the public purse if they benefitted the industry as a whole. Environmental impacts were thought to be particularly important to the level of public support that the industry will enjoy as it moves toward commercialisation. Careful attention to both the level of impacts and the interpretations of the acceptability of these were stressed by a range of respondents.

As with many renewables, connecting to the grid was widely seen as a major potential barrier. Concerns over availability of connection and the cost of that connection were discussed. There were calls for the Government to underwrite grid connection for the industry, giving tidal developments guaranteed and prioritised grid connection and improvements when they required it. An alternative suggestion was developers could form consortia to apply collectively for grid connections and improvements in particular areas. Whilst seen as a significant barrier, many respondents stressed that transmission companies were now much more engaged with the sector and a sense of optimism that the issue could be satisfactorily dealt with was evident across the range of stakeholders.

Testing facilities in the UK were seen as being the best in the world. However, there were argued to have been failures in the field that could have been identified at earlier stages of testing. However, because developers had committed to certain timescales and milestones in order to attract investment stages of testing had been 'jumped'. This was seen as an example of the sector 'over-promising'. There was some concern that if claims continued to not be met, government support, private investment and public enthusiasm may wane.

It was widely thought that a key priority for the industry was to prove the reliability and efficiency of the devices in real conditions over extended periods of time. However, whilst some respondents placed the responsibility for this with the developers themselves, others stressed the need for increased government funding and timely planning processes and licensing rounds in order to overcome the barriers that developers currently face. There was enthusiasm across a number of organisations for collaboration between actors on areas including: baseline environmental data collection, environmental monitoring, establishing standards and a publicly funded deployment vessel for the marine sector.

Whilst this study to some extent overlaps with the aims of DECC's Marine Energy Action Plan, here the interest has been specifically upon tidal stream and rather than looking to provide a definitive or single route map for the industry. This report offers more of a snapshot of the different views in the sector on both the current position and its future potential. It is hoped that this report will offer a useful input to the public consultation phase of the plan. In addition, whilst the MAP was spoken of very favourably by respondents, this study offered an opportunity for respondents to be more openly critical of Government's role and suggest alternative actions that it could or should take. Comments on this report are most welcome and should be sent to c.mclachlan@manchester.ac.uk.

APPENDIX 1

Topic Guide Tidal Interviews

This Tyndall Funded project is concerned with the different policy and institutional arrangements for tidal stream energy in the across the UK. We are interested in what you think are the main barriers and opportunities for the industry in the short and long term. The findings of the work will be used to provide practical policy recommendations and academic publications. A final report from the project will be publicly available on the Tyndall Website (www.tyndall.ac.uk).

BACKGROUND – YOUR ROLE IN THE TIDAL INDUSTRY?

1. Could you characterise the current state of the tidal stream industry in the UK at the moment?
    a. Is that national or are the devolved administrations or regions faring differently?
    b. Assessments of where tidal is on the 'S' curve
2. What potential do you think tidal energy has in terms of the UK and globally (consider unit they respond in – GW, £, %demand etc)
3. What are the barriers to development of the UK tidal energy industry?
4. What are the particular opportunities or advantages that the UK, or parts of it, have?
    a. 3&4 prompt on other topics if not mentioned in response and on the different interpretations and experiences of these in different administrations and regions of the UK
        i. ROCs – previous impact of this measure and potential impact of different bands (non UK? any mention?) – why tidal given less in Scotland? Why diff to rest of UK?
        ii. Funding support – availability/accessibility Role of funding bodies
        iii. Networks – sharing ideas and experience between actors – conflicts with commerciality?
        iv. Testing facilities – different capacities – is their enough/the right sort? (EMEC-other)
        v. Grid – upgrading and cost/delay of connection?
        vi. Planning – experience in different contexts – degree of proof
        vii. Public opinion and support
        viii. Subsidies – would they prefer non ROC measures?
        ix. The role of utilities –investing in smaller companies – impact on industry?
        x. When will convergence occur? Does it need to happen sooner or later?
5. What do you think needs to be improved or altered in relation to certain bodies/facilities to develop the tidal industry?
6. What are the key things that need to happen and who has responsibility for these?
7. Have previous issues in the industry been overcome – how? (level of funding, SEAs, IP)
    a. (considering degree of agreement and contestation here)
8. Wave and tidal tend to be grouped together – is this useful in a policy/institution/public sense?
9. Have you followed the Government's work on the Severn barrage projects – do you think this has had any impact on the development of or attitudes to tidal stream?

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