Renewables
Advisory
Board

Marine renewables: current status and implications for R&D funding and the Marine Renewables Deployment Fund

RAB (2007) 0182
URN 08/566

JANUARY 2008

Executive summary

The waters around the UK coastline represent an abundant source of clean renewable energy as yet untapped. It has been estimated that if exploited, their energy could contribute up to 20% of our electricity needs and help in reducing the UK's greenhouse gas emissions. The challenges facing the successful exploitation of this resource are great. However, the UK is currently leading marine renewable energy development through its R&D programmes, development facilities and its background industrial position in marine and offshore engineering. This provides a springboard for potential export business and economic development from this new industry.

The Department of Business, Enterprise and Regulatory Reform (BERR), formerly the Department of Trade and Industry (DTI), set up the Marine Renewables Deployment Fund (MRDF) to support the construction and operation of early-stage commercial wave and tidal stream projects using technologies that had completed their initial R&D phase.

The MRDF opened for applications in February 2006. A small number of applications have been received, none of which met the entry criteria of full scale operation for at least 3 months.

Through the Energy White Paper, Government asked the Renewables Advisory Board (RAB) to look at how progress towards the commercialisation of these technologies might be accelerated and specifically to consider the:

- reasons for slower than expected progress with Research and Development (R&D);
- reasons for low take up of MRDF.

To assess these questions, RAB's marine energy sub-group has examined a wide range of evidence including:

- published information from BERR's R&D programme, the Engineering and Physical Sciences Research Council (EPSRC) funded academic research and the Carbon Trust's Marine Energy Challenge and
- interviews and responses to questionnaires from key industry stakeholder groups.

Based on the evidence gathered for this report, it is clear that there have been many achievements in the UK, with a number of prototype systems being constructed, installed and tested in a harsh environment. Device developers have gained experience of manufacturing, installation and operation. Although progress has been slower than expected, given the size and difficulty of the challenge, the industry has achieved much to date. Internationally, the UK is still regarded as the leader in this field.

The immediate reason for the lack of take-up of MRDF funds is that no device concepts have yet met the criteria set out in the scheme, although there are expectations that a number will achieve the entry criteria in the next few years.

RAB considers that a number of factors that have contributed to this.

- Most developers have not set out to meet the MRDF entry criteria as their primary focus, choosing instead other milestones that align with their overall funding requirements. This may be their private investor's milestones or just the available budgets constraining what can be done.
- The technical challenges, particularly that of operating in a marine environment, are much larger and more difficult than originally expected, so time to deployment has been greater than planned.

- Some projects have been developed at scales other than full commercial scale or have developed only partial systems for open sea deployment, the MRDF entry criteria does not recognise this.
- There has been over optimism in the industry. It is also fair to say that some developers have been burdened or distracted by outside factors such as permits and environmental assessments, which have impacted on their programmes.
- BERR R&D projects have not delivered the extended continuous deployment of full-scale prototypes that their project plans promised. This is primarily because project costs have proven to be much higher than expected and timescales longer, leading to a reduction in resources available to complete the anticipated testing.
- Co-operation between different industry players could be improved. Whilst it is understood that companies wish to protect intellectual property, this inhibits co-operation and is leading to the same problems being addressed many times in parallel and the consequent inefficient use of available resources. There is a proliferation of device concepts that are only marginally different.
- Best use is not being made of the results of academic research, including the first UK wave programme and the current Supergen Marine initiative. This research could be made more accessible and useful to the industrial community and greater communication and co-operation between the industrial and academic communities would help to define and disseminate the academic research.
- The marine renewable energy industry is dominated by a large number of small, mostly start-up, companies, each developing different devices. We are anxious about whether these companies have all the required technical and managerial resources that are necessary for such complex and potentially dangerous projects. Large engineering and offshore companies that do have these resources have not so far become involved in the sector to a significant extent, but there may be a benefit in trying to encourage participation of such companies.
- The processes of allocating Government grant funding to R&D projects is not always as flexible as it might need to be, particularly when unforeseen problems, delays or cost over-runs occur.

In consequence, initial R&D is taking much longer than originally envisaged, is not delivering the technologies for the MRDF but, importantly, neither is it producing high quality research results on the current performance and costs of wave and tidal stream power. The published R&D results, including from a number of prototype marine renewable energy technologies, have not established with confidence the current cost of energy from wave and tidal stream power. Neither have they provided an understanding of their long-term commercial prospects nor identified a route to achieving the improvements needed for marine energy to make a material contribution to the UK's energy needs.

To address these issues, RAB recommends a more collaborative approach to R&D projects between industry, academia and Government, with pro-active and closer management of R&D projects. This will help ensure that projects are focusing on tackling the correct problems, that opportunities for information exchange are taken, that projects are generating relevant research information and that as many results as possible are published. It is not clear to us that there is a strong case for seeking yet more device concepts.

The MRDF was clearly established too early, however, it provided a positive signal to the industry and investment community.

However, RAB judges that the MRDF is fundamentally a sound scheme. It, in itself, is not a failure, but the R&D process has failed to supply the technologies that the MRDF was established to support. A small number of changes to the MRDF would be helpful to make it a little more accessible, but it should not be fundamentally changed, and should certainly be kept in place.

There has been much discussion within the industry and within RAB about the MRDF's eligibility criterion of three months continuous operation of a previous prototype, deployed in realistic conditions. We accept the spirit of this criterion, which is to help ensure that technologies have indeed completed their initial R&D and that MRDF projects have a high probability of successful and safe operation; we do not recommend that it should be removed. However, there may be a case in support of a more flexible interpretation, provided the spirit of the criterion is not eroded.

On a positive note, we can see that there is a good prospect for the MRDF receiving successful applications over the next 1-2 years.

During our work it has become apparent that, in common with other offshore renewables, the cost of wave power today is greater than when the MRDF was first devised in 2004. In consequence, the MRDF will not provide the levels of support that were considered necessary for wave power projects to come forward. When considering any adjustment to the MRDF, such as how to accommodate the proposed extra ROCs for wave and tidal stream under a banded Renewables Obligation (RO), Government may wish to consider the MRDF's financial parameters (capital grants and revenue support) for wave power.

RAB has taken note of the Sustainable Development Commission's (SDC's) report on tidal power and the SDC's recommendation to change the MRDF to solely a capital grant mechanism. RAB does not wholeheartedly support this idea, as it does not reward success. A modest increase in the level of capital grant though would be helpful, as the technical risks continue to be high and are probably higher than believed at the time the MRDF was developed.

Finally, although not specifically part of RAB's brief, our work has allowed us to consider the long–term commercial prospects for these emerging technologies. We are aware that our report might be seen as indicating that the long-term commercial prospects for wave and tidal stream are poorer than has been previously thought. That would not, in our view, be the correct interpretation. As already pointed out above, with the data that exists today, it is simply not possible to give a definitive analysis of the long-term commercial prospects for these technologies.

Table of contents

1 Introduction **1**

2 Methodology **2**

3 Overview of UK marine renewable energy funding landscape **2**

4 Experience and evidence gathering **3**

4.1 BERR's R&D programme 3

4.2 EPSRC Supergen marine programme 7

4.3 Survey of technology developers 7

4.4 Utilities' perspective 9

4.5 Private-sector finance providers 10

4.6 Engineering companies 11

5 Conclusions **11**

5.1 Different Development paths 11

5.2 Size of the technical challenge 12

5.3 Optimism 12

5.4 Delivery of R&D programmes 12

5.5 Innovation versus energy policy objectives 14

5.6 Results of academic research 14

5.7 SMEs 14

5.8 Finance and investment environment 14

6 Recommendations **15**

Appendices

Appendix 1 Acknowledgements

Appendix 2 References

Appendix 3 UK marine renewable energy funding landscape

Appendix 4 Device developers' questionnaire

Appendix 5 Databuild's report on its survey of device developers.

1 Introduction

This report by the Renewables Advisory Board Marine Group represents a comprehensive review of the status of marine renewable technology development in the UK. It includes a review of why progress has been slower than expected and as a result why MRDF support has not been taken up by developers. It should be noted that not all marine technology development projects have been funded by BERR's R&D programme, also that there has been some notable developments overseas.

The report is evidence based and draws on published information from BERR's R&D programme, EPSRC funded academic research and the Carbon Trust's Marine Energy Challenge together with interviews and responses to questionnaires from key industry stakeholder groups.

In this report the term "marine renewables" is used to mean wave and tidal stream energy collectively.

Marine energy resources worldwide represent a major potential source of renewable energy. The waters around the UK are considered to be amongst the best for these two resources. It has been estimated that the practical resource (that proportion of the resource that can be exploited taking into consideration external constraints) could provide up to 15-20% of UK electricity supply, thereby saving tens of Mte CO_2. Major technology developers and the financial community are beginning to take an interest in this market. The UK rationale for attempting to exploit this energy source is:

- The resource, and its potential to contribute to CO_2 emission reductions, could be large.
- The UK is currently home to the leading academic researchers and device developers.
- The UK Government has already invested in R&D and facilities such as EMEC, NaREC and Wave Hub, which is providing an industry lead.
- The UK could capitalise on the above factors to develop a new industry thereby contributing to employment and wealth creation.

Over the last decade the Government has awarded R&D grants to a number of companies to develop and demonstrate wave and tidal-stream energy devices.

In 2004 some of these companies indicated that their technologies had completed their initial R&D and were ready to deploy pre-commercial arrays. In response to this, in 2005 the Government introduced the Marine Renewables Deployment Fund (MRDF). This has a budget of £50M, £42M of which is dedicated to the "Wave and Tidal-stream Energy Demonstration Scheme". This Scheme supports multi-device power generation projects via a combination of capital grants (25% of eligible costs) and revenue support (£100/MWh) (in addition to the support projects receive under the Renewables Obligation), enabling early stage pre-commercial projects to move forward.

The MRDF opened for applications in February 2006. A small number of applications have been received, none of which have successfully met the entry criteria. Section 4 of this report discusses the possible reasons for this in detail.

Through the Energy White Paper, Government asked the Renewables Advisory Board (RAB)[1] to look at how progress towards the commercialisation of these technologies might be accelerated and specifically to consider the:

- reasons for slower than expected progress with Research and Development (R&D);
- reasons for low take up of MRDF.

This report sets out the results of RABs investigation into these questions. Section 2 below sets out the methodology we have adopted to come to sound, evidence-based conclusions. Section 3 gives an overview of the current marine energy funding landscape. Section 4 describes the experience and evidence on which the conclusions of this report are based and explains how that evidence was gathered. Section 5 presents the conclusions and Section 6 presents our recommendations.

[1] http://www.dti.gov.uk/energy/sources/renewables/policy/renewables-advisory-board/page16101.html

2 Methodology

RAB has obtained information from a number of sources.

Published reports, primarily final reports from industrially-led R&D projects supported by BERR's Technology Programme/New and Renewable Energy Programme, to help understand the current technical and commercial status of wave and tidal stream technologies. A full list of reports is given in the references.

Presentations from: leading academic researchers from EPSRC's Supergen marine project; the British Wind Energy Association (BWEA); NaREC; EMEC; AEA Energy & Environment (management contractor for BERR's R&D Programme and the MRDF); and the Carbon Trust on the results from the Marine Energy Challenge.

RAB commissioned an independent survey of device technology developers to obtain from them their perspectives on the reasons for poorer than expected progress with R&D. RAB has also received presentations from a small number of technology developers that, at the time the MRDF was announced, would have been expected to have entered the MRDF by now.

A number of utilities have provided written contributions to RAB. Utilities are potential customers of wave and tidal stream technology developers and they have, over a number of years, had their own discussions with device developers that could give RAB insight to the development status of marine renewable energy and the reasons for the low take-up of the MRDF.

A small number of telephone interviews were carried out with representatives of financial institutions and large engineering firms.

Using this information, RAB has formed a view on the current technical and commercial status of wave and tidal stream and the progress that has been made with developing the technologies. Furthermore, irrespective of the progress to date, wave and tidal stream represent an untapped renewable energy resource that offers the prospect for significant contribution to renewable energy supply, if the technologies are successfully developed. Consequently, RAB has also considered what the emerging results from R&D and other studies tell us about the long-term commercial prospects for wave and tidal stream and their potential contribution to energy supply, environmental goals and jobs and wealth creation. Again this is using published information.

3 Overview of UK marine renewable energy funding landscape

Since BERR re-launched its wave energy R&D Programme in 1999, a number of other public bodies have commenced supporting wave and tidal stream within the UK.

In Appendix 3 we give details on the full range of publicly funded schemes and policy measures to support marine renewable energy in the UK. We summarise Appendix 3 in this section.

In 1999, the BERR programme was "the only game in town". Today, for R&D and demonstrations, there are several possible routes for funding.

- Technology programme, formerly the New and Renewable Energy Programme (formerly BERR/DTI programmes but from July 2007 managed by the Technology Strategy Board).
- EPSRC's Supergen Marine programme.
- The Carbon Trust's Applied Research programme.
- The Carbon Trust's Marine Energy Challenge/Accelerator.
- The Marine Renewables Deployment Fund (MRDF).
- The Scottish Government's WATES scheme.
- Welsh Assembly Government.
- Energy Technologies Institute

- European Funding

In all, approximately £160M of public funding has been committed to marine renewable energy research, development, demonstration and infrastructure since 1999.

Of the total funding from the public since 1999, BERR (excluding the Regional Development Agencies,) has committed ~£85M, of which ~£35M has been for R&D of which £15.5M has been spent, and £50M for the MRDF of which £42M is for demonstration support none of which has been spent.

Approximately £53M has been committed to facilities and infrastructure for the testing of wave and tidal stream devices, at EMEC in Orkney, NaREC in Blyth, and WaveHub in Cornwall.

In addition, there are market support mechanisms, such as the Renewables Obligation and in Scotland in particular, the Marine Supply Obligation (MSO).

The MSO is specifically to support wave and tidal stream commercial projects in Scotland. The MSO has buy-out prices of £175/MWh for wave, and £105/MWh for tidal stream. The Obligation has been set at zero for 2007 and in future years it will not be set a level above zero unless there is going to be eligible capacity commissioned in the coming year that would trigger the setting of a target that suppliers could meet. The MSO is expected to support up to 75MW of wave and tidal stream and to cost no more than £45M per year.

Whilst this level of public funding to marine renewable energy is very welcome, this is an overly complex and rather disjointed funding landscape and there is little evidence of communication when making decisions to allocate funding, nor of communication of the results from different projects funded by different public sources.

4 Experience and evidence gathering

This section summarises the evidence gathered by the RAB marine group. These are grouped under the following headings:

- BERR’s R&D programme;
- EPSRC Supergen marine programme;
- survey of technology developers;
- utilities’ perspective;
- large engineering companies;
- private-sector finance providers.

4.1 BERR’s R&D programme

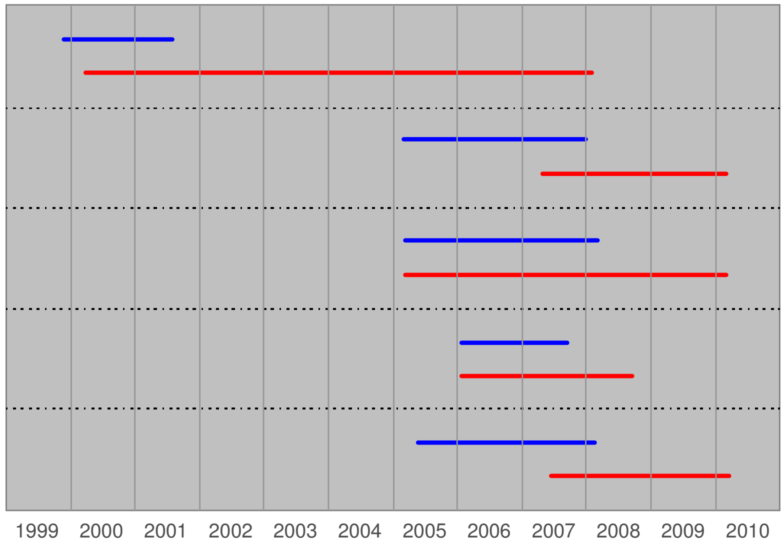
4.1.1 Progress and achievements

In 1999 the DTI's New and Renewable Energy R&D programme, which is now part of the Technology Programme, began to fund research into wave energy again, and in 2000 into tidal-current energy for the first time. Whereas in the past projects were 100% funded by Government, since 1999 they have been shared-funded with industry.

Since then DTI, now BERR, has committed over £35M on nearly 60 projects covering 27 device concepts and a number of ancillary technologies. However, only £15.5M of this has been drawn down by the companies.

The development of individual device concepts is taking longer than originally forecast, some substantially so. Figure 4.1 below shows the actual timetable (red) compared with initial forecast timetable (blue) for the prototype demonstration projects of a number of leading candidate technologies (we do not show the names of the projects) that were expected to have entered the MRDF by now. (This chart does not show the timescales for technologies that have been abandoned by the developers because of their judgements on the long-term commercial prospects for the technologies.)

Figure 4.1 - Actual (red) compared with initial (blue) forecast timetable for the prototype demonstration projects of a number of leading candidate technologies

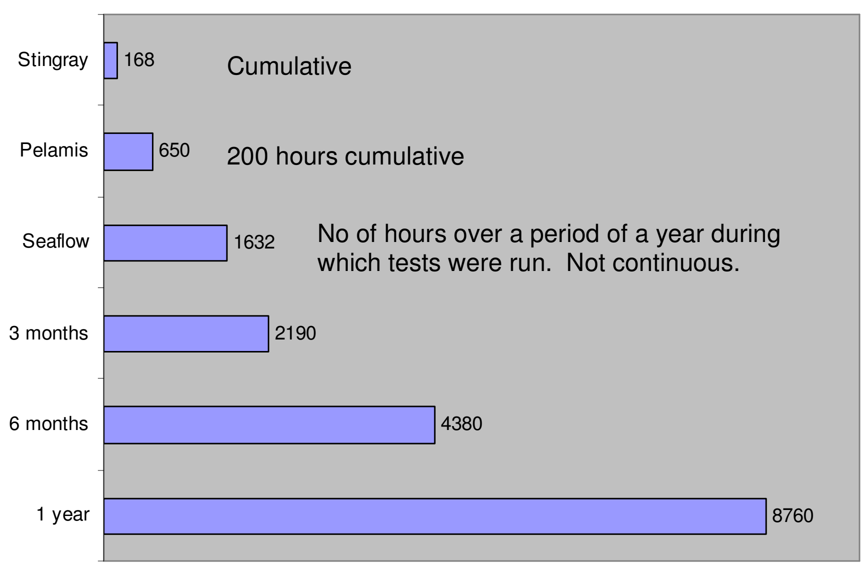


It is important that we take this information in context. It is not a reflection on the intrinsic merits or otherwise of the technologies, nor a criticism of the individual companies concerned. It is very common for R&D projects to take longer than originally forecast, reflecting a combination of optimism and the natural uncertainty of research.

The achievements and results of the projects are disappointing, however.

Figure 4.2 below shows the operating hours accumulated by full-scale prototypes under the programme, which represent the best operating hours of any device that we know of to date, and compares them with the time needed for MRDF qualification (3 months continuous operation).

Figure 4.2 - Cumulative operating hours reported to date under BERR's R&D programme



The figures in Figure 4.2 are those reported by the developer to BERR under the R&D programme. In some cases it is believed further operating hours have been achieved but these have not yet been reported through the R&D programme.

So, not only are the individual R&D projects taking longer than anticipated, those that have progressed to prototype demonstration have not yet met the Scheme's key eligibility criterion that the technology must have accumulated three months of continuous operation at full-scale in a representative range of sea conditions. This is the main reason for the lack of uptake of the MRDF.

Individual projects are also costing more than originally envisaged, some substantially so, although this is not unusual for new technologies, and again is not necessarily related to the long-term commercial prospects for a particular technology. It is typical for a new technology to go through a period of increased costs while unexpected problems are identified, to then be followed by the cost reduction through learning and new solution development. In addition some external factors have resulted in increased costs which may not have been possible to predict in advance, This includes the cost of basic materials such as steel and copper as well as a large increase in the cost of leasing of offshore vessels because of increased oil and gas activity.

There have been very limited published results from the research carried out to date, including the knowledge and understanding generated. This lack of sharing means that the industry progresses more slowly. This may be because developers are keeping their research findings secret:

- to protect their intellectual property thereby maintaining its value to investors and/or;
- to control public and investor perceptions of the technology,
- or that there is insufficient results yet available.

This situation represents a failing of the R&D programme, and more should be done to elicit and publicise early results. However, consideration would have to be given to the commercial sensitivity of such a move.

Current costs estimates (p/kWh) of wave and tidal stream are relatively uncertain because of the lack of progress and disclosure of information to date.

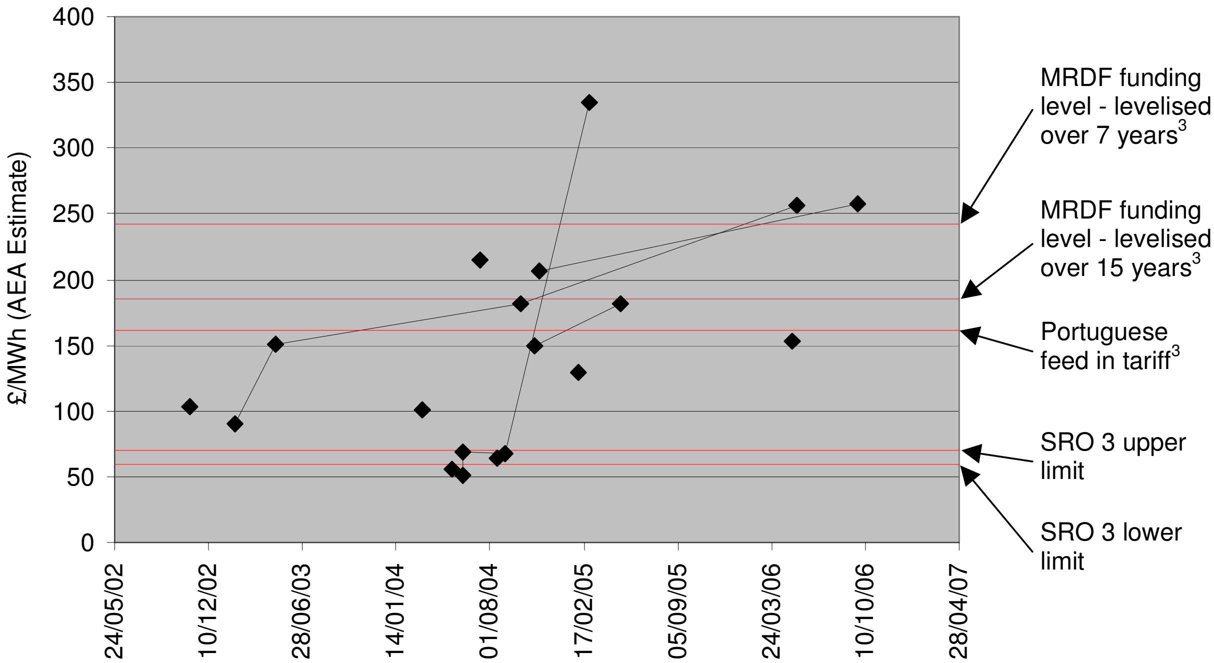
Figure 4.3 below shows the estimated generation costs of the technologies that have been developed under BERR's R&D programme. The costs were estimated by AEA from data in proposals and projects reports. Most of these costs are based on project lives of 20 years and so care must be taken when comparing with the incentive schemes levels shown. As many of these data are confidential, we have not identified any of the technologies involved. Where the points are joined together by a line, it indicates that they refer to the same technology. This demonstrates that, as a technology develops from the initial idea stage through R&D projects of increasing scale and cost, the estimated generation cost tends to increase. This is because, as more research is carried out and previous estimates of capital and operating cost are revised, in the early stages of development these.. The horizontal red lines refer to the levels of support available from the MRDF and the 3rd Scottish Renewables Order which was announced in 1999 and included 3 wave projects that were awarded contracts through competitive tender process to supply electricity at prices ranging from 5.95p/kWh to 7.0p/kWh (in 1998 prices).

Although the cost of any technology at an early stage in its development is likely to be uncertain, it would be reasonable to expect that once a technology has had a full-scale demonstration its cost and performance characteristics should be understood quite accurately at that stage of its development. The full-scale demonstrations that have been conducted to date have not yielded such an understanding. However, the prototype devices may not have been optimised for manufacture as their primary purpose is one of demonstrating both survivability and ability to capture energy.

Current estimates of the generating cost of wave and tidal-current energy are greater than most other renewable energy technologies, except current generation photovoltaics[2] if deployed in the UK. However, marine is also at an earlier stage of development than most other technologies.

[2] Ernst & Young LLP, "Impact of banding the Renewables Obligation - Costs of electricity production", April 2007, URN 07/949, downloadable from http://www.berr.gov.uk/files/file39038.pdf (checked 12/07/07)

Figure 4.3 - estimated generation cost as a function of the date that the estimates were made[3]



4.1.2 The wave and tidal stream resource

It is acknowledged that the wave and tidal stream resource is large and clearly worth pursuing.

However, previous studies into the size of the usable resource may not have adequately considered the constraints on the use of the resource, such as environmental, other uses of the sea and access to the grid. For example, substantial grid reinforcement will be necessary to fully utilise much of the most energetic resource, the cost of this does not appear to have been included in previous cost-resource studies. Much of the UK's onshore wind resource may also require the same grid reinforcements.

The remaining resource after these constraints have been allowed for may still be able to make a major contribution to UK CO_2 reduction targets. The Carbon Trust Marine Energy Challenge estimated the contribution to be potentially between 15 and 20%.

4.1.3 Environmental impacts

There is little published information on the potential environmental impacts of wave and tidal stream devices. This is not surprising given the few numbers of devices that have been installed. However, with the work being taken forward by BERR's Research Advisory Group[4], in co-operation with COWRIE[5], there is in place research programmes that will develop a much deeper understanding of the potential environmental impacts from the future deployment of these technologies. This will provide an important body of evidence to all stakeholders.

---

[3] For a facility with a capital cost of £3,000/kW and a capacity factor of 25%, provided that the farm is not large enough to exceed the £9M cap, the MRDF capital grant annualised over 7 years using a discount rate of 12% is equivalent to £72.5/MWh. Adding this to the MRDF revenue support level (£100/MWh), the price of brown electricity (£35/MWh) and ROCs (£35/MWh) gives a total of £242.5/MWh.

If the farm is operated for 15 years, receiving revenue from brown electricity and ROCs for the full 15 years, MRDF revenue support for the first 7 years and the same capital grant, the MRDF support would be equivalent to £186/MWh spread over the 15 years.

These results depend on the cost and performance of the technology, as well as the prices of electricity and ROCs, all of which will fluctuate from time to time. They also depend on the discount rate used.

The Portuguese feed in tariff of €230/MWh is equal to £161.6/MWh at an exchange rate of 1€ = £0.70266 current on 12/11/2007 (see www.oanda.com). This result depends on the exchange rate, which will fluctuate from time to time.

[4] http://www.dti.gov.uk/energy/sources/renewables/policy/offshore/research-advisory-group/page22590.html

[5] http://www.offshorewindfarms.co.uk/

4.1.4 Jobs and wealth creation

Several estimates have been made of the potential contribution of marine energy (wave and tidal-current taken together) to employment and wealth creation in the UK. The main two sources of jobs predictions are the Scottish Government's FREDS MEG report, "Harnessing Scotland's Marine Energy Potential", published in 2004[6]. This predicted 7000 direct jobs in Scotland by 2020. The other is in a report prepared by AEA Technology for the Clyde Shipyards Task Force in 2002[7]. This predicted 3000 direct jobs in Scotland by 2015.

However, these estimates involve a number of major assumptions concerning the rate of technical progress in the technology, the size of the potential global market and the nature of the supply chain that would service such an industry. Whilst the report provide some useful context such studies are ultimately driven by forecasts of how fast the sector develops, which is difficult for anyone to gauge. A more rigorous analysis of this topic may provide more clarity on this subject.

4.2 EPSRC Supergen marine programme

There is now an improved understanding of the fundamental science of wave and tidal stream, the nature of the resource and its extraction, which has a greater level of complexity than previously thought.

Key unknowns and critical areas for fundamental research have been identified, and this has revealed far more questions than previously thought. Much work on the fundamental science remains. As this research progresses there will be a greater understanding of the resource and how it can best be exploited. Much of the research will assist technology developers in improving device performance and help in addressing the cost of generation in the future.

More information can be found at www.supergen-marine.org.uk.

The UK Energy Research Centre (UKERC) is developing an International Marine Renewable Energy Road Map. This work is currently under peer review and should be published in the near future.

4.3 Survey of technology developers

RAB commissioned Databuild Ltd., a specialist and independent market research company to undertake a questionnaire survey of 27 device developers, to obtain their perspectives on the slower than expected progress with R&D. In some cases questionnaire responses were followed-up by more detailed telephone interviews where clarification was required.

Appendix 4 presents the questionnaire that was used. Appendix 5 presents Databuild's report. The following is the summary included in the report:

- More than half of the respondents have found that operating in the marine environment and establishing commercial viability have been more challenging than originally anticipated. Their perceived problems cover 4 main areas:
  - Technical problems
  - Funding
  - Knowledge and resources
  - Practical issues that increase costs and slow down the development

- A number of the issues raised by developers appear to be factually incorrect, such as that if a device fails then the government will want any funding originally given out to be returned and that the government has set unrealistic expectations of the sector. It is important that these perceived inaccuracies are corrected.

---

[6] Forum for Renewable Energy Development in Scotland (FREDS) marine Energy Group (MEG) report, "Harnessing Scotland's Marine Energy Potential", published in 2004. Downloadable from http://www.scotland.gov.uk/Topics/Business-Industry/Energy/19185/17613 (checked 30 October 2007)

[7] Opportunities for marine energy in Scotland, AEA Technology report AEAT/ENV/R/1293, November 2002, . Downloadable from http://www.scotland.gov.uk/Publications/2003/02/16470/18727 (checked 30 October 2007)

- Some developers are struggling to get funding from the public sector because of a lack of understanding of what the funders are looking for (section 2.2.1 of the report). The developers that have been in the sector for a number of years have a better understanding of what funders are looking for as they have gone through the process a number of times.

- Both of these issues suggest that there needs to be more communication between the government and the developers on both what they are expecting from the sector but also clearer information and guidelines on funding streams.

- As well as having difficulty with public sector funding, developers have also found it challenging to get private investors on board (2.2.2 of the report). There is a general feeling among developers that private investors lack the confidence in marine renewables and therefore find it difficult to convince private developers to invest, when the benefits are often achieved a number of years after the investment.

- In addition to the difficulties in raising funding for the developments, developers have had difficulty in estimating the amount of funding needed. Nine out of the twelve developers felt that they had underestimated the amount of money they would need, five of these felt they had significantly underestimated (section 2 of the report). The difficulty in estimating the amount of funding required obviously also impacts on the ability to plan where to get the funding from.

- A number of developers mentioned the difficulty of predicting problems that will occur throughout the stages of development (section 2.3 of the report). Until the developers are at the stage where they are ready to go out to sea and test the device, they do not know what will happen. It has therefore been difficult for the developers to set realistic expectations of where they expect to be.

- One further area that developers are also finding difficulty is recruiting staff with appropriate skills (section 2.3.2 of the report). They face competition from the oil and gas industries that can pay much higher salaries. Developers could therefore benefit from help on how to attract new people to their organisation.

Picking up on the reference in the report to government funding programmes the following comments were made in the report:

  - BERR’s Technology Programme had application forms that were considered too restrictive and didn’t always give the best opportunity to make the case for the project. However, where organisations had been applying for BERR funding for a long time they felt that the process had become easier.
  - The Carbon Trust’s processes were seen as costly and onerous by some developers, were too focussed on consultants, and developers were unhappy about relinquishing control of IPR.
  - Many respondents liked the flexibility of the Scottish Government’s Wave and Tidal Stream Energy Demonstration Scheme (WATES). The Group accepted, however, that only one project of the kind anticipated for the MRDF had been supported, and that the remainder were prototype devices of the kind also supported by the Technology Programme.
  - Some developers had mentioned a “gap” between R&D funding and the MRDF. However, the testing of full-scale prototypes for extended periods can be and have been funded under the Technology Programme. All of the full-scale prototypes deployed to date under the R&D programme have had their testing curtailed by the developers after very short periods. This has been for various reasons, principally cost overruns and technical difficulties.

Most of the group found some of the developers’ views surprising, especially those concerning a perceived lack of testing facilities, which was particularly surprising given the Government expenditure on NaREC and EMEC in recent years.

The difficulty of recruiting suitably qualified graduates is perhaps less surprising given the mix of skills required is not as yet taught in universities, especially a combination of good engineering design with hydrodynamic understanding. Such skills might be found in the oil and gas industry, but would be in demand there and therefore expensive. This picture is not universal and some companies have found no difficulties in this area, this may be due to external factors such as location.

4.4 Utilities' perspective

RAB has also received written contributions from a number of utilities that are actively considering marine renewable energy- these are the potential future customers for the technologies that are being developed. A number of the utilities have made major commitments to investing in the marine renewables market. These have been widely publicised in the media.

These views are summarised in this section, grouped under the following headings:

- technology status;
- realism;
- skill-sets and technical resources;
- external factors;
- the MRDF.

4.4.1 Technology status

There have been some considerable achievements in the development of marine energy technology to-date, with a small number of full-scale devices having been built, tested and operated at sea for short periods. However, the majority of device concepts are still very much in the R&D phase.

Even the leading devices have only been operated at sea for short periods. Much more operational experience needs to be accumulated, and learned from, before the risks involved in developing marine energy facilities can be more fully quantified.

There are very many device concepts currently under development, indicating that the optimum solution has not yet been identified. Consolidation of ideas may help a better design to emerge and lessen competition for funds thereby helping investors in the sector to target their funding.

4.4.2 Realism

The technical and commercial risks involved in developing marine energy technologies differ depending on the type of technology and the resources of the developer. Some technology developers appear to have underestimated these risks, taking a naive and over-optimistic view of the rate at which their technologies can be developed. High stakeholder expectations have been built up that cannot yet be fully justified.

It appears that some device developers may have an exaggerated estimation of the value of their intellectual property and their technologies, given the state of development and achievements to-date.

4.4.3 Skill-sets and technical resources

There is evidence that some technology developers do not have the complete skill-set required. Where this is the case, the areas that are of particular concern are:

- project management of large complex projects;
- experience and expertise in marine operations;
- understanding of the planning process;
- knowledge of grid code compliance issues.

Large engineering multinationals and oil majors could bring many of the required skills and resources but have not so far become involved in the sector. This is somewhat surprising but they may be focussed on more immediate opportunities in other sectors.

4.4.4 External factors

It is stated elsewhere in this report that generation costs for wave and tidal technologies appear higher now than when the financial parameters of the MRDF were first set in 2004. Similar increases have also been observed in BERR R&D projects (see Figure 4.3 above).

In recent years the prices of some input materials and services have significantly increased due to changes in market conditions. This is one of a number of critical areas where costs have risen and is outside of the technology developer's direct control. This has had similar impact in other industries such as the wind turbine industry.

4.4.5 The MRDF

There were two main issues addressed by the utilities on the group regarding the MRDF design: the three-month eligibility criterion; and the funding levels provided by the MRDF.

On the MRDF's three-month eligibility criterion there was not a consensus on the desirability of keeping it. A majority (3 to 1) were of the opinion that it should be kept.

The argument for keeping the three-month criterion is that most utilities would not normally invest in a commercial project using a new generating technology unless it had been demonstrated in a representative range of sea conditions for an appropriate period of time. Developing a multi-device project with a technology that had not been properly demonstrated would be too risky.

The argument against keeping the criterion is that most technologies are only just approaching that stage, and so cannot gain access to the scheme.

The intent of the three-month criterion is to help ensure that projects within the MRDF have completed their R&D, that the performance of the concept is known and predictable, and to allow MRDF projects to have a high probability of technical and financial success. There may be a case to allow a more flexible interpretation of the three-month criterion provided this intent is maintained.

All four utilities agreed that the MRDF's current levels of funding are not sufficient to bring forward wave projects, given that these have turned out to be more expensive than was understood when the MRDF financial support parameters were formulated.

4.5 Private-sector finance providers

A number of interviews were held with private investors who had invested, or had considered investing, in marine renewable energy companies, to gain an understanding of their perspectives on the industry and their attitudes to investing in it. These are summarised below. We have not named any of these organisations and the following discussion is presented in an anonymised way. The main conclusions are:

- Financiers generally have a positive view of the technology and its commercial prospects, although some commented that there were still many unknowns and that the risks are high.
- Having a strong management team in the technology developer is viewed as at least as important as the technology itself. Some of the interviewees considered that not all marine energy companies have good management; there are a few exceptions and it is these exceptions that are viewed as having good commercial prospects.
- The regulatory regime, particularly requirements for environmental impact assessment was seen as a potential barrier.
- The sector was viewed as having too many small players with insufficient resources and that the industry could benefit from some larger companies becoming involved.
- More public funding was not generally seen as a panacea but is helpful.

- The Government commitment to carbon dioxide reduction, renewable energy targets, the RO, MSO, WATES, MRDF etc., provides a strong long-term market signals to encourage investment.
- Commenting on the proposed banding of the RO to give two ROCs for wave and tidal stream financiers thought it was too early to tell whether this would be sufficient to support the industry, suggesting that costs and performance are not yet fully known.

4.6 Engineering companies

A number of conversations were held with large engineering companies that had become involved in, or considered becoming involved in, marine energy, mostly through direct or indirect involvement in BERR-funded R&D projects. These are summarised below. We have not named any of these organisations and the following discussion is presented in an anonymised way. The main conclusions are:

- The companies surveyed generally thought that the technical challenges facing the industry were surmountable, although significant.
- Doubts were expressed over some technologies and companies' ability to deliver.
- The view was expressed that some device developers are narrowly focussed on their technologies at the expense of developing experience in the other aspects of successful implementation such as installation and O&M.
- Unrealistic expectations have been built up over the rate at which the technology will develop.

5 Conclusions

Based on the evidence gathered for this report, it is clear that there have been many achievements in the UK, with a number of prototype systems being constructed, installed and tested in a harsh environment. Device developers have gained experience of manufacturing, installation and operation. Although progress has been slower than expected, given the size and difficulty of the challenge, the progress that has been achieved can still be regarded as considerable, and the industry achieved much. The UK is still regarded as the international leader.

The immediate reason for the lack of take-up of MRDF funds is that no prototype devices have yet met the Scheme's key eligibility criterion of three-months continuous operation at full scale in a realistic set of sea conditions. No full-scale grid connected systems have yet been tested for an extended period. There are a number of contributory factors to why this is the case and these are discussed below.

5.1 Different Development paths

Some developers have not set out to meet the MRDF entry criteria as their primary focus choosing instead other milestones that align with their overall funding requirements. This may be their private investor's milestones or just the available budgets constraining what can be done.

Some projects have been developed at scales other than full commercial scale or have developed only partial systems for open sea deployment, the MRDF entry criteria does not recognise this.

Both of the above approaches are legitimate development paths but do mean that the readiness for commercial deployment is much more difficult to assess and in any case do they do not meet the criteria set out in the MRDF. An alternative criterion for MRDF may be to subject the entry application to a detailed scrutiny to see how the development compares with the equivalent of three months full scale open sea testing.

5.2 Size of the technical challenge

Developing marine energy is technically very difficult. The resource is highly complex and its behaviour is not yet fully understood at a theoretical level, although academic researchers are making much progress. The marine environment is harsh and unforgiving.

Although many device developers have constructed full-scale prototype devices, it appears to be at the deployment stage that the problems occur. This may be due simply to the difficulty of operating in a marine environment for extended periods, which represents unexplored territory for marine energy devices or that there is a lack of resources available to install devices while there is a high demand in other more lucrative markets (oil and gas).

It may also, in part, be due to an over reliance on oil and gas services which are now in heavy demand, although at this stage in the development of the technology this is almost inevitable as there is not yet the industrial base to justify the investment in marine plant and equipment that will help insulate the industry from the full brunt of the external forces currently acting against it. Such effects could be expected to decrease as the industry matures.

5.3 Optimism

This is not in itself a reason for slow progress, but is a reason why expectations have been unrealistically high. Device developers appear to consistently underestimate the time needed to achieve results, the cost of doing so, the size of the technical challenges involved and the risks.

The marine renewable energy sector is not unique in this regard. It is very common for R&D projects on all renewable energies to take longer than originally forecast, reflecting a combination of optimism and the natural uncertainty of research. In general, though, the marine renewable energy industry has overstated its current development status and level of achievement.

Device developers conducting R&D are burdened and distracted by project development tasks. A significant portion of project development costs, whether for MRDF projects or projects designed to gain 3 months operational experience, are associated with environmental assessment and permits. Whilst these are necessary they are not high-risk R&D activities. Nevertheless, these tasks distract device developers from their main responsibility to develop their device. They introduce delays and project risks that also hinder true R&D. This also means that not only do device developers need to bring in technical skills but they need to acquire project development skills too. Additionally many of the consenting authorities are still learning and rely heavily on device developers to provide information they need. Targeted support for this process alongside R&D is worth considering.

5.4 Delivery of R&D programmes

It is clear that in many cases the current R&D process is not delivering technologies for the MRDF and the published results from R&D projects are very sparse and are not establishing the current cost and performance of wave and tidal stream.

There is a need to look at the levels of investment required to get to the stage where the criteria for the MRDF can be satisfied, and more broadly understand costs associated with device development, and later array and farm development. It's true to say that not all device development and project costs are in the public domain, and most stakeholders recognise why this is the case. The Carbon Trust report "Future Marine Energy" does present information on costs at different stages of development, which are derived from front running device developers. The more understanding we have in this area, the greater the likelihood of creating a joined up public sector support structure and a well targeted MRDF scheme. Further understanding the cost components of marine energy projects will help identify when and where private sector investment from industry stakeholders can also be attracted and expected. We believe there is a case to conduct more work in this area, but further study should review and build on prior knowledge, such as that generated through the Marine Energy Challenge as well as BERR R&D programmes.

Furthermore, the majority of the projects that have been funded to date have been focussed on designing and building a large machine, apparently on the assumption that it will work first time, with little actual research involved to understand or assess different options and optimise designs. There needs to be a greater focus on the critical development issues and reducing key risks and uncertainties through more computer modelling and intermediate testing of both components and systems. Building a prototype at a cost of several £M is an expensive way to see if a concept will work; when prototypes are deployed they should work largely as predicted and be a demonstration of this.

With better communication, co-operation and sharing of research results, it may not be necessary for each device developer to have to construct an entire device to prove its concept. Device developers are very protective of their intellectual property, to the extent that they are wary of sharing any information at all. This leads to the same problems being solved many times by different companies, which is time and effort consuming and very inefficient.

A more proactive approach to managing R&D grants, by specifying how projects should be structured, for example by using a published protocol such as the Irish Marine Institute's and Sustainable Energy Ireland's *Wave Device Development and Evaluation Protocol*, and by taking a more active role in the detailed management of the projects, such as what measurements are required and which data shall be published, may enable a more disciplined approach to be imposed.

There has also been criticism of the lack of flexibility of certain of the processes for receiving and allocating R&D grant funding, particularly when unforeseen problems and challenges arise. Presently, grant funding is on the whole delivered through open and competitive processes, normally a two-stage process of outline proposals followed by full proposals. In some situations this can introduce delays into the development of their devices.

When costs overrun on R&D projects, this can be particularly damaging to the value of the research – particularly where the project is a prototype, expected to generate critical results on the performance of the device. Technology developers cannot always obtain additional funding to complete the work as originally intended, or to do so could introduce delays. This means that the most valuable aspect of these prototypes – the data on how they perform in the real sea – is not generated, or only partly generated.

All of the projects supported under the Technology Programme that have involved full-scale prototypes were originally planned to deploy for a period of twelve months but in every case to date these deployments were curtailed by the grantee after only a few weeks. The reasons for this vary from insufficient funding to new priorities for the limited resources available.

A further issue is communication. There is some misunderstanding among developers about key aspects of both R&D funding and the MRDF, which is allowing a number of myths to propagate, such as:

- The government sets unrealistic expectations on developers - in fact the government has never set any expectations.
- The government asks for its money back if the device fails - this is not the case.
- The R&D programme doesn't allow full-scale prototypes to be deployed and operated for extended periods thereby enabling technologies to qualify for the MRDF - in fact that is exactly what the programme ***is*** intended to do.
- The MRDF doesn't allow profit - profit ***is*** allowed. Although, given that costs are turning out to be higher than was thought when the scheme was designed, some projects may not actually *be* profitable with current levels of support.

There would be a value in greater and more regular communication between technology developers and agencies that provide funding.

5.5 Innovation versus energy policy objectives

Since 2004, with the establishment of the Technology Programme, we have seen an increased emphasis of innovation as the primary driver for the R&D that is being supported. There is a proliferation of new device concepts now under development, many of which only seem to have marginal differences.

Other objectives, such as to evaluate and understand the long-term commercial prospects of new technologies, to understand their potential contribution to the UK and global energy markets, and contributions to environmental targets seem to now have a subsidiary role. These objectives can only be met if results are published and shared. Every technology developer is now expecting to receive grant support all the way from initial concept to multi-device demonstration. This is very costly and potentially wasteful. With more sharing of results this would not be necessary.

5.6 Results of academic research

Developers do not appear to be making best use of the academic research that has been performed.

This is not entirely their fault, as the results of some of the older research are no longer easily available and academic publications generally are difficult for those outside the academic community to access.

It is of concern that the majority of technology developers do not value academic research or appreciate its relevance. More could be done to make the results of academic research more focused on the industry's critical challenges, results more easily accessible, for example by the publication of summary reports that draw together and interpret the current state of the art. The Supergen Marine group get very good attendance at their dissemination events and have seen an increasing level of interest being shown by developers as their work has progressed.

5.7 SMEs

The marine energy industry is populated by a large number of small companies. We are anxious about whether these companies have all the resources and skills to undertake large-scale marine projects, which are complex and risky. Both the Utilities and Finance community suggested that the sector could benefit from:

- consolidation;
- the involvement of larger engineering companies with experience of operations at sea, particularly service and subsea engineering companies from the oil and gas sector.

It may be beneficial for the Government to look at ways stimulating the interest of oil and gas service companies in marine energy.

5.8 Finance and investment environment

The private-sector finance and investment community is already taking an active interest in marine energy and the leadings firms have secured substantial private investment. Generally, the finance community seems to have a positive evaluation of the prospects for those marine energy companies with strong management teams. Private finance providers do not view the availability of public funds as a barrier to development of the industry and are content that there are sufficient long-term market signals for marine renewable energy.

6 Recommendations

For a combination of reasons that have been identified, technologies have not progressed through the R&D stage as rapidly as anticipated. Our assessment is that marine renewable energy is still largely in the R&D stage so our recommendations are focused on how the success of future R&D might be improved.

- In general, there needs to be much greater co-operation and communication within Government, and between Government, its agencies, industry and academia. The current lack of co-operation between device developers, academia and Government funding agencies is wasteful of resources and inefficient.
- More could be done to make the results of academic research more focused on the industry's critical challenges and results more easily accessible.
- Ideally, the number of public bodies that issue grant-type funding should be reduced, but if this is not possible, they should at least share information and results.
- Mechanisms for funding R&D would benefit from greater flexibility both in terms of their design and delivery. This has proved to be particularly critical when project costs escalate, as technology developers are some times forced to curtail the monitoring and evaluation of their prototypes, which is the primary purpose of their projects in the first instance. There are a number of ways in which R&D can be supported and these should be considered in the context of the very unique challenges facing marine renewables.
- There is in the public domain a lack of data on the actual performance of marine renewable energy technologies. We would encourage full publication of results from all Government funded projects. By results, we mean the measured performance of devices, not details of a device's design that are clearly proprietary. We understand there will be reluctance from technology developers to agree to this, but without this, we cannot as a nation obtain full value from the research, will be duplicating effort and repeating mistakes.
- There would be a benefit from a greater focus on the critical research and development issues and reducing key risks and uncertainties through more computer modelling and intermediate testing.
- A proactive, outcome-focused approach to the award and management of R&D grants would be of value.
- Adopting a staged R&D approach with specific, numerical and testable, development targets at each stage, with certainty of progressing to the next stage if results merit this.

We believe the MRDF should be kept in place. RAB expects a small number of technologies to enter the MRDF over the next year or so. That the MRDF has not yet allocated any of its funding is a reflection on the development status of the technologies; the MRDF was set up too early. However, its launch provided a strong signal to the market and potential investors. Nonetheless, some adjustment to its design would be beneficial.

- Increase the funding available to wave power in the MRDF, as the costs of wave power are higher to day than when the Scheme was developed. Without this, wave power projects cannot operate profitably within the MRDF.
- The technical risks for marine renewable energy are still very high and probably higher than thought at the time the MRDF was developed. We recommend that the Government consider increasing the capital grant element of the MRDF funding, whilst still retaining an element of revenue support to reward success.
- Maintaining the 3-months eligibility criterion, although perhaps allowing a little flexibility in its interpretation provided the intent of this criterion is not eroded.

Appendices

Appendix 1: Acknowledgements
Appendix 2: References
Appendix 3: UK marine renewable energy funding landscape
Appendix 4: Device developers' questionnaire
Appendix 5: Databuild's report on its survey of device developers

Appendix 1

Acknowledgements

The Chair would like to acknowledge the help of the following people in the preparation of this report:

Amaan Lafayette Craig Harwood	E.On
Alan Mortimer	Scottish Power
Paul Catterall Alex Linsell Bill Langley	npower Renewables
Robin Burnett	SSE/Aquamarine
Neil Kermode	EMEC
Alan Moore Mike Hay Gordon Edge Peter Madigan	BWEA
Jonny Boston	South West Regional development Agency
Neal Rafferty	Scottish Government
Carolyn Heeps Alex Adrian Ben Barton	The Crown Estate
Prof Ian Bryden Henry Jeffrey	University of Edinburgh
Ron Loveland	Welsh Assembly Government
John Callaghan Steve Wyatt	Carbon Trust
Malachy McKernan	DETI, Northern Ireland
John Spurgeon	BERR
Howard Rudd Phil Michael	AEA Energy & Environment
Peter Fraenkel	Marine Current Turbines

Appendix 2

References

References referred to directly in the report

References referred to directly in the report are shown as footnotes on the page on which the reference is made.

References not referred to directly in the report but which form a general background to the work.

General

1. Department of Trade and Industry; ‘Atlas of UK Marine Renewable Energy Resources’, produced in two volumes; ‘Technical Report’ (URN 04/1532) & ‘Atlas Pages’ (URN 04/1531).
2. ‘Opportunities for Marine Energy in Scotland’ a report by Future Energy Solutions for the Scottish Executive, November 2002, Report No AEAT/ENV/R/1293. Downloadable from http://www.scotland.gov.uk/Publications/2003/02/16470/18727 (checked 05/11/07)
3. ‘Harnessing Scotland’s Marine Energy Potential’, Forum for Renewable Energy Development in Scotland (FREDS) Marine Energy Group (MEG) Report 2004. Downloadable from http://www.scotland.gov.uk/Topics/Business-Industry/Energy/19185/17613 (checked 05/11/07)
4. Future Marine Energy, Publication ID CTC601, 20 January 2006. Downloadable from: http://www.carbontrust.co.uk/Publications/publicationdetail.htm?productid=CTC601(Checked 06/10/2006)
5. Cost Estimation Methodology - The Marine Energy Challenge approach to estimating the cost of energy produced by marine energy systems. Report and Spreadsheet. Downloadable from:http://www.carbontrust.co.uk/technology/technologyaccelerator/mec_cost_estimation_methodology.htm(Checked 06/10/2006)
6. "Scotland’s Renewable Energy Resource 2001- Volume 1: The Analysis” Garrad Hassan 2001
7. International Energy Agency, Implementing Agreement on Ocean Energy Systems, Annual Report 2003. Downloaded from:http://www.iea-oceans.org/publ/index.htm(Checked 12/09/2006)
8. International Energy Agency Implementing Agreement on Ocean Energy Systems. Review and analysis of ocean energy systems development and supporting policies. 28th June 2006 http://www.iea-oceans.org/_fich/6/Review_Policies_on_OES_2.pdf (checked 05/11/07)

Tidal

1. Engineering Power Development Consultants Ltd with Binnie & Partners, Sir Robert McAlpine & Sons Ltd and IT Power Ltd, ‘Tidal-Stream Energy Review’, ETSU T/05/00155/REP, 1993.
2. Binnie, Black & Veatch, ‘The Commercial Prospects for Tidal Stream Energy’, ETSU/T/06/00209/REP, URN 01/1011, 2001.
3. NOAA Technical Report NOS CO-OPS 022, ‘Assessment of The National Ocean Service’s Tidal Current Program’, April 1999. (Downloaded from http://140.90.121.76/pub.html on 05/10/05)
4. GEC Hirst Research Centre, ‘A Literature Survey and Data Search Related to Tidal Current Energy Devices and Systems’, 1979.
5. ‘UK, Europe and Global Tidal Stream Energy Resource Assessment’, A report by Black & Veatch Ltd for the Carbon Trust. Available from www.thecarbontrust.co.uk/ctmarine10/Page4.htm (accessed 18/5/05 but since removed)
6. ‘Phase II UK Tidal Stream Energy Resource Assessment’, a report by Black & Veatch Ltd for the Carbon Trust. Downloadable from www.thecarbontrust.co.uk/ctmarine3/Page5.htm (checked 25/8/05)
7. ‘Tidal Stream Energy Resource and Technology Summary Report’, a report by Black & Veatch for the Carbon Trust, July 2005. Downloadable from http://www.thecarbontrust.co.uk/ctmarine3/res/TidalStreamResourceandTechnologysummaryReport.pdf (checked 13/10/2005)

8. ‘A Scoping Study for an Environmental Impact Field Programme in Tidal-Stream Energy’, ETSU/T/04/00213/REP, URN 02/882, 2002. Downloadable from http://www.dti.gov.uk/renewables/publications/pdfs/t0400213.pdf (checked 14/10/05)
9. The Engineering Business Ltd, ‘Stingray Tidal Stream Energy Device - Phase 3’, T/06/00230/00/REP, URN 05/864. Downloadable from http://www.dti.gov.uk/renewables/publications/pdfs/t06002301.pdf (checked 14/10/05)
10. IT Power et al, ‘Development, Installation and Testing of a Large-Scale Tidal Current Turbine’, T/06/00210/00/REP, URN 05/1698. Downloadable from
11. Bryden IG and Couch SJ, ‘Marine Energy Extraction: Tidal Resource Analysis’, Journal of Renewable Energy, Elsevier, RENE2412, paper 10.1016/j.renene.2005.08.012
12. Bryden I and Melville G, ‘Choosing and Evaluating Sites for Tidal Current Development’, Proc Instn Mech Engrs, Vol 218, Part A: J. Power and Energy, pp. 567-578, Professional Engineering Publishing Limited, London, UK, ISSN 0957-6509, 2004.
13. Bryden IG, Grinsted T and Melville GT, ‘Assessing the Potential of a Simple Tidal Channel to Deliver Useful Energy’, Applied Ocean Research, Elsevier, 2005, Vol 26/5, pp. 200-206, 10.1016/j.apor.2005.04.001. (Publication details confirmed 19/8/2005)
14. Bryden IG and Melville GT, ‘Optimising the Performance of Tidal Current Turbines’, Final report to the CECDGXII, 2001.

Wave

1. Presentation given by Max Carcas at a meeting of the Society for Underwater Technology, Aberdeen 8 September 2004. Downloadable from http://events.sut.org.uk/past_events/040908/programme.htm (checked February 2006)
2. “Wave Energy: the department of Energy’s R&D Programme 1974-1983”, P.G. Davies (ed), ETSU Report Number R26, March 1985.
3. The Energy Challenge - Energy Review Report 2006. Cm 6887 July 2006Downloadable from http://www.dti.gov.uk/energy/review/page31995.html(Checked 5/10/2006)
4. DTI, Digest of UK Energy Statistics, 2005.
5. European Wave Energy Atlas (WERATLAS), Joule project JOU2-CT93-0390
6. “Development of the south west wave hub”, in Proceedings of the 6th European Wave and Tidal Energy Conference, Glasgow, August 29th - September 2nd 2005
7. Graw, Kai-Uwe. “Wave Energy Breakwaters - a Device Comparison”, Conference in Ocean Engineering - COE'96, 17-20 December 1996, Madras, INDIA
8. http://www.jamstec.go.jp/jamstec-e/30th/part6/page2.htmlChecked 5/09/2006
9. H Maeda, S Santhakumar, T Setoguchi, M Takao, Y Kinoue & K Kaneko; Performance of an impulse turbine with fixed guide vanes for wave power conversion; Renewable Energy 17 (1999) 533-547
10. Murray, Robin D, “Economic Wave Energy Resource Assessment Methodology & European Assessment”, MSc thesis, university of Strathclyde, 2004.
11. “Pelamis WEC - Conclusion of Primary R&D - Final Report”, V/06/00181/REP, URN 02/1401
12. “Pelamis WEC – Intermediate Scale Demonstration”, V/06/00188/00/00/REP, DTI URN 03/1434, 2003
13. “Pelamis WEC – Full-Scale Joint System Test”, V/06/00191/00/00/REP, URN 03/1435
14. “Pelamis WEC – Main Body Structural Design and Materials Selection”, V/06/00197/00/00/REP, DTI URN 03/1439, 2003
15. www.oceanpd.com press release dated Tuesday 14th March 2006
16. www.oceanpd.com/LatestNews/default.html press release dated 19 May 2005.

17. Performance and Innovation Unit, Background paper H to the 2001 PIU Energy review: “Technical and economic potential of renewable energy generating technologies: Potentials and cost reductions to 2020”. Downloadable from http://www.strategy.gov.uk/work_areas/energy/background.asp (checked 20/04/2006)

18. Prado, Miguel GS; Neumann, Frank; Damen, Michiel EC and Gardner, Fred: “AWS Results of Pilot Plant Testing 2004”, in Proceedings of the 6th European Wave and Tidal Energy Conference, Glasgow, August 29th - September 2nd 2005

19. “The UK’s Shoreline and Nearshore Wave Energy Resource”, T. Whittaker, Queen’s University of Belfast, ETSU Report WV 1683, 1992.

20. Renewable Energy News. Issue 99, 7 July 2006. Article entitled “Marine Fund goes begging” on Page 1.

21. Renewable Energy News, Issue 99, July 7 2006.

22. “A Scoping Study for an Environmental Impact Field programme in Tidal-Stream Energy”, ETSU/T/04/00213/REP, URN 02/882, 2002.

23. The potential for using disused coastal mineshafts to exploit wave energy - main report, V/06/00196/00/REP, DTI URN 04/1791 and The potential for using disused coastal mineshafts to exploit wave energy - appendices, V/06/00196/00/REP, DTI URN 04/1792

24. “Matching Renewable Electricity Generation with Demand”, a report produced for the Scottish Executive by the Institute for Energy Systems, University of Edinburgh. February 2006. Downloaded from:http://www.scotland.gov.uk/Publications/2006/04/24110728/0(checked 18/09/2006)

25. Seapower SW Review; Resources, Constraints and Development Scenarios for Wave and Tidal Stream Power in the South West of England. January 2004. Metoc Report No 1220. Downloadable from:http://www.regensw.co.uk/press/docs-list.asp?catid=17 (checked 15/09/2006).

26. “A Brief Review of Wave Energy”, T W Thorpe, ETSU Report Number R120, May 1999.

27. MJ Tucker & EG Pitt, “Waves in Ocean Engineering”, Elsevier, 2001, ISBN 0 08 043566 1

28. “Islay Limpet Project Monitoring Final Report”, V/06/00180/00/Rep, DTI URN 02/1435, 2002

29. “Research Into The Further Development of The Limpet Shoreline Wave Energy Plant”, V/06/00183/REP, URN 02/1487

30. World Energy Council Survey of Energy Resources 2001http://www.worldenergy.org/wec-geis/publications/reports/ser/wave/wave.asp(Checked 12/09/2006)

31. World Energy Council Survey of Energy Resources 2001, Section on Norway. http://www.worldenergy.org/wec-geis/edc/countries/Norway.asp(Checked 28/11/2006)

32. RW Yemm, “The history and status of the Pelamis wave energy converter”, in “Wave power - moving towards commercial viability”, IMechE Seminar Publication 2000-8.

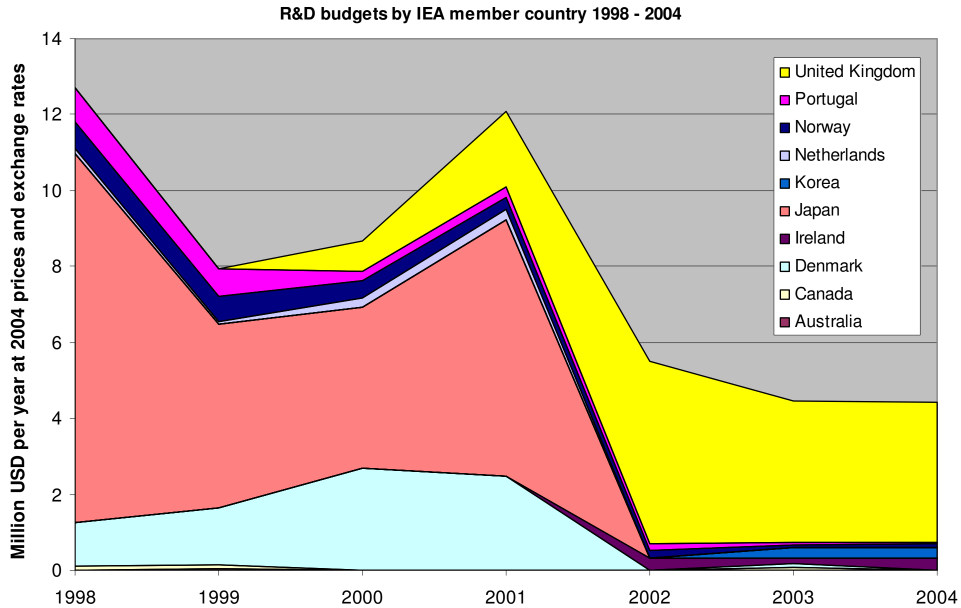
Appendix 3

UK marine renewable energy funding landscape

A3 UK marine renewable energy funding landscape

In 2004, the most recent date for which international comparisons are available, the UK accounted for the majority of R&D funding for marine renewable energy worldwide. Figure 1.1 below shows marine energy R&D funding for IEA member countries between 1998 and 2004.

Figure 1.1 - marine energy R&D budgets by IEA member country



Until 2001 Denmark had an active wave energy programme. During an initial stage the programme assessed 40 new wave power concepts. Nine concepts advanced to the next stage of more detailed design and testing. Following a change of Government in 2001 all renewable energy R&D funding was stopped, including the wave energy programme. Since then, there have been other new and renewable energy projects funded under the Danish Energy Authority's Energy Research Programme (ERP) but so far none have been on marine renewable energy.

In 2001 Japan's Mighty Whale project came to an end and following a review of its results the Japanese government decided not to support further work on this project.

A3.1 Funding sources and facilities

This section gives an overview of the current UK funding landscape for marine renewable energy. Altogether, these amount to £169M of public funding having been spent or committed to marine energy research, development, demonstration and deployment since 2000.

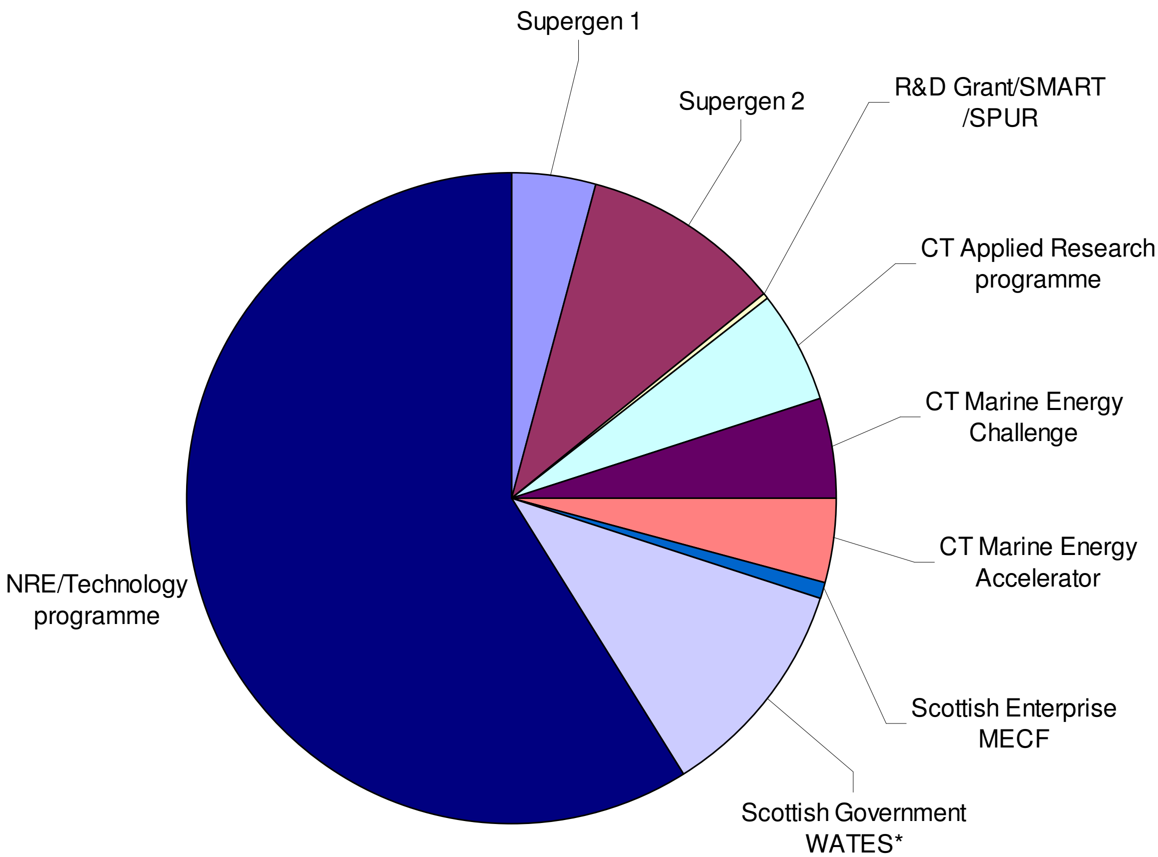
There is a range of funding sources in the UK that support marine energy technology. These are principally:

- EPSRC's Supergen Marine programme.
- BERR's Technology programme, formerly the New and Renewable Energy Programme.
- The Carbon Trust's Applied Research programme.
- The Carbon Trust's Marine Energy Challenge/Accelerator.
- The MRDF.
- The Scottish Government's WATES scheme.
- The Scottish Marine Supply Obligation.

- Welsh Assembly Government.
- The Renewables Obligation.

Figure 1.2 below shows the relative proportions of R&D funding provided cumulatively by the different UK funding sources.

Figure 1.2 - UK R&D funding for marine energy since 2000



* The Scottish Government's WATES scheme funds a mixture of R&D projects and multi-device farms of the type envisaged for the MRDF. Of the projects announced for the scheme, one was of the latter type. We have therefore included the sum of all the grants except this one under the heading of R&D.

In addition to these, a number of facilities have been established or approved:

- NaREC – New and Renewable Energy Centre (£10M).
- EMEC – European Marine Energy Centre (£14.5M).
- Wave Hub (£28M).

The sections below briefly describe these funding sources.

A3.2 Supergen Marine

The Engineering and Physical Sciences Research Council (EPSRC) has a programme called Sustainable Power Generation and Supply (SUPERGEN)[8], that funds consortia of universities researching different power generation and supply technologies. One of these consortia, Supergen Marine[9], led by Edinburgh University, is researching marine renewable energy. The first Supergen

[8] http://www.epsrc.ac.uk/ResearchFunding/Programmes/Energy/Funding/SUPERGEN/default.htm (checked 30/10/2007).
[9] http://www.supergen-marine.org.uk/news.php

Marine programme ran from October 2003 to September 2007 and had a budget of £2.6M. A follow on programme, Supergen Marine 2, with a budget of £6M, began in October 2007.

The consortium is carrying out fundamental research to improve our understanding of the extraction of energy from waves and tides and to reduce risk and uncertainty in the development of marine renewable energy. Supergen Marine has published a full progress report in October 2007 citing 150 peer-reviewed papers. A number of dissemination meetings have been held including some overseas, to highlight the progress and findings of their research. The work packages cover a wide range of topics from marine renewable energy resource assessment through engineering and environmental topics. Further information on this work can be obtained from the website www.supergen-marine.org.uk.

A3.3 BERR's R&D programme

In 1999 BERR re-opened its R&D Programme on wave power following the inclusion of three wave power contracts, at prices of ~£60-70/MWh, in the Scottish Renewables Obligation. Tidal stream was included in BERR's R&D Programme in 2000, following a review of the technology and its prospects, commissioned by BERR[10].

Since then, BERR has supported the development and evaluation of 27 different device concepts and has committed £26M to the development of a number of wave and tidal-stream energy technologies. Several other technologies are also being developed in the UK and overseas. The device concepts that have received funding under the programme are:

Wave
- BWEC
- Edinburgh sloped buoy
- EB Frond
- Limpet
- Oyster
- Pelamis
- Plymouth MOWC
- Wavegen floating attenuator
- Wavegen near shore floating OWC
- Waveshaft

Tidal-stream
- CJD Associates "Seahorse"
- Cormarent
- QinetiQ cycloidal turbine
- TGL Deepgen
- Edinburgh Designs vertical axis turbine
- Boreas flettner rotor
- JA Consult
- Log + 1
- Lunar Energy
- MCT Seaflow & Seagen
- Project Neptune
- IT Power "pulse generation"
- Scotrenewables
- SMD Hydrovision
- EB Stingray
- THGL "deltastream"

The programme adopts a phased approach to R&D funding, with new device concepts being awarded grants to carry out a series of projects at increasing scale and cost, starting with initial desk based evaluations and culminating in a full-scale prototype to be deployed at sea with operation and monitoring for typically a year. At the large-scale end of this progression, grants can amount to many millions of pounds. This approach reduces risk, but it can also introduce uncertainty and delay. The different projects listed above are at different stages in this process, but several of them were expected to have achieved full-scale prototype demonstrations by this time.

A3.4 The Carbon Trust's Applied Research programme

Carbon Trust Applied Research Grant funding is available to businesses and research institutions and aims to support the development and commercialisation of technology with the potential to reduce UK carbon dioxide emissions. Application for an Applied Research Grant is through a two-stage open-call

[10] Binnie, Black & Veatch in association with IT Power Ltd. "The Commercial Prospects for Tidal Stream Power". ETSU/T/06/00209/REP URN 01/1011, 2001

process that is run three times a year. Following an initial online application, in which there is around a 15% success rate, applicants are invited to submit a detailed proposal for assessment against the Carbon Trust's objectives for the funding. Around four out of five applicants are successful at this second stage, and are awarded grant funding of up to £250k, for up to 60% of eligible project costs.

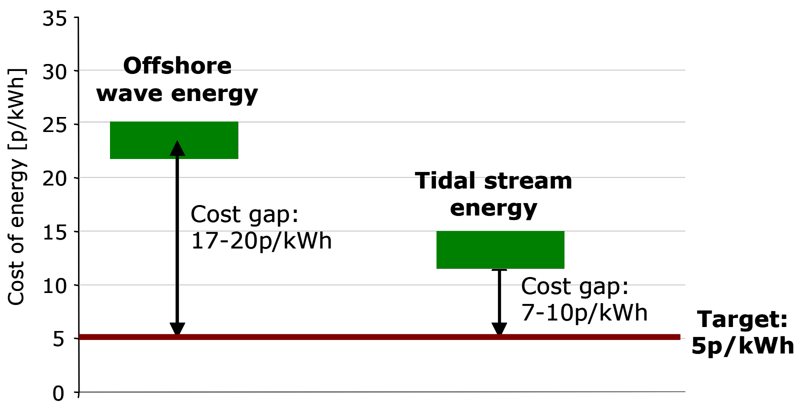
Since 2001 the Carbon Trust has awarded over 130 grants to companies and universities worth over £17M and leveraged over £43M of matched-funding from the private and public sectors. The marine renewables industry has been particularly significant; 15 projects have been awarded grant funding worth over £3M. The Carbon Trust continues to offer Applied Research Grants with three calls scheduled for 2007/8, and although the funding available for each call depends on the number and quality of proposals received, grants worth around £2M were offered over the last three calls."

A3.5 The Carbon Trust's Marine Energy Challenge/Accelerator

In October 2006, the Carbon Trust launched the Marine Energy Accelerator (MEA). The MEA aims to accelerate progress in cost reduction of marine renewable energy (wave and tidal stream) technologies, to bring forward the time when it may become cost-competitive so that significant carbon emissions reductions are achieved.

The MEA project follows on from the Marine Energy Challenge (MEC), the findings of which were published in January 2006 and highlighted that marine energy could supply up to 20% of the UK's electricity needs. The costs of marine energy are currently higher than conventional and other alternative energy sources, reflecting the early stage of technologies. However, the MEC found there is potential for costs to reduce considerably in future and for the technologies to become competitive with other generation forms. Figure 1.3 below shows the cost of current front running wave and tidal energy devices as calculated in the MEC compared to the cost of conventional generation technologies.

Figure 1.3 - cost of current front running wave and tidal energy devices as calculated in the MEC



The current MEA project will help industry close the cost gap quantified in the MEC. Figure 1.4 below shows the predicted relationship between the cost of energy and the installed capacity of wave and tidal devices at different posible learning rates. The graphs also show the intended outcome of the step change expected from initiatives such as the MEA, compared to on going development at the 10 and 15% leaning rates assumed in the MEC.

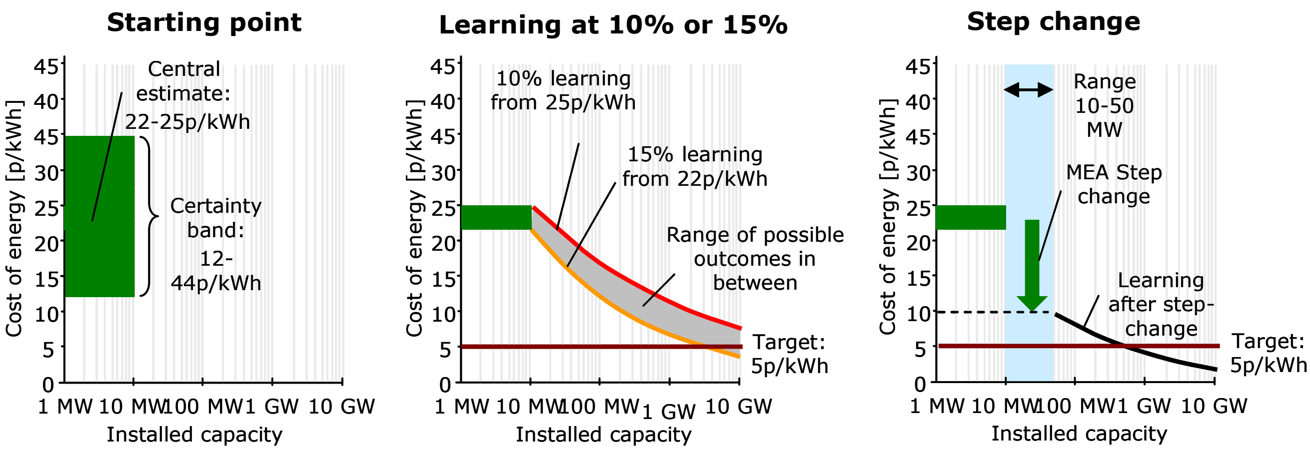
Specifically the MEA expects to create a step change in the cost of marine energy through:

- Development of new marine energy device concepts with potential for significantly lower costs than front-runner technologies;
- Research and development into specific component technologies of marine energy devices that are common causes of high costs; and

- Development of low cost installation, operation and maintenance strategies for marine energy devices.

For the projects under these three strands £3.5M is available to device developers, component technology manufacturers, engineering consultants/contractors and academic research groups. Through conducting the projects, individual participants will directly benefit, but important cross cutting learnings will also be derived to help accelerate the industry as a whole towards cost competitive marine energy.

Figure 1.4 - predicted relationship between the cost of energy and the installed capacity



A3.6 The MRDF

In 2004, developers of some marine energy devices indicated that R&D was nearly complete and that they were ready to build and deploy their prototype devices. The developers' predicted electricity generation costs of these technologies are still much higher than those of many other renewable energy technologies. This means that they could not operate profitably under the market conditions then current. However, it was expected that experience gained during the early years of pre-commercial operation would enable developers to reduce electricity generation costs by:

- improvements in design and operation and maintenance regimes;
- reducing the capital cost of the devices themselves;
- increasing power capture efficiency;
- improving reliability.

It had been argued that these improvements were more likely to be achieved as a result of learning by doing during the early stages of pre-commercial manufacturing and operation than by carrying out further R&D. Analogy with the development of onshore wind suggested that generation costs sufficiently low to enable commercially viable operation under some future support mechanism might be achieved if the technology developed in a similar way.

At the time, there were no Government support schemes to fund early stage pre-commercial demonstration projects in this area. Device developers identified this situation as a "funding gap" that was holding up the commercialisation of the technologies.

The joint DTI/Carbon Trust Renewables Innovation Review, published in February 2004, identified the need for accelerated trials of small numbers of arrays of devices, of different technologies, to discover whether feasible cost effective solutions can be developed.

In August 2004 the Secretary of State for Trade and Industry announced the setting up of a £50M Marine Renewables Deployment Fund (MRDF) that aims to support innovative and visionary businesses to take first class research and development (on wave and tidal-stream energy technologies) to market.

After a period of consultation with the industry, the Wave and Tidal Stream Energy Demonstration Scheme (the Scheme) was developed, being the major element of the MRDF. £42M of the MRDF was allocated to the Scheme, with the balance available to support infrastructure, to undertake research on the environmental impacts of wave and tidal stream, and for further necessary research to enable the Scheme and the MRDF to achieve their goals. This was considered by the industry to be a far-sighted programme.

The main features of the Scheme are that it provides a capital grant of 25% of eligible costs plus £100/MWh for every MWh generated, up to a maximum of £9M in total from the Scheme to each project, comprised of multiple devices for which the R&D has been completed.

The Scheme was launched in February 2006. Since then, three competitions have been held, but there have been no successful applications to the Scheme. In March 2007, the Scheme moved away from regular competitions, to “open-access”, so that developers could apply to enter the Scheme whenever they were ready to do so, rather than to a fixed timetable. Since then, no further applications have been received.

A3.7 The Scottish Government’s WATES scheme

In 2006, the Scottish Government launched its Wave and Tidal Energy Support Scheme[11] (WATES). This scheme had total funding at its introduction of £8m (although this was later increased to £13 million). Its objective is to support the early development of wave and tidal technologies that need to complete pre-competitive R&D through deployment and demonstration in Scotland.

The scheme has awarded grants totalling £10.651M to nine projects, one of which is a multi-device array of the kind anticipated for the MRDF, four are single prototype devices of the type normally supported under the Technology Programme, one is funding for a cost increase on a BERR Technology Programme grant and three are subcomponent tests.

In addition, £2.5m was allocated to site and infrastructure upgrades at EMEC, bringing the total to £13.151M.

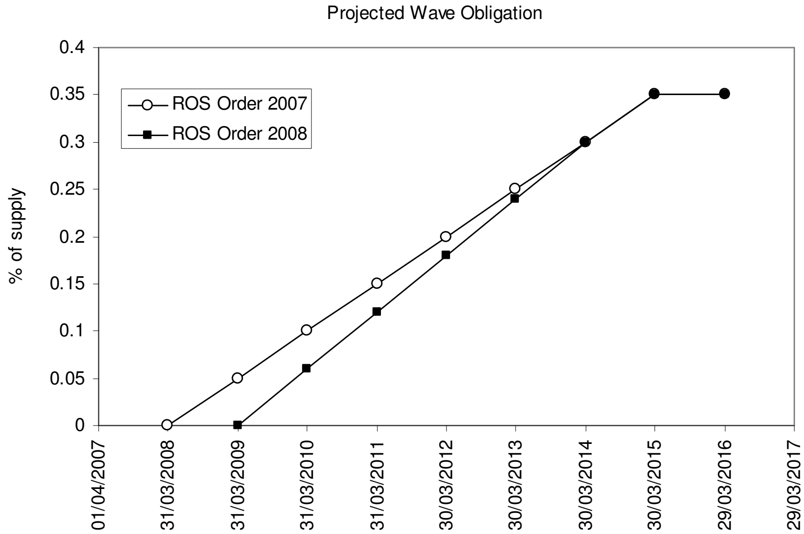
A3.8 The Scottish Marine Supply Obligation

In 2007, the Scottish Government introduced, as part of the Renewables Obligation (Scotland), a Marine Supply Obligation (MSO)[12], with buy-out prices of £175/MWh for wave devices and £105/MWh for tidal devices, with guaranteed headroom of 30%.

The Obligation levels have been set at zero for 2007, and the Obligation in future years will not be set at a level above zero unless there is going to be eligible capacity commissioned and connected in the coming year that would trigger the setting of a target that suppliers could then meet. Figure 1.5 below shows the expected levels of the obligation for wave (those for tidal are the same) published in two successive ROS orders.

[11] http://www.scotland.gov.uk/Topics/Business-Industry/infrastructure/19185/WTSupportScheme/WTSupportSchemeIntro
[12] http://www.scotland.gov.uk/Topics/Business-Industry/infrastructure/19185/MSOLev07. The tidal and wave obligations are set at identical levels for all years.

Figure 1.5 - future projections for the Scottish Wave Obligation[13] .



The cost of supporting 75 MW of capacity for each of the two technologies under the MSO would be, at a maximum, £45M/year.

A3.9 Welsh Assembly Government Support

The Welsh Assembly Government also provides support for marine projects. Approximately £6m of grant support was offered to three wave and tidal projects under the Objective 1 Structural Funds programme, and under the new Convergence Structural Funds programme (2007-2015), marine energy projects will be eligible for innovation and deployment support. Around £60M is currently allocated to the general energy strategic framework and £100M to the general innovation strategic framework. Further details are available at http://www.wefo.wales.gov.uk/sf_static.htm

A3.10 The RO

In May 2007, BERR published its Energy White Paper[14]. This included proposals for strengthening the Renewables Obligation to give a long-term market framework for renewables (Obligation extended to 20% on a guaranteed head-room basis, retaining the link between the buyout-price and inflation). It also included specific measures to create a market for marine renewable energy and to encourage investment through the introduction of banding, at 2ROCs/MWh for wave and tidal stream.

A3.11 NaREC

The New and Renewable Energy Centre (NaREC) at Blyth, Northumberland has testing facilities for a wide range of renewable energy technologies. For marine energy it has a large-scale wave tank in a former dry dock and a tidal current testing facility located in the Tees Barrage[15]. More than 10 wave device developers have used the wave flume over the last 4 years for 1/10th scale testing. The tidal facility is of similar scale. NaREC has tested 2 tidal devices for developers. Both the wave and tidal testing facilities feature calibrated instrumentation, DAQ support, mobile crane & handling equipment and experienced on-site electrical and mechanical labour.

In addition to wet testing NaREC offers blade testing for tidal devices as well as for wind turbine blades in its purpose built blade test facility. NaREC not only offers test facilities but also R&D support in the form of a team of highly qualified and experienced mechanical, electrical, instrumentation, electrical control, power systems and naval engineers.

[13] The Renewables Obligation (Scotland) Order 2007, SSI 2007 No. 267, Draft Renewables Obligation (Scotland) Order 2008.
[14] http://www.berr.gov.uk/files/file39387.pdf
[15] The Tees Barrage is owned & operated by British Waterways.

To date, NaREC's energy development and testing facilities have benefited from approximately £16M of direct funding of which over £10M support marine renewables activities.

A3.12 EMEC

The European Marine Energy Centre (EMEC)[16] in Orkney provides a site, grid-connection and data-collection services for open sea testing of full-scale prototype wave and tidal stream devices. The facilities enable performance and survivability testing as well as an R&D base for the interaction of devices with the marine environment. EMEC has tested 2 wave and 1 tidal device to date and has commitments from a number of developers for testing 2008 onwards. The facility includes grid connection, calibrated instrumentation, DAQ support, and experienced support staff.

The total funding for both capital project costs and certain developmental costs that form part of EMEC's revenue budget is in the region of £14.5M[17] EMEC is leading work on standards for the industry, an important aspect of commercialising the technology.

A3.13 Wave Hub

The proposed WaveHub[18] off the north coast of Cornwall will provide grid connection and an 8 sq km consented sea area for up to 20MW of wave power demonstration projects. The project is being led by the South West RDA, with financial support of £4.5M from BERR through the MRDF, and expects to reach financial close by January 2008, with construction in summer 2009. Four device developers are negotiating berthing agreements and expect to have their first devices installed by 2009. A programme of associated research activity is being developed in partnership with the Universities of Exeter and Plymouth and other research institutes. This will cover areas of importance to external stakeholders and also assist with more rapid development of the device technologies and their installation, operations and maintenance regimes. The Hub has not yet been built but is expected to cost £28M to build and has a capacity of 20MW.

A3.14 Environmental R&D

BERR's Research Advisory Group[19], is taking forward a research programme that will develop a much deeper understanding of the potential environmental impacts from the future deployment of these technologies. This will provide an important body of evidence, necessary if any future expansion of wave and tidal is to happen. This programme is being funded with £2M from the MRDF.

[16] http://www.emec.org.uk/
[17] http://www.emec.org.uk/general_funders.asp
[18] http://www.wavehub.co.uk/
[19] http://www.dti.gov.uk/energy/sources/renewables/policy/offshore/research-advisory-group/page22590.html

Appendix 4

Device developers' questionnaire

Dear Marine Energy Developer

The Renewables Advisory Board (RAB) was set up in 2003 to advise the Government on renewable energy issues[1]. It is made up of people from a wide range of backgrounds including government, industry and academia.

The recent Energy White Paper has given RAB a key role in helping the government drive forward progress in the marine energy sector (see Box 6.2 on Page 226 of the White Paper[2]).

The development of wave and tidal-current energy technology appears to be taking longer and costing more than was envisaged a few years ago. This is highlighted by the fact that no technology has yet met the Marine Renewables Deployment Fund's entry criterion that requires technologies to have completed a minimum of 3-months continuous operation at full scale.

RAB's Marine Energy Sub-group is working to better understand the underlying reasons for this slower than expected progress. The results of the RAB work will help inform the future delivery of support in the marine area.

Your answers to these questions will be of great value in helping the Renewables Advisory Board to understand the lack of take up of the MRDF and understand how developers could be assisted in making steps necessary to make applications to the fund.

To ensure confidentiality and independence; we have engaged an independent market research consultancy, Databuild Ltd, to collate and analyze the responses to the survey. They will treat your response in complete confidence. Please return the completed questionnaire to Databuild either by email to kate.lawson@data-build.co.uk or by post to Databuild Ltd, 21, Graham Street, Birmingham, B1 3JR.

Thank you for your help

Andrew Mill

Chair, RAB Marine Energy Sub-group

---

[1] More information about RAB can be found on http://www.berr.gov.uk/energy/sources/renewables/policy/renewables-advisory-board/page16101.html

[2] The Energy White Paper can be downloaded from http://www.berr.gov.uk/energy/whitepaper/page39534.html

Marine Renewable Energy Development Questionnaire

Thank you for completing this questionnaire which will help to inform the future delivery of support for marine renewable energy development. The questionnaire should take no more than 15 minutes to complete. If you need more space for any of your responses please feel free to add additional sheets.

Q1. When did you start your development?

M	M	Y	Y	Y	Y

Q2. The table below shows eight stages of development. Please put a cross to show the stage that is closest to the stage you have completed and also, thinking about when you started the development, the stage you had expected to have completed by now. Please put one cross in each column only.

Stage reached	**Current position**	**Originally expected**
Initial desk-based investigation Relatively simple calculations of costs and power output using simple formulae or rules of thumb, to assess design options	❑	❑
Numerical modelling & detailed costing Further assessment of design options at a more detailed level than above, involving the production of detailed designs of individual options, optimisation using numerical modelling and costing based on suppliers' quotes	❑	❑
Small-scale physical model testing Validation of numerical model using small scale physical models (typically 1/100 to 1/25 scale) and refinement of the numerical model in the light of the results	❑	❑
Intermediate-scale physical model testing Further validation of numerical model using intermediate scale physical models (typically 1/25 to 1/10 scale), with further refinement of the numerical model	❑	❑
Large scale physical model testing Physical model, typically of 1/4 scale or above, tested in large scale laboratory facilities such as NaREC's	❑	❑
Scale prototype at sea Reduced scale device, typically 1/4 to 1/2 scale, not necessarily with the full functionality of a production device, operated for a limited period in a narrow range of sea conditions possibly in a sheltered location	❑	❑
Full-scale prototype Full-scale device, not necessarily with the full functionality of a production device, operated for a limited period in a narrow range of sea conditions	❑	❑
Demonstration Fully functional full-scale production model generating electricity for an extended period (3 months to 1 year) in a wide range of sea conditions, ideally grid connected	❑	❑

Q3. Have you encountered any problems during the development of your device?

No problems ❑	Some problems ❑
What have been the main problems and why did they occur?	

Q4. Comparing your current understanding of the development issues with your view at the start of the development, do you feel that the following aspects are easier or more challenging than you anticipated?

	Much easier	**Somewhat easier**	**As expected**	**Somewhat more challenging**	**Much more challenging**
The technical development itself	❑	❑	❑	❑	❑
Obtaining funding	❑	❑	❑	❑	❑
Project management	❑	❑	❑	❑	❑
Devising and implementing an R&D Programme	❑	❑	❑	❑	❑
Establishing commercial viability	❑	❑	❑	❑	❑
Working in the marine environment	❑	❑	❑	❑	❑

Q5. If you found any of the areas above more challenging than anticipated please explain why.

Q6. Is there anything that would have helped you to overcome these challenges?

Funding

Q7. The table below lists common sources of funding for renewable energy development. Please put a cross for each to show whether you considered, applied or obtained funding from that source. Where you did obtain funding; please write in the proportion of all your funding that the source represents.

	Not considered	Considered but did not apply	Applied but did not obtain	Obtained but not spent	Obtained and spent	Percent of all funding
BERR (formerly DTI) R&D programme	❑	❑	❑	❑	❑	
SMART/SPUR/SPUR+	❑	❑	❑	❑	❑	
Carbon Trust Applied Research Programme	❑	❑	❑	❑	❑	
Carbon Trust Marine Energy Challenge/ Accelerator	❑	❑	❑	❑	❑	
EU Framework programmes	❑	❑	❑	❑	❑	
Venture capitalist	❑	❑	❑	❑	❑	
Parent company	❑	❑	❑	❑	❑	
Other including other government, partners and academic funding, please specify	❑	❑	❑	❑	❑	

Q8. In retrospect, how accurately did you estimate the total amount of funding that you would need?

Significantly overestimated	Slightly overestimated	Correctly estimated	Slightly underestimated	Significantly underestimated
❑	❑	❑	❑	❑

Q9. Did you have any problems obtaining funding?

No problems ❑	Some problems ❑
If yes, what were the problems? Which funding sources were problematic?	

Academic Research

Q10. Have you used any academic research during your development?	Yes ❑	No ❑
Q11. Have you worked with any universities during your R&D?	Yes ❑	No ❑

If yes, what research have you used?

Q12. Please answer the following questions on a scale of 1-5 where 1 is not at all and 5 is extremely

	Not at all **1**	**2**	**3**	**4**	**Extremely** **5**	**Not applicable or don't know**
How useful was the academic research you used?	❑	❑	❑	❑	❑	❑
How useful was working with the university?	❑	❑	❑	❑	❑	❑
How easy was it to find relevant academic research?	❑	❑	❑	❑	❑	❑

Q13. Please answer the following questions on a scale of 1-5 where 1 is not at all and 5 is greatly. If you had easier access to academic research do you think that it would have

	Not at all **1**	**2**	**3**	**4**	**Greatly** **5**	**Not applicable or don't know**
Speeded up your development?	❑	❑	❑	❑	❑	❑
Improved the effectiveness of your development?	❑	❑	❑	❑	❑	❑
Increased your confidence in your development?	❑	❑	❑	❑	❑	❑
Improved your access to funding?	❑	❑	❑	❑	❑	❑

Co-operation

Q14. In your experience, how much co-operation is there between device developers?

None	A small amount	A fair amount	A great deal
❑	❑	❑	❑

Q15. Is this level of co-operation appropriate?

Too little	Just right	Too much
❑	❑	❑

Why do you say that?

Q16. If there is too little co-operation what would you like to see done?

Thank you very much for your assistance, if you have any other comments, you are welcome to add additional sheets. Please return this questionnaire to Databuild, 21 Graham Street, Birmingham, B1 3JR or by email to kate.lawson@data-build.co.uk.

All the information you provide will be kept by Databuild in complete confidence and will not be passed to BWEA or RAB. However, it would be helpful to have your contact details in case Databuild have any queries about your replies.

Name	
Company	
Email	
Telephone	

Appendix 5

Databuild’s report on its survey of device developers

Marine Renewable Energy Development

DATABUILD
Research & Solutions

DATABUILD
Research & Solutions

Marine Renewable Energy Development

Final Report

Charles Michaelis
Kate Lawson
Andrew Williams

Databuild Ltd 21 Graham Street Birmingham B1 3JR
tel 0121 687 1144 fax 0121 687 1155
email research@data-build.co.uk www.data-build.co.uk

Contents

1 INTRODUCTION 1

1.1 Background 1
1.2 Methodology 1
1.2.1 Questionnaire 2
1.2.2 Reporting 2
1.3 Summary 2

2 ISSUES SLOWING DOWN PROGRESS 4

2.1 Technical issues 6
2.2 Funding 6
2.2.1 Public sector funding 6
2.2.2 Private sector funding 8
2.3 Knowledge and resources 10
2.3.1 Lack of information 10
2.3.2 Finding skilled people 12
2.4 Practicalities 13

3 WHAT HELP DO DEVELOPERS WANT? 15

3.1 Funding 15
3.2 Knowledge and resources 15

1 Introduction

1.1 Background

The Renewables Advisory Board (RAB) was set up in 2003 to advise the Government on renewable energy issues. It is made up of people from a wide range of backgrounds including government, industry and academia.

The recent Energy White Paper has given RAB a key role in helping the government drive forward progress in the marine energy sector.

The development of wave and tidal-current energy technology appears to be taking longer and costing more than was envisaged a few years ago. This is highlighted by the fact that no technology has yet met the Marine Renewables Deployment Fund's entry criterion that requires technologies to have completed a minimum of 3-months continuous operation at full scale.

RAB's Marine Energy Sub-group is working to better understand the underlying reasons for this slower than expected progress. AEA Energy and Environment has created a questionnaire to be sent out to marine energy device developers via the British Wind Energy Association. They commissioned Databuild to develop this questionnaire, to analyse the results and report on the findings.

The key objectives of the research were to understand:

- Why has progress been so disappointing?
- The technical, engineering & project management issues that have contributed to the slow progress. What has proved technically harder to do?
- To what extent have developers benefited from the results of academic research carried out by the university sector?
- What issues have there been with any funding sources used, clearly identifying which funder each identified issue refers to?

1.2 Methodology

RAB emailed the questionnaire to contacts within 27 organisations working in the Marine Renewable Energy Sector. Of these 27 RAB identified 9 organisations as being of particular interest because of the length of time they had been operating in the sector.

Respondents were instructed to send their replies to Databuild. Details of the 27 organisations were forwarded to Databuild who followed up the email with telephone calls over a 7 day period to those organisations who did not complete and return the questionnaire by email.

In total 12 of the 27 organisations responded in one form or another. 7 of these 12 were from the group of 9 identified as being of particular interest. Where the answers from these 7 organisations differed from the other respondents this has been noted in the report.

6 organisations returned the questionnaire via email. Databuild conducted supplementary interviews with 3 of these respondents in order to clarify and expand on points raised in the returned questionnaire. The other two were not available during the data collection period.

In addition to these 3 supplementary interviews, Databuild conducted 6 full interviews with respondents who did not have the time or were not willing to fill in the emailed questionnaire.

Of the 14 organisations who did not respond:

- Databuild managed to speak to the correct respondent in 3 cases, all 3 promised to return the email questionnaire, but they were not returned within the data collection period and subsequent telephone calls were not answered.
- 2 organisations could not be reached by telephone, despite numerous attempts.
- 2 organisations could be reached by telephone but the correct respondent was not available for comment during the data collection period.
- The remainder were not contacted by telephone as most resource was placed on those that had been identified as being of particular interest.

1.2.1 Questionnaire

The questionnaire contained 16 questions, a combination of both open and closed questions. A copy of the questionnaire is attached in the appendices.

1.2.2 Reporting

The report presents the views and perceptions of the developers who responded to the survey, this does not however imply that these perceptions are factually correct.

1.3 Summary

More than half of the respondents have found that operating in the marine environment and establishing commercial viability have been more challenging than originally anticipated. Their perceived problems cover 4 main areas:

- Technical problems
- Funding
- Knowledge and resources
- Practical issues that increase costs and slow down the development

A number of the issues raised by developers appear to be factually incorrect, such as that if a device fails then the government will want any funding originally given out to be returned and that the government has set unrealistic expectations of the sector. It is important that these perceived inaccuracies are corrected.

Some developers are struggling to get funding from the public sector because of a lack of understanding of what the funders are looking for (section 2.2.1). The developers that have been in the sector for a number of years have a better understanding of what funders are looking for as they have gone through the process a number of times.

Both of these issues suggest that there needs to be more communication between the government and the developers on both what they are expecting from the sector but also clearer information and guidelines on funding streams.

As well as having difficulty with public sector funding, developers have also found it challenging to get private investors on board (2.2.2). There is a general feeling among developers that private investors lack the confidence in marine renewables and therefore find it difficult to convince private developers to invest, when the benefits are often achieved a number of years after the investment.

In addition to the difficulties in raising funding for the developments, developers have had difficulty in estimating the amount of funding needed. Nine out of the twelve developers felt that they had underestimated the amount of money they would need, five of these felt they had significantly underestimated (section 2). The difficulty in estimating the amount of funding required obviously also impacts on the ability to plan where to get the funding from.

A number of developers mentioned the difficulty of predicting problems that will occur throughout the stages of development (section 2.3). Until the developers are at the stage where they are ready to go out to sea and test the device, they do not know what will happen. It has therefore been difficult for the developers to set realistic expectations of where they expect to be.

One further area that developers are also finding difficulty is recruiting staff with appropriate skills (section 2.3.2). They face competition from the oil and gas industries that can pay much higher salaries. Developers could therefore benefit from help on how to attract new people to their organisation.

2 Issues slowing down progress

Respondents were asked about their development's current position and what stage they had expected to be at by now when they first started the development. Overall, 6 out of the 12 respondents are where they thought they would be, the remaining 6 are further behind than they had hoped (there does not appear to be any difference between the length of time the developer has been involved in the device and whether they are on schedule or not). The following table shows where organisations currently are and where they expected to be:

Stage reached	Current position	Originally expected
Initial desk-based investigation Relatively simple calculations of costs and power output using simple formulae or rules of thumb, to assess design options		
Numerical modelling & detailed costing Further assessment of design options at a more detailed level than above, involving the production of detailed designs of individual options, optimisation using numerical modelling and costing based on suppliers' quotes	1	1
Small-scale physical model testing Validation of numerical model using small scale physical models (typically 1/100 to 1/25 scale) and refinement of the numerical model in the light of the results	1	
Intermediate-scale physical model testing Further validation of numerical model using intermediate scale physical models (typically 1/25 to 1/10 scale), with further refinement of the numerical model	2	
Large scale physical model testing Physical model, typically of 1/4 scale or above, tested in large scale laboratory facilities such as NaREC's	1	
Scale prototype at sea Reduced scale device, typically 1/4 to 1/2 scale, not necessarily with the full functionality of a production device, operated for a limited period in a narrow range of sea conditions possibly in a sheltered location	2	5
Full-scale prototype Full-scale device, not necessarily with the full functionality of a production device, operated for a limited period in a narrow range of sea conditions	2	2
Demonstration Fully functional full-scale production model generating electricity for an extended period (3 months to 1 year) in a wide range of sea conditions, ideally grid connected	3[1]	4[2]

Table 1: Stages reached[3]

[1] Although three developers responded that their devices are at the demonstration stage they have not demonstrated their device for three months continuously.
[2] Two of these developers had expected to be beyond the demonstration phase.
[3] Some of the developers are working on a number of stages concurrently; where this is the case the furthest stage reached has been included in the table.

Respondents were asked about whether they had found particular aspects of the development more or less challenging than originally expected. The following chart shows their responses:

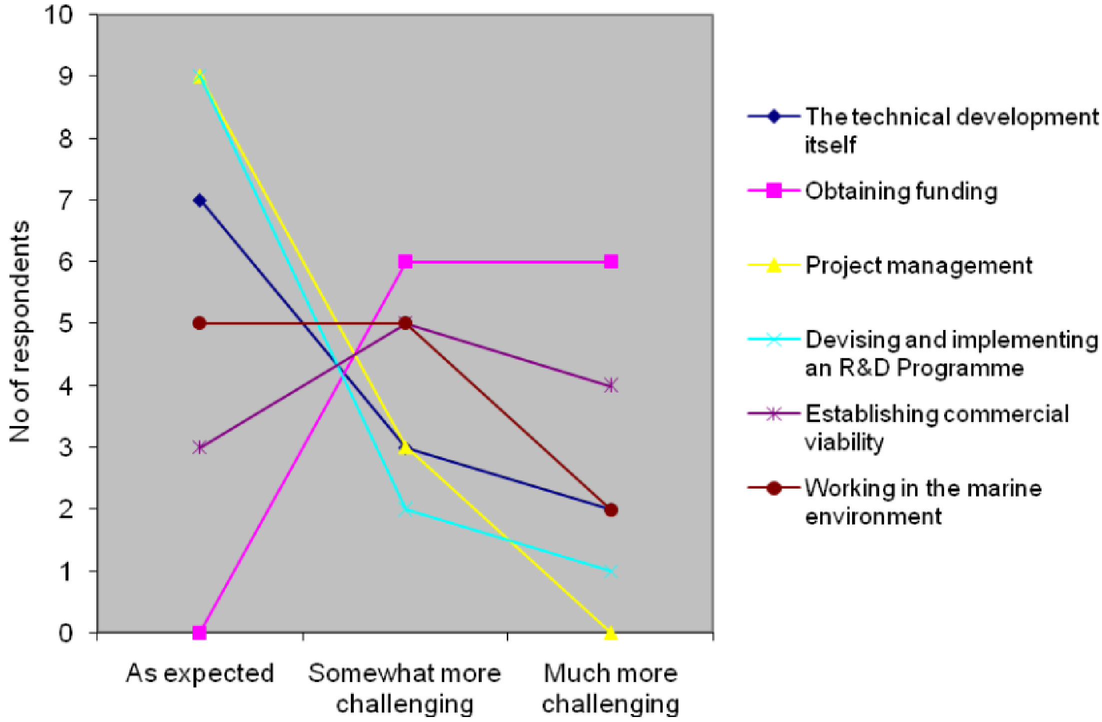


Figure 1: Aspects more or less challenging than originally anticipated

Figure 1 shows that all aspects have proved to be more challenging then originally expected. The areas where this has been a particular problem are obtaining funding, where 6 respondents said it was much more challenging, and establishing commercial viability, where 4 respondents said it was much more challenging. There does not appear to be a relationship between how challenging they have found the aspects and their stage in the development.

All respondents encountered problems during the development of the device. These problems can be grouped into the following areas:

- Technological problems
- Difficulty with funding (both public and private)
- A lack of knowledge and resources
- Practical issues that lead to an increase in costs or a slower progression

This report now focuses on each of these areas. It should be noted that these problems are not mutually exclusive and that one problem can be the cause of another, where this is the case this is illustrated with examples.

2.1 Technical issues

There are a number of technical issues that developers are concerned with. As discussed in section 2.3.1, many of their concerns on the technical areas are because so little has been done in this area which makes the process slower and more difficult to predict potential problems. There is more for developers to think about than the actual technical design but also the practicalities of working within the marine environment and whether the device will work in practice.

One particular area that developers are concerned about is the deployment of the devices. Developers see it as a potentially hugely expensive and difficult task *"It is a really big and expensive problem - taking a prototype and bolting it to the sea bed."* Three developers mentioned the fact that there are very few test centres and so until you take the device out to sea they do not really know what is going to happen *"There are limited test facilities, there are none really in the UK and those that do exist do not really replicate the real environment. The only place to test is in the open sea but this environment cannot be controlled and that is expensive and risky*. " [Although, EMEC in Orkney and NaREC in Blyth have been set up specifically to do this, some developers still feel that these do not sufficiently replicate the real environment]. None of these three organisations were out of the nine organisations recognised as particularly important. The developers felt that the current test centres do not do everything they want them to do for tidal devices, they had not however been to EMEC or NaREC for themselves.

Other technical issues that have caused particular problems include mooring, electrical connectors and hydraulics.

2.2 Funding

All developers have reported problems with funding. Nine developers had underestimated the amount of funds they would need with 5 underestimating significantly. Normally this is because costs were higher than expected – this is dealt with later in the report.

2.2.1 Public sector funding

The main issues with public sector funding are:

- The application process
- The stop start nature of the funding

Many respondents felt that current application processes for BERR (formerly DTI) funding do not allow them to explain fully their ideas. They felt that the current application form was far too short and did not ask the right questions "w*e are looking at forms at the moment for more funding and half of the questions relate to things such as 'what is the UK's chance of developing technology like this?' and general waffly stuff [therefore not issues relating to the project itself]."* Respondents felt that they were not given the opportunity to go into detail about the technology and therefore were not able to adequately justify the reasons why they should be awarded a grant *"with application forms for DTI you are limited to how many words you can use, when we get comments from assessors they are querying things we would have had chance to address if we were given* *the opportunity in the form. You only get the comments once the decision has been made and so it is too late to try and clarify."*

Respondents felt that there should be more guidance on what to focus on in the application; others felt that it would be useful if there was an opportunity for them to make a face to face presentation to justify the investment. Indeed, where organisations had been applying for public funding from BERR for a long time they felt that the process had become easier as they were now starting to receive funding but this was only after failed attempts and learning from experience.

The length of the application process was also cited as a problem. The majority of developers stated that the private sector investment required to really make a device viable is difficult to procure without public sector backing (the reasons for this are examined in more detail in section 2.2.2) however public sector funding can take up to a year to attain during which time no work of any consequence can be done " *if you had an idea today you would look at the websites and find out when the next call for proposals was, if you were lucky you will not have just missed one. So it could be a few months before a deadline, once it had been submitted there would be a month or two of review then you would be asked to produce a detailed plan. So between the original idea and getting a contract you would be very lucky if it was under a year."*

One of the other problems with public sector funding, is the perceived "stop, start" nature of the funding. There are two main issues with this; firstly the funding is awarded in rounds and so can only be applied for at certain times and secondly the funding is often awarded in small amounts as it is spread across a number of developers. This means that when developers receive the funding they are able to start working on the development but know that they will need to receive more funding in order to continue. The long periods between funding windows and the perceived onerous nature of the application process inevitably means that there are periods during which funding runs out. Organisations find that they spend so much time sustaining the business through these periods that they cannot focus on the technology itself. Some organisations find that they have to diversify into other more profitable areas to see the business through these periods however this change in focus only delays work on the marine renewable technology the organisation was set up to develop in the first place.

Three developers identified a gap between technology innovation funding and the funding given by MRDF. They feel that the process needs to be more flexible as there is currently insufficient support available to fund the three months testing that is required to become eligible for the MRDF. The reasons for this expense are discussed later on.

Many developers whose applications had been rejected by BERR did not understand why their application had been rejected. Some had received funding from other bodies such as the Carbon Trust but then been rejected by BERR. They could not understand why one public body could see merit in their idea whilst another could not, even though the two funding streams had the same objectives. There was a feeling that because there are different people on the panels with different levels of knowledge and experience the process for all types of government funding can be very subjective depending on who is on the panel.

Many developers thought that the Scottish Executive funding had a more thorough application process and was more flexible than the BERR schemes "*This gap in public funding was bridged by the Scottish Executive when it introduced the WATES scheme. This scheme was designed with reference to the needs and stage of development of the industry. Whilst it recognised the need to fund array deployment, it also offered a degree of flexibility which enabled developers to secure funds in line with their stage of development.* "

Some comments on particular funding streams include the following:
"*The academics have taken over a lot of the public funding and they are not commercially focussed. The Carbon Trust love funding consultant studies but we don't want to do these; we want to do our own work. So the way the public finance is targeted does not fit in with what the developers really want.*"

"*Carbon Trust application process is very onerous, and has the highest transaction costs of any available funding. It is capped at £250,000, but the application process is more resource-intensive by far than Technology Innovation or other public funding applications for millions of pounds. The Carbon Trust's evaluation criteria and application processes would benefit from a review.*"

"*DTI is the worst process. Carbon Trust is OK. Scottish Executive and Enterprise is right up there as being excellent. The whole DTI process made it extremely difficult for us to convince them to give us any money. Everyone else says it is a great project yet the DTI says it is rubbish. It comes back to comparing with others who do not tell the truth and the DTI's unwillingness or inability to distinguish the fiction from the fact.*"

2.2.2 Private sector funding

9 of the developers had managed to obtain funding from private investors, for example energy suppliers, however all of these mentioned there were many difficulties in obtaining this costing them time and money and, in turn, delaying the development. These issues are discussed below.

Developers believe that private investors lack confidence in marine renewables. Respondents reported that private investors like to see backing from the government, whether this be in terms of public funding or approval of an idea before they will consider putting any money into a development; this gives a certain level of endorsement of the idea. The risk for investors is too high if a developer cannot guarantee their revenue stream; however, even if public funding is achieved it is often on too small a scale and over too short a time period to assuage these misgivings. Also, the terms and conditions the public sector puts on the funding it does give out only confirms to the private sector, in its opinion, that the government is not confident in the marine renewable sector as a whole.

- "*If you are lucky enough to get a grant the amount of caveats the government puts in in terms of clawback does not increase the appetite of investors. Investors and ourselves put our own money in and we take that risk but the government wants its money back if [the device] fails.*" [It should be noted that this is not the case and where a device fails the government does not ask for the money back]
- "*We keep tight control of intellectual property. The problem with funding streams, is that for some reason they want to force partnerships and dilute intellectual*

property however the key thing to securing investment from venture capitalists is full control of intellectual property."

Another issue that developers see as being unattractive to private investors is the potentially long lead time between investing and commercialisation and seeing a return on their investment. The investors are often interested in a shorter rate of return and it therefore makes it very difficult for developers to make the investment look attractive. This is particularly true of those organisations at an early stage of development. *"We have spent a lot of time raising money but at this stage but we have a long way to go before we are commercial. If we are successful in this round [of funding] then we then have to provide matching funds. We have worked on this… but we are 5 years from making money…and this is too long for many private investors."*

Private investors also want to see that there is going to be a market for the development, if they can't see a market they are not interested. Some respondents referred to other European countries, such as Portugal, Spain and Denmark where the governments have facilitated the growth of feeder markets which makes the sector attractive to investors. An initial market built on cheap energy tariffs creates an environment for growth. Some respondents felt that the government should be creating the conditions for private investment that would allow the market to grow rather than trying to manage the sector through grants and requiring that developers give up their intellectual property – something they will never do. Developers did not feel that the renewables obligation went far enough as there is no guarantee of how long it will be in place for or how much it is worth.

2.3 Knowledge and resources

Developers feel there are two main problems with regards to knowledge and resources:

- The general lack of information on marine renewables because it is a new sector
- Difficulty in recruiting staff with the skills they need

2.3.1 Lack of information

One of the main problems that developers are facing is that there is generally a lack of knowledge of marine renewable energy thereby making it very difficult to anticipate problems before they occur. Although this is inevitable in research and development, developers feel that although it is acknowledged as a new sector there is a general over-expectation within the industry and that developers and the government do not know what problems to expect and therefore, there is an assumption that the developments will occur more quickly than is possible. The lack of information available leads to this over-expectation. To some extent, because the organisations involved in marine energy device development are so focussed and driven they may not be able to see that the information that is available can actually be of use to them.

The main problem is the uncertainty about what will happen when the devices are tested at sea and other practicalities. This uncertainty comes from three areas:

- Unrealistic expectations set by government and other developers [Government has not set any expectations however, developers obviously feel that there are expectations of them]
- Unforeseen problems occurring and slowing down the development
- The lack of skills and experience to be able to predict some of the potential problems.

There are people that think they have the answers but until anyone actually goes out to sea no one can predict what is going to happen, and so the developers feel to some extent it is just theoretical, *"I am going to the European wave and tidal energy conference. I bet there is not a single wave energy expert there who has deployed or done any serious marine operations at sea. The problem is that the sector is populated by experts who are not experts. They know about calculating waves, wave tank testing but they do not have the first clue about what we really have to do- take 1000 tonnes of steel, attach it to the sea bed in a very hostile environment where even the off shore oil and gas sector would struggle. Over expectation and lack of knowledge is a big issue. You don't know what you don't know, people have good ideas but until they get to the stage where we are they don't know what problems they will face."*

11 out of the 12 developers had used academic research for their development. Whilst a couple of developers mentioned looking at academic research such as the Supergen project, many of the developers have commissioned or are working together with universities on a consultancy basis. The developers had used universities on areas such as mathematical modelling, design work and looking at the marine environment. The developers have essentially used the universities as an extra resource as and when they need some external expertise.

The following table shows how useful developers found the academic research:

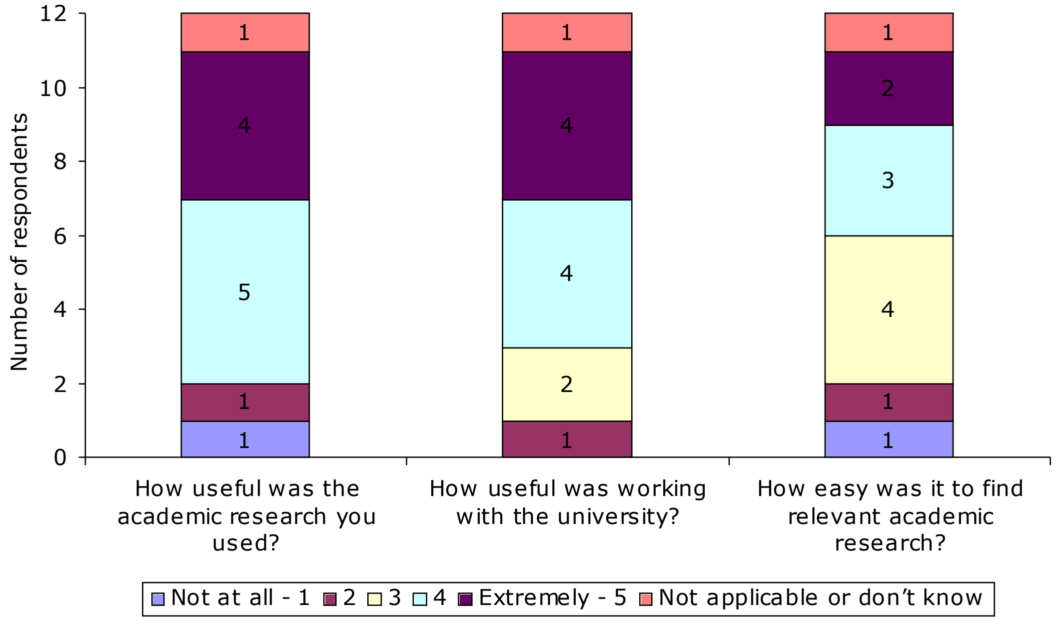


Figure 2: Usefulness of working with universities

Figure 2 shows that generally where developers have used information from universities (usually working together with the university) they have found the information useful. Fewer developers felt that it was easy to find relevant academic research. Where developers worked closely in a collaborative manner with the universities and had had previous experience of working with them they found the experience more useful. Where they worked less closely and contracted parts of the work to the universities the relationship worked less well. This was because the developer knew a lot more about the device than the university and therefore the amount of time and effort the developer had to put in with the university the developer may as well have done the work themselves. Those that found working with the universities extremely useful for one aspect generally found the other aspects equally useful.

Where developers have mentioned looking at secondary academic research such as Supergen, they have not found it particularly useful "*we are in touch with it [Supergen] and what is going on there. It is a bit hit and miss, bits of results come up on the academic side but it is patchy and there is not much to get stuck in to. In terms of stated goals it appears to be doing what we want but in terms of published papers it is very thin."*

Developers were asked what impact easier access to academic research would have had on the development; the following table shows the results of this:

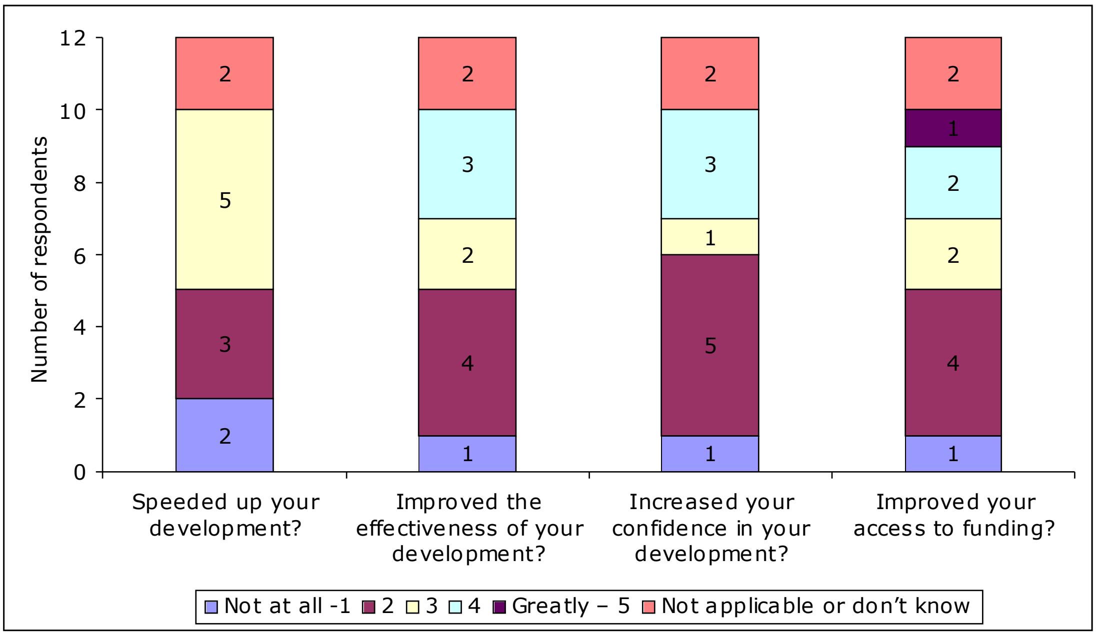


Figure 3: Impact of easier access to academic research

Three developers rated the impact of easier access to academic research at 4 or 5 for three of the aspects. These developers have all been involved in device development for a number of years and so were the early pioneers of developments, there would have been less information around at this time. The main areas where easier access to academic research would have an impact are on the effectiveness of the development, an increase in confidence in the development and improved access to funding. The developers felt that by being able to cite academic research on the proposals for funding, the funders would look more favourably on the proposal giving them a better chance of receiving funding.

There is very little information sharing among device developers. Developers feel that there is a role for co-operation among developers on generic issues such as grid connection, environmental issues and safe working environments. 7 developers felt that it would be good to have more co-operation but they also mentioned they are not willing to share their information with others as this will comprise their intellectual property. Some developers felt uneasy about using consultants as they felt that they can be commissioned by other people as well so it could be a conflict of interest. One developer mentioned consolidation and felt that this would be accomplished by the organisations with greatest commercial strength.

2.3.2 Finding skilled people

Four respondents found that it was difficult to recruit people into the industry. People with the right skills, such as general engineering and more specific skills such as mathematical modelling, often work in the oil and gas industry as they can get better paid jobs than in the marine renewable sector. This problem has two impacts; firstly it slows down the development of the device if it is difficult to recruit the individuals with the necessary skills and secondly there is a financial impact if the developers have to pay more than first expected. It is thought, however, that more and more people want to work in the marine industry so it is possible that candidates are not attracted to the individual companies rather than the sector itself. If the developers present themselves in the right way and have the necessary HR procedures in place, such as a clear career progression and training opportunities they may be more successful in finding the right people for the job.

A few developers have taken on PhD or final year students. This has enabled the organisation to do research which they may not otherwise have been able to otherwise afford. The students also have access to university facilities which are often better than the facilities that they would normally have access to. Mathematical modelling is one area that many respondents commented on, one respondent stated that access to university facilities allowed him to carry out complex calculations that would just not have been possible to do on the desktops his organisation works with.

A lot of relationships with universities are built on personal contacts. One respondent stated that the personal nature of this relationship is important as it makes the relationship viable. Universities generally want to be able to publish research under their own name as it is on this basis that they secure funding and rankings in University league tables. However in order for them to do this, developers would have to forfeit their intellectual property. One developer who had a personal relationship with the university they contracted stated that *"if you [the developer] do get involved anything you generate or we generate you have to ask us prior consent [for in order to use]."* If the respondent had approached a university he didn't know it *"would have been more difficult to get compliance with these terms and conditions".*

Some respondents, especially those moving beyond the theoretical research and into more specific technical issues, questioned the usefulness of academic research. The industry and technology are new and so, one respondent argues, there is no research of consequence being done until it is commissioned by a developer [In fact, marine energy research began in 1974]. However, because it had not been done before the Universities could not contribute anything. The developers themselves have an understanding of the device they are developing whereas the Universities do not. *"We said do a resource assessment in a certain area. They said what do you want measured? I was going to them but they didn't know how the machine works. If I tell them what to measure I may as well commission a survey vessel and do it myself, why should I pay them to do it?"*

2.4 Practicalities

As mentioned in section 2.2, developers said that they have encountered problems with being able to continually fund their development. They identified a lack of continuity in the funding process, arguing that follow-on funding should be awarded as soon as an organisation has reached a certain milestone, whereas currently once the milestone has been reached it is only then that they can start applying for the funding. Some of the organisations appear to be very entrepreneurial and so if funding runs out for one idea, they look for another idea and follow that. This means that the organisation can survive as a commercial enterprise however, the momentum is lost with the marine renewable energy device the organisation originally intended to develop which does not help the marine renewable industry. This shows that these more entrepreneurial companies will find better ways to spend their money (mentioned by 5 developers) rather than ploughing money into a development that has come to a standstill. It is therefore important in terms of developing the sector that these developers can focus on the device rather than looking for other more viable opportunities.

Other organisations focus solely on marine renewable and so problems with funding seriously inhibit the activities of the business. One respondent stated that "*gaps in funding have affected continuity [and that there have been periods when] not much has been happening. I think we would have something in the sea by now if we had had continuous funding. This would then have given us entry to the marine renewable development fun.*"

One practical problem which was mentioned by three respondents (who had been involved in device development for differing amounts of time) was the cost and availability of sea going vessels to hire to go out to sea. The majority of vessels are taken up by the oil and gas industry that book them up to a year in advance and can pay much more for them than any of the marine renewable energy developers could afford. One respondent stated that "*you are coming in as a small company with a limited budget unable to guarantee or put down a financial bond against the vessel. You can't access the vessels and if you could you couldn't afford them.*"

Four developers mentioned that there is much more environmental legislation that developers have to comply with than there used to be. This takes up developers' time prolonging the duration of the development. Concerns on the basis of environmental grounds require developers to carry out extra surveys and data collection. The submission for formal consent process overall costs a lot more money than many respondents had anticipated or budgeted for. One respondent stated that "*consenting is always a problem as it has not been done before…the reality is wherever we go we are up against it. The consents we have have taken 2 years. We go through the wringer with the environmentalists and have had to do so many surveys and data collection that our costs have doubled to £2.3 million.*"

Some respondents feel that this is an area where more co-operation could be useful so that surveys and adhering to standards do not lead to a duplication of effort by all developers.

3 What help do developers want?

Respondents were asked what help they would have liked to overcome the challenges they have come up against. This section looks at some of their suggestions.

3.1 Funding

There were a number of suggestions for improving funding:

- Account for newer technologies – there is now a wide range of technologies approaching commercialisation than there were a few years ago. Eligibility criteria for R&D grants should be flexible enough to cater for new technologies.
- The overall objectives and design of the MRDF are extremely welcome, and will work very well in the future. The support offered by the Scottish Executive's WATES fund offered a bridge for many companies and accelerated their progress towards becoming eligible for MRDF funding. It would be reasonable to consider allocating a small proportion of the existing MRDF funds to overcome remaining barriers and accelerate uptake of full MRDF array funding.
- A more planned route to commercialisation – one single programme that can be applied to from the start, for example you can be given a certain amount to prove it's a worthy idea, once you've done that you will get a further amount and so on. This will show developers that as long as they can show that their device is working and viable and they continue to meet milestones they will get a certain amount of public funding which will also give more confidence to the private investors.
- Improved application process for BERR funding – longer forms and/or a face to face process.

3.2 Knowledge and resources

Many respondents felt that it would be useful to have more academic research. However there is a feeling that although there is now a focus on academic funding for research the universities are not commercially focussed. Therefore, it takes a long time for anything to be published and when it is it does not go into enough depth. It would also be helpful for the newer developers to have access to some of the more general information on the marine environment but a lot of this information has been collected by some of the more established companies and is covered by their intellectual property and therefore can't be released.

No developers thought there was a lot of information available and no one felt there was particularly difficulty in finding information. There is however, a wealth of information out there and so it is likely that the developers are unaware of this information and don't know where to look for it. It would be helpful if there was a central information point that held all of the relevant research.

Another suggestion was for BERR to support generic research such as looking into grid connection which has currently been funded by the private sector. There was a concern among a couple of developers that the BERR makes its own mind up about what the developers want (ie not funding the research into grid connection) and that there is not enough consultation. Developing a working group to consult developers on generic issues would help the sector to share more information yet if it was funded with public money then there would not be an issue with intellectual property.

DATABUILD
Research & Solutions

Databuild Ltd 21 Graham Street Birmingham B1 3JR
tel 0121 687 1144 fax 0121 687 1155
email research@data-build.co.uk www.data-build.co.uk