R and D and Ocean Energy

A review of Research and Development in Ocean Energy in the Republic of Ireland

Discussion Paper

September 2012

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Executive Summary

Ocean energy – wave and tidal generated electricity - is at the Research and Development, pre-commercial stage. Ireland has a significant effort underway in ocean energy R and D which represents a potential competitive advantage for the country particularly in light of other advantages such as the highly energy intensive wave resource, possible access to major markets through the Anglo Irish talks on electricity supply now underway and other factors.

This Paper records the views of the three key stakeholders in ocean energy R and D- Third Level institutions, Government Agencies and Industry. It sets out the boundaries to ocean energy at the present as discerned by these stakeholders and it identifies the five research priorities for the next few years: develop and grow the database; develop understanding of the economics of the industry; promote a series of projects to deal with practical engineering problems; continue to invest in infrastructure; and build the research effort into the environmental dimension to ocean energy. Overarching all of this is the need to provide funding for R and D in this (Government-determined) research priority area.

1. Marine Renewables Industry Association

The Marine Renewables Industry Association (MRIA) represents all of the main interests on the island of Ireland engaged in the wave and tidal sector of marine renewables energy, also known as ocean energy[1]. The Association includes firms engaged in device development and manufacture, utilities and site developers, professional firms and consultants, R & D businesses, supply chain activities and academic researchers. The Association is an all-island body. Representatives of Government agencies in both Northern Ireland and the Republic of Ireland attend the Council in an observer capacity.

2. Ocean Energy and Ireland

2.1 Potential Economic Impact of Ocean Energy

The Republic of Ireland is in the midst of an economic 'perfect storm' while Northern Ireland is also going through a period of economic difficulty with consequent loss of employment and income. Ocean energy has the potential to make a significant employment and wealth creation impact over time. A study commissioned by the relevant State agencies on the island, Sustainable Energy Authority of Ireland (SEAI) and Invest Northern Ireland, on the potential economic impact of ocean energy (*Economic Study for Ocean Energy Development in Ireland* SQW, 2010) states that:

There is currently sound quantitative evidence that by 2030 a fully developed island of Ireland OE sector providing a home market and feeding a global market for Renewable Energy could produce a total Net Present Value (NPV) of around €9billion and many thousands of jobs ....It is possible that an island of Ireland wave energy industry meeting the 500MW 2020 target could produce at least 1,431 additional FTE jobs and an NPV of €0.25bn, increasing to 17,000-52,000 jobs and an NPV of around €4-10bn by 2030.....Similarly a tidal industry providing 200MW of capacity by 2020 may deliver around 600 FTE jobs and an

[1] Wave + tidal energy = ocean energy (+ offshore wind) = marine renewables or marine energy

NPV of €111m, increasing to 8,500-17,000 jobs and an NPV of between 41.5-2.75bn by 2030 -SQW Executive Summary

The opportunity in Irish ocean energy has two possible dimensions- ENTERPRISE and ELECTRICITY EXPORT-for the purposes of this Paper. Both of these points are dealt with briefly below (see also: *MRIA's Response to Public Consultation on draft Ocean Energy Development Plan* at www.mria.ie)

2.2 Enterprise

The ENTERPRISE element ranges from research and development and device manufacture to operations and maintenance, finance and legal support. This 'supply chain' faces an immediate opportunity in offshore wind in the UK which is developing rapidly into a major industry. This prospect will both give early job and income benefits to Ireland and will also build companies and grow their experience and their skills to capitalise on the forthcoming wave and tidal opportunity.

2.3 Exporting Electricity

All of the stakeholders in ocean energy accept that the enormous scale of the Irish resource in wave (with a lesser, resource in tidal) represents a potentially huge opportunity for ELECTRICITY EXPORT via grid interconnectors. This is based on the likely emergence of an EU energy market and a Euro grid; potential export demand in the UK; the development of ocean energy technology and other factors. Moreover, large scale deployment of ocean energy devices will drive the cost of ocean energy down as 'economies of scale' and the 'learning curve' effect kick in.

3. Background and Terms of Reference

3.1 Background

Firms engaged in ocean energy have expressed informally the view to the MRIA that Research and Development (R&D) associated with the sector is fragmented and lacks in an overarching view or strategy. This view was expressed even though firms were sympathetically cognizant of the efforts of SFI, SEAI and Forfas (via the national research prioritisation exercise) in

particular to identify the needs of ocean energy and to support these in various ways.

The Association decided in 2011 to undertake a study of R&D to gain a deeper and comprehensive knowledge of the R&D underway or planned and to identify in more detail the needs of the industry.

The views of industry, government agencies and Third Level institutions were gathered, almost always by face-to-face interviews, during the second half of 2011. The support of the Sustainable Energy Authority of Ireland for this project is gratefully acknowledged.

The Paper focuses exclusively on the Republic of Ireland in the light of SEAI support. However, it should be noted that the Association is an all-island one and this is reflected in the make-up of MRIA's membership and its overall approach.

A list of those institutions interviewed is contained in the Appendix.

3.2 Terms of Reference

The terms of reference for the work which resulted in this Paper were, as follows

> *The study will review the R & D efforts in individual firms; gather the views of companies on 1.their own needs in R & D 2.the work in Ocean Energy in the Third Level and elsewhere. It will also seek views of expert bodies such as SEAI and of Third Level participants in Ocean Energy and of Expert Bodies. It is intended to be an input to the national work underway in SEAI and others* - extract from MRIA application to SEAI

This Paper is intended to provide a factual basis for the ocean energy element of the national debate on the allocation of resources in R & D generally. It is a statement of industry's views in particular and is targeted on stakeholders in ocean energy across the board and participants in Research and Development generally in Ireland.

4. The Research and Development Landscape

Ocean energy- wave and tidal – is still at the experimental and development stage and this was reflected in the research effort underway in Irish academic institutions in the period 2004-2010[2] compared that relating to the mature wind technology: there were fifty-five marine energy (including some in offshore wind) projects supported with total funding of €18m compared to just 21 projects in wind with total funding support of €2m. Altogether, marine energy accounted for 10% of all energy research activity.

4.1 Research Priorities

The publication of the Government's research priorities[3] in March 2012 arose from the need to ensure that this key strand of economic development policy – research and development – is properly co-ordinated and that funding is focused on priority areas, particularly in light of the recession. Marine renewable energy was identified as one of fourteen priority areas:

> '*The focus of this priority area is to position Ireland as a research, development and innovation hub for the development of marine renewable energy technologies and services. This would facilitate the creation of an early stage industry and research cluster and open up the possibility of becoming a significant exporter of electricity...*' p12

Interestingly, the research priorities report identified inter alia broad policy issues, often highlighted by MRIA, as 'Key Actions Required' including:

- *'Draft a national policy statement on marine renewable energy*
- *Introduce clear licensing and permitting procedures*
- *Ensure environmental requirements ....are satisfied*
- *Provide test and demonstration facilities*

[2] Source: *Energy Research in Ireland 2004-2010 – People, Funding and Technologies* Sustainable Energy Authority Ireland, February 2011

[3] *Report of the Research Prioritisation Steering Group,* Forfas March 2012

- *Develop and implement effective inter-departmental and inter-agency co-ordination mechanisms'*

The pace picked up as 2012 went on with the declaration in the *Strategy for Renewable Energy*[4] of the Strategic Goal (one of just five) to achieve

> *Green growth through research and development of renewable technologies including the preparation for market of ocean technologies*

Finally, the Integrated Marine Plan for Ireland published in July 2012[5] recognised the growing potential of ocean energy as a tool to create future economic growth and proposed a number of actions which are focused on the research and development area

Key Action 21: Continue to fund strategic marine RTDI...across a range of national and international funding mechanisms (including)

- *Develop and implement a new Strategic Marine Research Agenda 2014-2020.....*
    - *Increase industry R and D activity and industry- academia collaborations*

Key Action 25: Support existing and new test- beds/facilities for demonstration and commercialisation purposes that promote Ireland as a test-bed for renewable energy technologies...

Key Action 27: Continue to build marine research capacity and capability through targeted national and international research funding

4.2 Funding for Early Ocean Energy Technology- A Policy Contradiction

At the time of writing, the key building blocks for ocean energy – a new foreshore licensing and leasing system and the final Ocean Renewable Energy Development Plan - are imminent (likely to be published before year end) and

[4] *Strategy for Renewable Energy:2012-2020* Department of Communications, Energy and Natural Resources, 2012

[5] *Harnessing Our Ocean Wealth An Integrated Marine Plan for Ireland* July 2012

the key R and D area has been recognised, as set out earlier. The big challenge now for Government is to provide financial resources to back up the rhetoric of recent policy statements of support for ocean energy. The vital Prototype Research and Development Fund of SEAI's Ocean Energy Development Unit (OEDU) has a discretionary budget of approximately €300,000 this year to support new projects. This compares to a grant expenditure of over €150m on science as a whole by Science Foundation Ireland in 2011 while Scotland's support for R and D in ocean energy companies amounts to multimillions p.a.

Ireland has, correctly in MRIA's view, developed a sophisticated and well funded ecosystem of support for R and D. Government, see 4.1 above, recognises the potential of ocean energy e.g. as a source of new jobs; it actively advocates support for R and D in ocean energy and proclaims it to be a priority; but it provides limited funding support even when compared to other sectors. This contradiction can be explained in part by the location of the funding mechanisms for ocean energy in the Department of Communications, Energy and Natural Resources and not in the major source of funding for R and D in Ireland, the Department of Jobs, Innovation and Enterprise. The solution would appear to lie either in some reallocation of funds between the two Departments or a transfer of responsibility for funding of ocean energy R and D to Jobs, Innovation and Enterprise.

5. Who undertakes R and D in Ocean Energy?

5.1 Status of the Industry

New industries can emerge for a variety of reasons. Inventors can play an important role. For example, Alexander Graham Bell invented (and, perhaps more importantly patented) the telephone; John Baird's work in developing television is well remembered as is that of George Stephenson in developing the world's first steam locomotive. Invention, of course, rarely happens in isolation and, thus, the various wave and tidal energy conversion devices now under development would not have been possible without modern advances in materials sciences. Other factors that can be important include: natural resource availability can be critical (e.g. the world's most energy intensive waves off the west coast of Ireland) as can local education and science

excellence (Stanford University is often regarded as the key ingredient in the development of Silicon Valley); high risk capital availability (again, held to be important in the case of Silicon Valley); and cultural factors such as attitudes to entrepreneurism...and so on.

Ireland, like rivals such as Scotland, is at the pre-commercial stage of the development of the ocean energy industry. We have generated or invented a series of different approaches to wave and energy devices through our companies and Third Level institutions. These devices are still at the experimental, growth stage and more of the same is likely for their sponsors until at least 2015- or even later- when commercially viable solutions should begin to emerge. We have huge natural resources suitable to ocean energy around our coastline, North and South. We have significant educational efforts in fields relevant to ocean energy (see the MRIA's discussion paper on *Third Level Education Needs of the Ocean Energy Industry* at www.mria.ie) and more are planned. A national debate is underway on energy matters (e.g. a new Energy White Paper is promised for 2013) and Government is seeking ways and means of growing an energy export industry, including the key supply chain element, at a time of great austerity.

In the light of the developmental status of the industry, it is not surprising that the bulk of the effort today in ocean energy in Ireland - in the Universities and Institutes of Technology, in the Government agencies and, above all, in industry – is focused on R&D.

A total of 191 people work in ocean energy R and D in Ireland, accounting for the bulk of those engaged with the sector at present.

5.2 Third Level's Contribution

Institute of Technology Sligo has a team devoted to anchoring/mooring systems and has one of only two drum centrifuges in Europe. National University of Ireland Galway (NUIG) is a significant participant in ocean energy with a focus on modelling, structures and ICT. Interestingly, in light of findings later in this Paper, NUIG has a group focused on marine economics. The university is a partner with the Marine Institute in the 'Smart Bay' and 'Smart Ocean' initiatives and also has an important relationship with IBM. University

of Limerick has specialist skills and experience in the fields of Unmanned Autonomous Vehicles (UAVs), 'smart ocean' and ocean engineering. University College Cork claims to have the largest single group of ocean energy researchers in the world through the Beaufort Laboratory (for which a new facility costing c€16m is about to commence construction) and it is a member of the IMERC initiative together with Cork Institute of Technology and the Irish Naval Service. National University of Ireland Maynooth focuses in ocean energy on control systems, hydro dynamic fluid modelling, wave forecasting, etc. University College Dublin is engaged in pioneering work in the earth sciences (terrestrially based ocean wave observation system) and mathematics (experimental modelling in conjunction with Aquamarine Power) areas.

5.3 Supports from the Agencies

The Government development agencies are actively involved in ocean energy R & D. The Ocean Energy Development Unit of SEAI is the key source of Government support for the industry- its grant schemes have helped to develop infrastructure (e.g. 'Smart Bay' and the Beaufort Laboratory) and to support studies and prototype development by industry. The Industrial Development Agency (IDA Ireland) is actively seeking FDI in marine renewables while Enterprise Ireland provides financial and advisory support to local ocean energy firms as they begin to reach commercial maturity. Science Foundation Ireland (SFI) is the door to support for basic research and proposals are being formulated in the University sector (with support from industry) for a Strategic Research Cluster in ocean energy under SFI's current Call. Finally, the Marine Institute provides infrastructure and services e.g. data collection, research funding and support for SEAI's Ocean Energy Development Unit.

5.4 Industry Engagement

The current, emerging technology- stage of development of ocean energy (particularly in regard to wave and tidal energy conversion devices) dictates that all of the firms in the industry are principally engaged in R & D. The key device manufacturers e.g. Open Hydro account for the bulk of this activity while Aquamarine Power, whose R&D facility is located in Belfast, has an important involvement with University College Dublin. Seapower is probably

the most important of the smaller companies in terms of R & D activity at present. Other firms such as Techworks Marine are engaged in R & D in a more indirect but nonetheless substantial fashion. In particular, the utilities ESB (through WestWave) and Bord Gais (shareholder in Open Hydro and sponsor of Beaufort Laboratory) make an important contribution.

6. Scale of R and D in Ocean Energy

The figures set out below for jobs and, where available, investments in ocean energy are sound in the view of the Association. They were gathered during interviews with key players in each of the bodies listed in the Appendix but have not been audited or cross-checked against accounts (where these are available). The reasons for this are several: institutions such as universities undertake R & D in ocean energy across several departments and formal disaggregation would not be cost-effective; the marginal improvement in accuracy of the figures provided by companies would not be justified by the effort needed to extract them formally, etc. They are of the right order of magnitude which is sufficient for this Paper.

6.1 Third Level

There are six universities and Institutes of Technology engaged in research and development which is directly related to ocean energy. In total, c121 academics, post- doctoral fellows ('post-docs') and PhD candidates are involved[6]. MRIA estimates that the annual operating expenditure associated with ocean energy amounts to c€6m pa and the 'sunken investment' in fixed assets amounts to €6.5m- this will jump by at least a further €16m when the Beaufort Laboratory building is completed and outfitted in Cork and other institutions may also undertake further investment under an SFI funding competition now underway.

[6] This figure excludes the staff involved in the 'SERG' and 'CMRC' elements of the Beaufort Laboratory, many of whom are involved in ocean related activities and together employ a further c50 researchers.

6.2 Agencies

There are only a handful of staff- say, six full-time equivalents- devoted to work on ocean energy in the public service and perhaps two of these are devoted to R & D. Nonetheless, the amount of financial support to date is quite impressive. Enterprise Ireland has given (to end 2011) €6m in support to companies in the sector. SFI support amounts to over €5.5m+ while SEAI had provided companies with €7.6m by late 2011 with a further €2.5m + provided for equipment for the Beaufort Laboratory. In addition, Beaufort is receiving support from the PRTLI fund of the Higher Education Authority.

6.3 Industry

R & D in industry is confined principally to the device developers and to the support activities of the utilities. The annual operating expenditure here amounts to at least €7m pa, a total of 68 staff are employed in R & D and the 'sunken' investment in all categories amounts to at least €50m

Table 1 Number and distribution of researchers in 2011

	Third Level	*Agencies*	*Industry*	*TOTAL*
No. of researchers	121	2	68	191

6.4 Forecast of Future Activities

Almost all 'players' in ocean energy R & D in the Third Level institutions and in industry envisage a substantial expansion over the next four years. MRIA sought a measure of this mainly in the form of the number of extra staff planned. The universities and Institutes of Technology envisage a further 90 jobs up to 2015 and an annual operating budget of €25m while industry is forecasting a jump of a further 77 staff. It is assumed here that the number of people involved in research administration in the Agencies will increase only marginally by, say, 2 people. Thus, there could be an increase of 169 in the number of researchers.

By 2015, there could be as many as 360 full time researchers in R & D in ocean energy in the Republic of Ireland.

Table 2 Forecast number of researchers in 2015

	Third Level	*Agencies*	*Industry*	*TOTAL*
Increase forecast	90	2	77	169
Total in 2015	211	4	145	360

7. Partners in R and D in Ocean Energy

The emerging technology dimension to ocean energy is also reflected in the limited level of business or research partnerships which are a feature of more mature sectors. Thus, a notable part of the Third Level activity in ocean energy has limited involvement at this stage in partnerships with industry or, indeed, EU schemes. There are some exceptions: NUIG's relationships with IBM, Beaufort Laboratory's heavy engagement with EU Framework, etc. Most of the R & D in ocean energy has been funded with assistance from SEAI and Enterprise Ireland.

The position in industry is more complex and reflects the need for young companies to seek out development funding on a global basis. Thus, for example, Ocean Energy has relations with Wave Hub (the test facility in Cornwall, England); Bord Gais are engaged with Open Hydro and IMERC; and ESBI has a range of associate partners in the WestWave project while Open Hydro are engaged with DCNS of France.

8. Views on Agencies, Third Level and Facilities

8.1 Third Level

Overall, the comments made were supportive of the agencies and facilities. The universities and institutes of technology believe that Ireland has a good reputation internationally for ocean energy research and that, broadly, the research capability in Ireland is complementary with little overlap. A flavour of the views expressed is set out below

'Enterprise Ireland's FP 7 office is very good...although projects must be close to market before EI will invest'

'SFI is very good, strategic thinkers'

'IRCSET PhD programmes inflexible'

'SEAI very helpful...but claims procedures slow'

'We envy no-one, nobody has the system of supports that we have (in Ireland)'

'SFI too focused on basic research, marine renewables is about applied engineering and science'

'Requirement to handover/share intellectual property with industry is hindering industrial policy'

8.2 Agencies

There was support for the development of R & D infrastructure- IMERC, AMETS and 'Smart Ocean'- across the agencies. It should be borne in mind here that the interviews took place prior to the degree of Government cutbacks in 2012, which have borne heavily on ocean energy, becoming evident.

The agencies had clear views on a number of matters

'Need an offshore wind test site on the Irish Sea coast'

'Third Level retention of Intellectual Property is a barrier to development'- a Third Level source expressed the totally opposite view, see above!

'Research lacks focus'

'Real issues for the sector are at policy level e.g. REFIT'

'Need a co-ordinating mechanism to avoid duplication in R & D'

8.3 Industry

Industry was generally positive about Third Level and the Agencies but there was strong criticism of the lack of resources available to them and criticism too of the lack of co-ordination of research. Again, there was support for R & D infrastructure development. Some representative comments:

'*OEDU schemes under-resourced, claims process challenging'*

'Funding badly needed for companies to keep them afloat at intensive R and D stage'

'Scottish support for this industry is tops across all areas of activity'

'Need co-ordination of research'

'Research is too fragmented'

'Lots of scope for intellectually- intensive companies to emerge on the back of R & D; MCS emerged from NUIG and is a world leader in a specialist oil industry field - a good example of what can be achieved'

'Level of awareness of Third Level research is low'

'DCENR needs to have and to communicate a clear vision for marine renewables generally'

'Research capability is world leading'

9. Boundaries and Future Agenda

9.1 Boundaries

The review by MRIA focused on gathering views and opinions on where the various bodies and interests discerned the boundaries of knowledge to lie in ocean energy and on the potential agenda for future R & D arising from these boundaries.

In the course of a round of intensive discussions, a number of common threads emerged.

First, a practical and applied approach should apply to ocean energy R & D. There is a general opinion that the fundamental scientific and engineering issues in ocean energy are being cracked. Surprisingly, second, there was a lot of interest across the board in more work on moorings, data collection and economics. There was consciousness too that supply chain development would not occur as a result of market forces alone and that R & D is required in various aspects to the supply chain. Finally, there was almost universal support for the various R & D infrastructure developments planned or underway at Smart Ocean, AMETS and IMERC (Beaufort Laboratory).

9.2 Views of Third Level

The universities and institutes of technology concentrated on broad areas: marine science (e.g. data collection) and engineering (e.g. practical dimensions to devices). Comments, on the engineering side, included:

'The viability of various devices in the harsh marine environment needs further work'

'Robustness of devices is a concern-cannot access devices in Orkney for six months of the year due to weather'

'Doubts about devices where the conversion to electricity takes place ashore'

'Sediment properties to allow cable burial needs further research'

'Engineering of multi device farms with substantial underwater components needs research'

'How can we cut engineering costs to improve IRR?'

'Bio fouling and corrosion and their impact on devices needs investigation'

'Moorings are a big issue as are umbilical's

Turning to marine science, the academics expressed these views:

'*Need to understand the resource more'*

'Too much in ocean energy turns on modelling'

'Resource is not properly quantified'

'Data collection is an issue'

'Need more data on the ecological impact of large arrays'

'Everything to do with getting power ashore'

'Smart devices'

'Electrical system design to allow integration of large arrays'

'Give priority in research to robotics and smart ocean energy infrastructure'

'We don't know enough about the impact (of ocean energy devices) on the seabed and on the mud line down'

Some other concerns were also expressed:

'Lack of interest in environmental issues'

'Potential bio diversity 'hotspots' around arrays

'Floating wind platforms (represent a major challenge)'

'Supply chain (will be a boundary) e.g. planning for a 100MW array, shipping and logistics'

9.3 Agency Opinions

The government agencies covered a number of topics with repeated concern expressed about resource data, 'soft' issues such as economics and infrastructure

A representative sample of the opinions expressed includes:

'More detail on resource needed'

'Too much modelling- need data'

'Soft issues- economics, environmental studies- require attention'

'Resource modelling, moorings, structural design, environmental modelling, economics'

'Infrastructure- finish off (AMETS) Belmullet; build test (particularly for offshore wind) off the east coast; IMERC'

'No further fundamental research needed'

'Challenges still in grid modelling, material science, grid integration, control systems'

'Need long-term funding- a la the UK- to support development of the sector'

9.4 Views of Industry

Industry's views ranged over a diverse range of topics with repeat mentions concerning data, economics, deployment and infrastructure. Funding received special mention. The following is a sample of the views expressed:

'New IMERC tank facilities badly needed'

'Not enough thinking and research about full-scale devices'

'Modest tidal site (needed) on east coast'

''Galway test site very cost effective but where do they want to go with it?'

'Need long- term funding like in UK to support development of companies'

'Need one service provider for structural analysis, physical modelling, tank testing, numerical modelling and hydrodynamics'

'Need more work on the tidal resource: lack understanding of what constitutes 'good' and 'bad' sites.

'Research required on longevity of materials- impact of wear on different materials in the marine environment

9.5. The Research Agenda

The conversations across industry, researchers and agencies led MRIA to some broad conclusions about Research and Development in ocean energy in Ireland

- There is a remarkably wide effort in R and D in ocean energy in Ireland

- It is, perhaps sub optimal scale at any location but moving in the right direction e.g. at UCC
- Funding support is a major problem at present
- There is a need to tie together the R and D effort across the RoI and projects of common interest is possibly a key way of achieving this e.g. the current SFI Strategic Research Cluster application supported by a number of colleges and a variety of companies
- The division of effort between the Third Level, industry and agencies is probably normal for an emerging technology

Against this background and the issues identified in previous sections, the Association has identified five research priorities:

Research Priority 1
Develop and grow the DATABASE. More effort is needed to gather data (and to develop robust standards for data) and to reduce dependence on modelling- there is a serious concern about the robustness of modelling in the light of limited data availability

Research Priority 2

An increase in the effort to develop understanding of the ECONOMICS of ocean energy is needed at both the micro and the macro levels, including the supply chain.

Research Priority 3

A series of tailored projects to deal with practical ENGINEERING PROBLEMS including cost reduction and manufacturability of devices, O&M, grid integration, power conversion, ICT, noise, moorings issues. The question remains as to priorities in this area

Research Priority 4

INFRASTRUCTURE: get the Atlantic Marine Energy Test Site (AMETS) project built and operational; construct the Beaufort Laboratory in IMERC, Cork, get demonstration devices in the water; continue to develop Smart Bay

Research Priority 5

ENVIRONMENT: research needed into ecological impact of arrays; generally a closer link should be forged between ocean energy and the environmental research community

None of the Priorities can be tackled without a significant uplift in Government financial support for the sector, particularly those sponsored by SEAI. The priorities set out and the rhetoric in support of ocean energy in recent Government policy papers must be matched with action and the (re) allocation of resources.

Appendix

Third Level institutions, agencies and companies interviewed for this Paper

National University of Ireland Galway

National University of Ireland Maynooth

University College Dublin

Sligo Institute of Technology

IMERC

Atlantic Ocean Energy Association

HMRC- University College Cork

University of Limerick

Enterprise Ireland

Industrial Development Agency Ireland

Marine Institute

Science Foundation Ireland

Sustainable Energy Authority of Ireland- Ocean Energy Development Unit

Forfas

Ocean Energy Ltd

Vattenfall

Bord Gais

ESB International

Open Hydro Ltd

Wavebob Ltd

Carnegie Wave

Arup

Techworks Marine Ltd