MRIA Energy from Ireland's Waves and Tides

Funding the Development of the Ocean Energy Industry in Ireland

Discussion Paper

FEBRUARY 2016

This study was supported by the Sustainable Energy Authority of Ireland (SEAI) through the Renewable Energy Research Development & Demonstration Programme. SEAI is partly financed by Ireland's EU Structural Funds Programme co-funded by the Irish Government and the European Union

Preface

Ocean energy is an emerging technology which must overcome tough engineering challenges arising from its 'home' environment, the sea, before it can become a pervasive source of electricity. However, there is a remarkable convergence of opinion about the prospects for ocean energy and about its potential economic impact which serve to underpin the case for the Irish State's support for the sector. Ocean energy is *not* a niche opportunity. It could one day stand alongside or even surpass offshore wind as an energy source. Most important of all, it is a sector from which Ireland can benefit significantly in jobs and income terms: we have perhaps the best wave resource in the world, outstanding R&D facilities and a wide range of industrial competences suited to ocean energy development. A key obstacle on the pathway to this prize, however, is pre-commercial technology finance, particularly funding to support device and component developers in the middle ground from the key TRL 3 and upwards stages (to cTRL6) in the evolution of their projects.

Ocean energy has had an unusual financial journey so far. Although an emerging *technology* (and despite its overall economic promise), it has received relatively little State support *globally* compared to other forms of energy such as nuclear and solar. Indeed, policy instruments drove early ocean energy pioneers, although arguably not in Ireland, into the commercial financial sphere at a uniquely early stage with almost predictable adverse consequences. An important finding of this Paper is that the financial sector in Ireland is informed about energy, including ocean energy, but that there is little prospect of significant commercial financial support at this stage of tidal and, particularly, wave development.

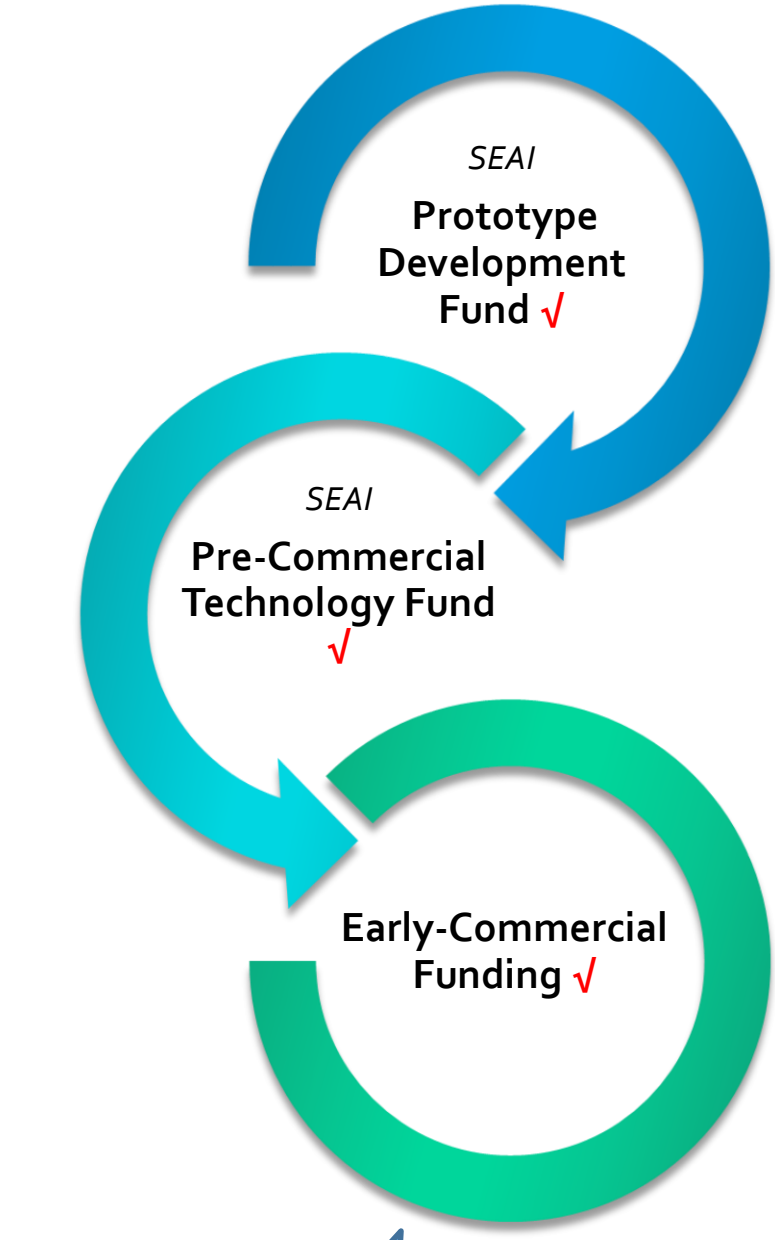
Ocean energy policy in Ireland has developed well in recent years (exception: out of date laws governing consenting - 'planning permission' - of projects) with a fit-for-purpose policy framework (the 'OREDP') and funding increases ensuring that the industry and the supporting infrastructure continue to progress. However, a critical 'funding gap' has been identified and this Paper suggests how it might be filled (*Pre Commercial Development Fund*) within existing or proposed budget envelopes and it also outlines a way forward to meet future, probably post 2020, needs to fund early commercial ocean energy arrays.

Summary of Recommendations

The Marine Renewables Industry Association recommends, in summary, that Ireland should:

- Establish an SEAI-run *Pre-Commercial Technology Fund* (PCTF) to close the 'funding gap' for device and sub-system developers at TRL3+ and to complement the current *Prototype Development Fund*. The PCTF would give Ireland a needed and viable 'roadmap' for ocean energy and it could be accommodated within the funding already envisaged for ocean energy in the *Offshore Renewable Energy Development Plan* (OREDP).
- Involve Enterprise Ireland, IDA and NTMA's Strategic Investment Fund as partners in the PCTF. The partners should be engaged in the design of the Fund and in its project decision-taking body.
- Establish metrics of success for the PCTF which should facilitate a further round of funding in c2020.
- Develop a solution for financing needs at the early commercial (i.e. post-PCTF) stage of ocean energy. This should involve the State's Strategic Investment Fund and the immediate challenge is to examine all the options for a solution. This early work could be carried out under the aegis of the Offshore Renewable Energy Steering Group (ORESG).
- The ORESG should also initiate a debate on a National Ocean Energy Ambition (NOEA) for the period 2020-2030 to guide and to support Ireland's drive to become a major global supplier to the ocean energy industry…it should build on the OREDP.
- Develop the framework for co-operation and collaboration with Scotland to advance ocean energy without unnecessary duplication and to make best use of available resources.
- Make every effort to drive European support for the sector particularly in finance and in related areas such as warranties, performance guarantees and insurance.
- Develop an innovation learning and support scheme for young ocean energy device and component development.

Proposed Ocean Energy Financial Support Roadmap for Ireland



- Tried and tested
- Meets early stage needs in particular
- c€5m pa + 'Apple'
- Keep flexible-could be key to finacing major prototypes later

- For TRL 3+-c6 area
- Involve agencies; ties in to OREDP
- Draws on SBIR but made fit for purpose
- Build up to 2 x €2.5m calls pa; 100% funding; Prize at end?

- Financing the early commercial deployment projects at TRL 8+
- Engage SIF etc
- Start design soon e.g. via ORESG, learning experience in PCTF

PDF + PCTF + INFRASTRUCTURE NVESTMENTS = c€30M EXTRA FUNDING SOUGHT IN OREDP

Contents

1. Marine Renewables Industry Association

The Marine Renewables Industry Association (MRIA) represents the principal 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 developer interests, professional firms, R & D businesses and academic researchers. The Association is an all-island body. For further details, please go to the Association's web page, www.mria.ie. You may follow MRIA on Twitter at *@Marineireland*.

The purpose of this study is to examine the 'funding gap' identified by ocean energy device, sub-system and component developers and to determine ways and means of bridging it. The terms of reference are dealt with in more detail at 4.

2. Ocean Energy Potential of Ireland

2.1 Opportunity of Ocean Energy

Ocean Energy Europe[2] has noted steady progress in ocean energy:

'As a fledgling industry, the European ocean energy sector is making positive progress. Several European utilities and engineering giants from Europe, the US, Japan and Korea have all invested in SMEs, testing programmes and early project development in Europe. This clearly points to growing confidence in the viability of these technologies[3]*.'*

The opportunity in ocean energy in ocean energy resource-rich Ireland has two possible dimensions – the ENTERPRISE and the ELECTRICITY MARKETS. There may also be scope for local electricity supply (see MRIA's *Response to Public Consultation on draft Ocean Renewable Energy Development Plan* at www.mria.ie) in Ireland.

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'* in Ireland already has an opportunity in wind-based energy, particularly offshore wind, in the UK which is now a major industry. Wind energy on land is facilitating companies in Ireland to grow their experience and their skills…as will other forms of renewable energy such as solar…. and

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

[2] The EU-wide trade association for ocean energy. MRIA is a Board Member. Previously known as European Ocean Energy Association

[3] *Industry Vision Paper 2013* Ocean Energy Europe

it will facilitate a number of them to capitalise on the future wave and tidal opportunity.

2.3 Exporting Electricity and Local Market Opportunities

All of the stakeholders in ocean energy accept that the enormous scale of the Irish wave resource (together with a much lesser resource in tidal in the Republic, although not in Northern Ireland where substantial tidal projects are in train) 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 demand in southern England in particular; the development of ocean energy technology and other factors. The aborted *Inter-Governmental Agreement* negotiation on energy between Ireland and the UK could have enhanced this opportunity quickly. The likelihood is that the arrangements sought then will be revived in time due principally perhaps to UK generation-capacity problems. 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.

Opportunities for ocean energy to meet LOCAL MARKET OPPORTUNITIES in Ireland must not be ruled out.[4] A lot of technical issues could be resolved in ocean energy over the next ten years; the intermittency of renewables might be addressed by new electricity storage solutions; there may be technical breakthroughs which make ocean energy competitive with traditional energy feedstocks; etc.

3. Background

3.1 Ocean Energy Technology

Wave and tidal energy devices normally consist of four elements. In all cases, the movement of water moves an element of a device e.g. a flap or a rotor or a blade:

1. *Hydrodynamic system*: the 'engine' of any device which interacts with the water to extract energy
2. *Power take-off*: converts the energy extracted to electrical energy
3. *Reaction ('mooring') system*: holds the device in position
4. *Control system*: provides both supervisory and closed-loop control

Ocean energy is at a 'frontier of knowledge' with enormous tests of engineering arising from the might and the contrariness of the sea which impose great challenges across the spectrum from sheer survivability

[4] Recognised in the latest White Paper: *Ireland's Transition to a Low Carbon Energy Future 2015-2030* Department of Communications, Energy and Natural Resources December 16th 2015. See also 3.3

(particularly off the wild Irish Atlantic coast with its energy intensive waves…..and in energy-bountiful tidal areas such as the Bay of Fundy in Canada) to reliability and sustainability of systems and components to device installation and maintenance.

There are a variety of technology solutions or approaches to ocean energy under examination and trial at present. In the case of *wave* devices, the approaches include Attenuators, Point Absorbers and Oscillating Wave Surge Convertors. In the *tidal* area, the approaches include Horizontal Axis Turbines, Vertical Axis Turbines and Vertical Axis Hydrofoil Systems

3.2 Current Position and Development Prospects

Milestone	Priorities	Goals
By 2020- **Innovation**	• Innovation-TRL progress • Demonstration and testing	• Financial close on up to 10 pilot arrays • Tech Innovation: reduce costs, increase reliability and yields
By 2025- **Cost Confidence**	• Economies of Scale	• Arrays scaling up
By 2030- **Market Roll-out**	• Continued Innovation • Supply chain engagement • Accelerating cost reduction, standardization and scaling up	• Commercial array installations (30MW+)
By 2050 – **Mainstream**	• Rapid-cost reduction-volume production	• Supply up to 100GW of ocean energy.

Table 1: *Ocean Energy Europe* view

The Table above sets out the view of *Ocean Energy Europe* (the wave and tidal industry representative body) of what is likely to happen to the sector all the way out to 2050. The consensus appears to be that tidal energy

technology is, at present, ahead of wave energy technology in development terms[5].

Ireland (specifically, the ESB) should have the pioneering 5MW WestWave wave project up and running around 2020 and there is a possibility of at least two other pioneering wave arrays off the west coast. Given these projects and various projects planned in Scotland and elsewhere, there may be more than ten pilot arrays at work in Europe by 2020. However, the overall views of *Ocean Energy Europe* are in line with those of MRIA. In practical terms, this means that ocean energy array deployment at scale off the West coast will not occur until the latter part of the 2020's at earliest.

3.3 National Ocean Energy Policy

Ireland – North and South – is a potential renewable energy powerhouse and the sum of its wind (both onshore and offshore), wave and tidal resources is deemed by Siemens to account for 1/3 of all such resources in Western Europe[6].

Ocean energy is a clear policy concern of the Government of Ireland. It has been singled out as a national priority for research and development support[7]. Supporting the emergence of this industry was set as one of a handful of strategic goals fixed for national energy policy to 2020[8]. The policy statement on the Green Economy, published in November 2012, also highlighted the potential importance of the sector and pledged support.[9]

The huge Beaufort complex in Cork was opened on July 11th 2015 and houses the *LIR* national ocean energy tank testing facilities and the cornerstone *MaREI* ocean energy collaborative research project. The new complex and MaREI itself enjoy substantial financial support from the Department of Communications, Energy and Natural Resources (DCENR), Sustainable Energy Authority of Ireland (SEAI) and Science Foundation Ireland (SFI) while MaREI also enjoys a cash or a contribution-in-kind by around 50 companies.

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[5] There is an excellent description of the various technologies and the elements involved in developing, making, deploying and supporting ocean energy devices in *Wave and Tidal Energy in the Pentland Firth and Orkney waters: How the projects could be built*. A report commissioned by The Crown Estate and prepared by BVG Associates 2011

[6] Siemen's presentation

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

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

[9] *Delivering our Green Potential - Government Policy Statement on Growth and Employment in the Green Economy* Department of Jobs, Innovation and Enterprise November 2012

SmartBay, the test site e.g. for quarter-scale devices in Galway Bay, is also making a key contribution to the national tapestry of ocean energy support and has enjoyed €3.6m in capital investment support from industry, SEAI and SFI as well as a four year operational budget of €3.8m provided by the HEA under the PRTLI Cycle V programme. A total of 35 applied projects have been supported to use the facility under a special access programme[10] since 2012 to help sensor and materials developers to aid sensors to 'move up' the TRL [11] ladder. Moreover, SmartBay has received EU support of €850k towards various projects with a further €790k in applications under adjudication (end 2015). The scale of projects is rising: SeaPower was recently approved over €1m to test their device at SmartBay while several other major projects destined for Galway Bay are at an advanced stage of negotiation.

Work is also in hand to develop, on a phased basis, a full-scale test site (Atlantic Marine Energy Test Site-AMETS) at Belmullet in County Mayo.

The most important contemporary policy development in ocean energy was the publication of the *Offshore Renewable Energy Development Plan* [12] (OREDP) in February, 2014. The OREDP contains a number of new initiatives including extra financial support, an initial market support tariff for wave and tidal energy, etc. It is being implemented by a Steering Group of officials representing all relevant Departments and agencies. Financial support for ocean energy overall by Government has increased in the past three years and policy work continues apace e.g. the recent consultation on tariff supports[13]

As might be expected, there is still much policy and practical work to be done. For example, the need for an explicit decision about which arm of Government should act as 'landlord' for the seabed and operate a 'one stop shop', concerning leases and licenses, for potential developers must be sorted out. The timing and terms of reference of a first leasing round of an appropriate area(s) must be determined. The important WestWave project will require further support and the full package has yet to be decided. Most pressing of all, the 'consenting' legislation to support marine economic

[10] National Infrastructure Access Programme

[11] Technology Readiness Level – see 6.

[12] OREDP: *Offshore Renewable Energy Development Plan- a Framework for the Sustainable Development of Ireland's Offshore Renewable Energy Resource* Department of Communications, Energy and Natural Resources, February 2014. The Plan deals with offshore wind energy as well as wave and tidal energy.

[13] *Renewable Electricity Support Scheme Technology Review Consultation* Department of Communications, Energy and Natural Resources, July 2015

activity such as ocean energy must be updated via *the Maritime Area and Foreshore (Amendment) Bill* which is reportedly imminent.

The most recent energy policy event was the publication in December 2016 of the Energy White Paper which is explicit in its view that ocean energy has a place in the national energy supply framework[14]:

> *'Other ocean technologies (e.g. wave and tidal) are at the pre-commercial stage. Given the current state of readiness of these technologies, we do not anticipate that they will make a large contribution in the short term. However, we expect them to play a part in our energy transition in the medium to long term'*

In Northern Ireland, the first offshore leasing round has taken place and two significant tidal projects (100MW each) were among those selected. Significant R and D work continues to be recorded in Northern Ireland e.g. under the *Centre for Advanced Sustainable Energy* (CASE).

3.4 MRIA Policy Studies

This paper is the sixth in a series of studies into long-term development issues in ocean energy undertaken by the MRIA.

The first of these dealt with the third-level education needs[15] of ocean energy and has led directly to the establishment of a Master's degree in engineering focused on ocean energy which is being executed jointly by a number of institutions (led by University College Cork) in both Ireland and Northern Ireland. The new degree commenced in academic year 2013/14. The inter-college task force established to develop this project was led by the Association. So far, 19 students have completed the MEngSc programme (and further students are in the pipeline) and have been employed by companies ranging from a renewable energy start-up to international business advisors EY. One 2014 graduate, Darren Hayes, was UCC Entrepreneur of the Year and a national finalist in the EY Entrepreneur of the Year competition with his 'Mari-Turb' invention[16].

The second study reviewed research and development in ocean energy in Ireland[17] and was published in September 2012. It identified a series of five research priorities in ocean energy, both for the research community and, also, for those engaged in the allocation of research resources.

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[14] White Paper op cit p57

[15] *Third-Level Education Needs of the Ocean Energy Industry – to maximise the job and income potential of Ireland's ocean energy resource* MRIA August 2011

[16] Information sourced from Dr Paul Leahy, Programme Director, MEngSc UCC

[17] *Research and Development and Ocean Energy- A Review of Research and Development in Ocean Energy in Ireland* MRIA September 2012

The third study examined the supply chain for ocean energy[18] in Ireland and was published in June 2013.

The fourth Paper was published in December 2013 and dealt with the potential for co-operation between Ireland and Scotland in ocean energy[19]

The most recent Paper dealt with the maritime infrastructure needs of ocean energy[20] and was published in December 2014 and focused on ports in particular. A key recommendation was that preliminary planning should commence for a port facility in Mayo which might be needed in the 2030s

All of these Papers (and others on subjects such as initial development zones, consenting etc) are available on the Association's website, www.mria.ie .

4. Terms of Reference

There has been a change in the Irish ocean energy sector over the past five years. In 2009/10 (when MRIA was founded), the technology for wave and tidal energy conversion devices was deemed to be moving forward and there was confidence generally that the industry would be up and running as early as 2020 (Ireland had a 500MW 'in the water' target for that date[21]). On the other hand, there was not a clear public policy framework. Indeed, policy-makers seemed to be conflicted between regarding ocean energy as a promising *industry* on the one hand and looking at ocean energy as a potential member of the national *energy supply* portfolio on the other hand. Today, the policy framework (OREDP etc) is generally strong, coherent and even ambitious while the technology is facing technical challenges, e.g. in Power Take Offs, particularly in the wave energy arena.

Ocean energy policy in Ireland is aimed at two goals:

1. (Perhaps implicitly) To enable the development of an ocean energy *supply* option in the overall generation mix of long-term national energy policy which includes export–the work underway on consenting legislation, the ISLES project etc all contribute to this goal;
2. The development of an ocean energy *industry* for global markets with a particular emphasis on the energy conversion device portion (plus sub-systems and components) of the supply chain. This ties in with

[18] *The Supply Chain for the Ocean Energy Industry in Ireland – Discussion Paper* MRIA June 2013

[19] *The Opportunity for Co-Operation and Collaboration between Ireland and Scotland in Ocean Energy* MRIA December 2013

[20] *Maritime Infrastructure Development Priorities to Support Ireland's Future Ocean Energy Industry* MRIA Discussion Paper December 2014

[21] *Developing a Sustainable Energy Future for Ireland – the Energy Policy Framework 2007-2020 3.10.10* Department of Communications, Energy and Natural Resources 2007

SEAI's prototype funding, the substantial recent State investment in R&D and test facilities etc.

Focusing on policy goal 2, the challenge is the 'funding gap'[22] for promoters with devices at the upper end of TRL[23]3 onwards. Companies in this category have faced serious difficulty in securing adequate finance.

Accordingly, the MRIA decided to review the 'funding gap' and to examine ways of filling it. Views across a wide spectrum of interests and expertise in Ireland and, also, Scotland (a major centre for ocean energy) were gathered during the spring and summer of 2015. The support of the *Sustainable Energy Authority of Ireland* for this project is gratefully acknowledged.

In the light of SEAI support, this paper was written with a Republic of Ireland slant to it. 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.

A list of those companies and institutions interviewed for this Paper is contained in Appendix 1.

5. The Ocean Energy Opportunity

Ocean energy has the potential to make a significant contribution to the world's energy supply[24]; indeed, the theoretical potential easily exceeds human energy requirements. It could provide 'winning' countries – those with a wave and/or tidal resource to exploit and the policy ambition to become a global supplier of goods and services to the industry - with enormous opportunities to create income and jobs.

Ocean energy has the potential to make a significant employment and wealth creation impact over time in Ireland as a whole. An early (and, in retrospect, optimistic at least in terms of timing) study commissioned by the relevant State agencies on the island of Ireland (*Sustainable Energy Authority of Ireland* and *Invest Northern Ireland*) on the potential economic impact of ocean energy[25] stated in 2010 that:

[22] The term coined in a high level overview of this issue in the UK published in www.wavepowerconudrums.com recently

[23] See 6.1

[24] *Intergovernmental Panel on Climate Change - Special Report on Renewable Energy Sources and Climate Change Mitigation, Chapter 6 - Ocean Energy,* June 2011

[25] *Economic Study for Ocean Energy Development in Ireland* SQW, 2010. A number of other international studies have since underpinned the general thrust of SQW although the near term predictions won't be achieved- see 5.2

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 ……. could produce …….17, 000-52,000 jobs and an NPV of around €4-10bn by 2030.....Similarly a tidal industry…… may deliver….. 8,500-17,000 jobs and an NPV of between 41.5-2.75bn by 2030 -SQW EXECUTIVE SUMMARY

Expert opinion[26] since has underpinned the broad thrust of the SQW study although it is generally regarded today as being somewhat dated.

5.1 FORECASTS FOR EARLY INSTALLED OCEAN ENERGY CAPACITY

Relevant European Union Member States have set targets for ocean energy - based electricity generation capacity and these are included in their National Renewable Energy Action Plans (NREAP)[27]. Undeniably, over-ambitious (with the benefit of hindsight) targets were fixed in early years for installed capacity. Ireland, for example, set a target of 500MW of ocean energy 'in the water' by 2020[28]. The tough engineering challenges encountered by ocean energy device developers has since led to a more cautious approach being adopted. For example, a 2013 estimate by European industry[29] recognised that only 10MW of ocean energy generation capacity had been installed in Europe with an associated industry investment over seven years of €600m. Industry went on to forecast that there might be several installations by 2020 of up to 10MW each with some leading players installing up to 50MW each over the same time period while commercial installation rollout was envisaged from 2025….and even these estimates might be deemed to be on the high side. The Figure below is an illustrative estimate of what was judged in 2013 as likely to happen in the UK out to 2020.

[26] Referenced later in this section 5

[27] *Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of Energy from renewable sources and amending and subsequently repealing Directive 2001/77/EC/20 and 2003/30/EC Official Journal of the European Union. L 140/16*

[28] *Developing a Sustainable Energy Future for Ireland – the Energy Policy Framework 2007-2020* op cit.

[29] *Industry Vision Paper 2013* op cit.

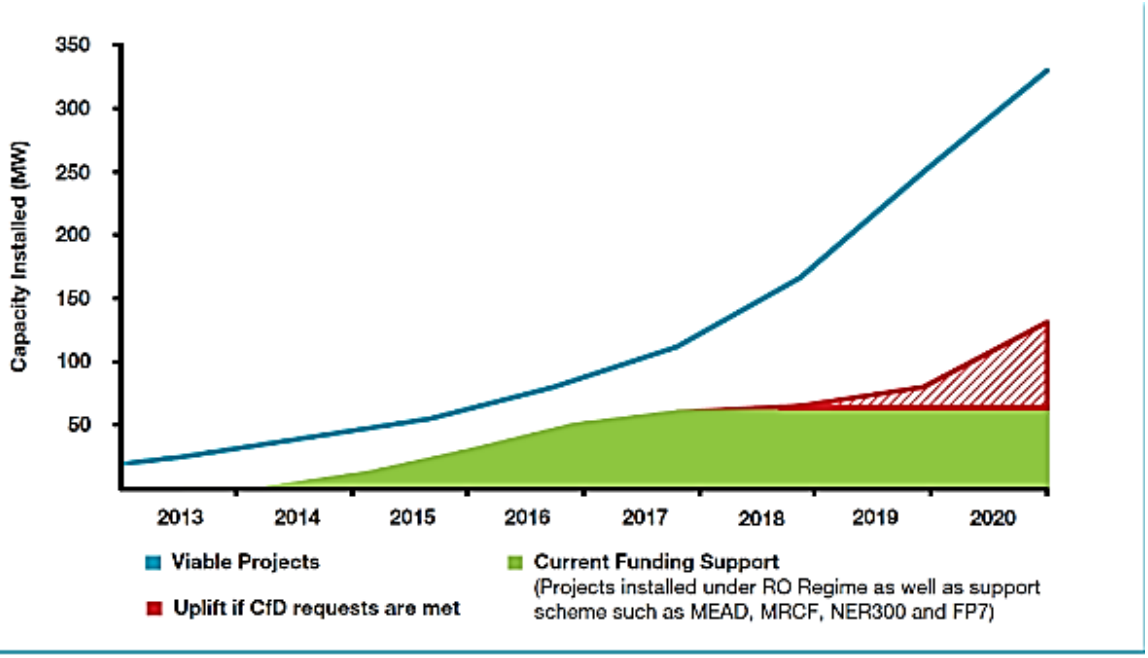


Figure 1: Likely deployment for UK wave and tidal energy 2013[30]

Most recently, *Ocean Energy Europe* has identified just under 20MW of ocean energy 'in the water' up to the end of 2014 and is now provisionally forecasting a further 170MW of tidal energy devices to deploy by 2020 (over 40% of this amount to deploy in the year 2020) and a further 45MW of wave devices over the same period[31].

Ireland has moved on to adopt a cautious approach based on experience and now focuses inter alia on supporting industry to get projects (such as WestWave) 'into the water[32]' without setting specific capacity targets. The OREDP took a prudent approach to targets:

'Given the current state of readiness of the technology, the projections previously outlined to 2020 will not now be achieved but the possibilities they represent remain valid over a longer time-scale looking out to 2030 and beyond[33]'

This practical strategy on the part of Ireland reflects latest European advice:

> *'.... first pilot arrays – consisting of three or more devices with a maximum installed capacity of 10MW – will be the cornerstones of a successful market deployment strategy for Europe. They will, for the first time, prove the viability of generating electricity from more than one device, and in doing so they will generate vital lessons which will help*

[30] *Ocean Energy Technology: Gaps and Barriers* SI Ocean 2013
[31] Presentation at *Ocean Energy Europe* Board meeting on December 2nd, 2015
[32] This approach is illustrated by the pragmatic *Offshore Renewable Energy Development Plan* op cit
[33] *Ocean Renewable Energy Development Plan* op cit

developers target future innovations in array performance, reliability and cost reduction. Successful demonstrations will not only pinpoint where further improvements are required; they will also build investor confidence. This will stimulate investment into all stages of technology development, and will help to engage the supply chain. Successful electricity generation from the first arrays will also galvanise planning for future grid connection and the development of efficient regulatory regimes.'[34] .

The European approach – focus on getting devices and small arrays working in the water – is also recommended by other authoritative sources, for example, the Carbon Trust:

'The next steps for the industry are to move on to building small arrays (around 5-10MW) to demonstrate that multiple devices can be installed and operated in the same location, and that arrays of devices are able to generate electricity at a significantly lower cost of energy than the individual prototypes'[35]

Nonetheless, given the risk and cost involved, it is fair to ask why nations and firms should commit resources to developing an ocean energy industry and this is tackled in the next sections.

5.2 FUTURE OPPORTUNITY FORECASTS

There is a remarkable confluence of informed opinion regarding the long term potential of ocean energy notwithstanding early modest progress and this underpins the case for the Irish State to continue investing in and supporting the development of the sector.

Ocean Energy Europe has estimated that 100GW of ocean energy could be installed in Europe by 2050[36]. The Carbon Trust[37] has projected that, as a high scenario, a cumulative, undiscounted market, of £460bn in wave and tidal is possible between 2010 and 2050 with the market reaching up to £40bn pa by 2050. This is based on estimates of 189GW of wave and 52GW of tidal energy being installed by 2050. The study stated that 70-75% of the market would be accessible (i.e. the market which it can access and in which it can compete) to the UK with a 'present value' contribution to GDP of £68bn.

[34] *Wave and Tidal Energy Market Deployment Strategy for Europe* SI Ocean June 2014
[35] *Accelerating Marine Energy* Carbon Trust 2011
[36] *Industry Vision Paper 2013* op cit
[37] *Marine Renewables Green Growth Paper* Carbon Trust 2011

The International Energy Agency[38] estimates a worldwide potential of up to 200 GW of wave (65%) and tidal energy capacity, again by 2050.

The global firm EY[39] drew on IEA Ocean Energy Systems work when it reported that:

> '*Ocean energy technologies could start playing a sizeable role in the global electricity mix around 2030…….ocean energy may experience similar rates of growth between 2030 and 2050 as offshore wind has achieved in the last 20 years….future developments could create 1.2 million direct new jobs by 2050'*[40].

The State agency Scottish Enterprise forecasts (under a 'central scenario') a cumulative market value in Europe in 2014-2030 of £6.4bn and £6.3bn of capital expenditure and £1.4bn and £1.1bn of operational expenditure for tidal and wave respectively. The agency believes that ocean energy companies have invested more than £200m into the Scottish economy while 62% of their supply chain is Scottish. They forecast over 10,000 jobs, direct and indirect, in tidal in Scotland by 2030[41]. Regardless of source, expert opinion believes that the ocean energy market will be enormous in 20+ years' time.

5.3 Development Volumes and Costs

How many MW's must be deployed at the prototype/demonstration/pre-commercial stages of ocean energy development before industrial roll-out is feasible? The latest provisional estimate is 520MW for wave at a cost of €4.3bn and 400MW for tidal at a cost of €3bn[42]. The bulk of the volumes (300MW each in both wave and tidal) and costs (67% of a total of €7.3bn) is attributable to still distant pre-commercial arrays involving cTRL 8 devices. Neither sets of figures are daunting in the overall scheme of energy costs. They are achievable provided relevant national Governments and international bodies can devise realistic funding schemes and develop inter-nation development models

5.4 Comparative Experience

The long term projections cited at 5.2 appear remarkable in the light of the current stage of development of what is an emerging technology. However, wind energy may be a broadly-illustrative comparative development experience for ocean energy. Onshore wind energy is not an overnight

[38] *Energy Technology Perspectives 2014* International Energy Agency

[39] Formerly Ernst and Young, then E and Y

[40] *Rising Tide – global trends in the emerging ocean energy market* EY 2013

[41] Presentation by Scottish Enterprise at joint MRIA/ Scottish Renewables Workshop, Edinburgh, September 2015

[42] *Ocean Energy Europe* Board paper, December 2015

phenomena. For example, there were just 10 MW of all sources of wind energy capacity in place in Europe in 1980 and it is estimated that the equivalent figure now lies at over 100GW[43]. In modern times, the first significant wind turbine was a three-bladed 200kw device installed in Denmark in 1956[44], almost 60 years ago which is illustrative of the great technical challenges all forms of renewable energy have faced. Germany faced the traumatic 'Growian' experience in wind in the 1980's ....and yet Growian is commonly regarded as the kernel of the huge modern German wind industry.

Growian –derived from the German word for 'wind-powered device' – was a pioneering 3MW wind turbine built by MAN in the early 1980's. It had a 100m tower, a 100m rotor diameter, a nacelle that weighed as much as a jumbo jet and cost €75m! Growian worked for 1% of its life and was closed in 1987. The influential *Der Spiegel* commented that 'We built Growian to prove that it cannot be done!'

The offshore wind experience is even more significant. The first offshore wind turbines were installed at Vindeby, Denmark in 1991. This 11 x 450KW array was slightly smaller than the 5MW now envisaged for the ESB's WestWave wave energy project anticipated in the 2018-20 period. The first *commercial* offshore wind farm was opened at Middelgrunden, Denmark only in 2000 (just fifteen years ago) with a total capacity of just 40MW[45].The European Wind Association has reported[46] that in mid-2015 there were 3,072 wind turbines with a total combined capacity of over 10GW fully grid connected in European waters in 82 wind farms across 11 countries……and the pace is increasing, if anything: in the first six months of 2015, a total of 584 offshore wind turbines were completed and grid connected creating 2.343GW[47] in capacity (up 200% on the same period in 2014) while a further 102 turbines with a capacity of 422MW had been installed but not yet grid connected.

The jobs and wealth creation associated with renewable energy are remarkable: a total of 7.7 million people was employed directly and indirectly in renewable energy globally in 2014 including just over 1 million

[43] *Industry Vision Paper 2013* op cit

[44] Wind turbines can be traced at least as far back as 1887 when 12KW devices were recorded in Ohio and in Scotland

[45] Ireland's first (and so far only) offshore wind turbines (25.2MW in total) were installed at Arklow Bank in 2002

[46] *The European offshore wind industry - key trends and statistics 1st half 2015* European Wind Industry July 2015

[47] Included in the 10GW count above

in wind (forecast[48] to rise to in excess of 2 million by 2030) including a modest 3,600 in ocean energy[49]. This is up from 2.2 million jobs worldwide in 2007[50]. Global new investment[51] in renewables in 2014 is estimated at $140bn and the fastest growing (at 110 % over 2013!) segment was ocean energy, albeit from a very low base.

The UK envisages £6.1bn added to the UK economy by ocean energy by 2035, creating 20,000jobs[52]. Scottish Enterprise forecast that Scotland could secure up to 30% of all wave projects going forward and 15% of all tidal projects.[53] SQW forecast a transformational impact by ocean energy on the all-island of Ireland economy by 2050[54]. The fact that, in 2012, Europe's renewable energy industry employed 1.2 million people and generated €130 billion of economic activity again indicates the potential possible for ocean energy and it's worth noting that the '*the vast majority (of this economic activity) did not exist just one decade ago'*[55]

As an illustrative aside, the long-term nature and complexity of offshore projects is illustrated in Figure 2[56] below setting out the time-scale associated with a typical (and roughly comparable to ocean energy) offshore wind project.

[48] *Wind in Numbers* Global Wind Energy Council
[49] *Renewables 2015 Global Status Report* REN 21 Renewable Policy Network for the 21st century 2015
[50] *Renewables 2007 Global Status Report* REN 21 Renewable Policy Network for the 21ST century 2007
[51] *Renewables 2015 Global Status Report* op cit
[52] *Wave and Tidal Energy in the UK- conquering challenges, generating growth* Renewables UK 2013
[53] MRIA/Scottish Renewables Workshop op cit
[54] SQW op cit
[55] *The State of Renewable Energies in Europe* EurObservER, 2013 Edition
[56] *Offshore Wind Towards 2020 – on the pathway to cost competitiveness* Roland Berger April 2013

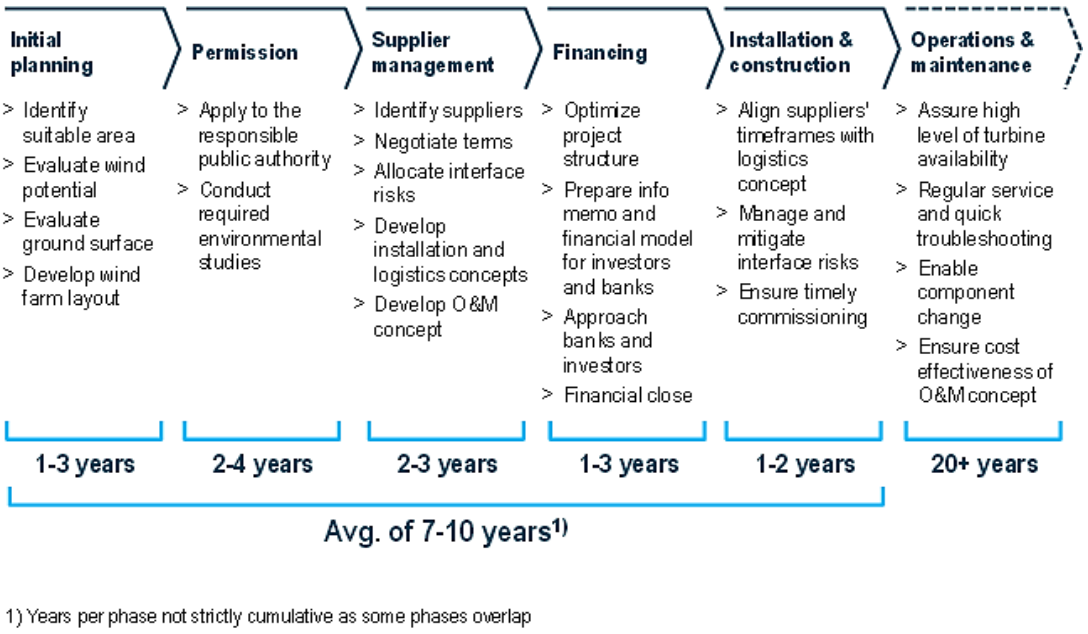


Figure 2: Timescale of typical offshore wind project

Overall, the broad argument here is that the precedent set for ocean energy by other renewable technologies, particularly by offshore wind, which was also born (and very recently too) to serious engineering and cost competitive challenges, suggests that ocean energy could scale-up fast – perhaps in the late 2020s (tidal)/early 2030s (wave) and make an impact globally, including to the benefit of Ireland, once engineering stability and basic competitiveness are attained.

5.5 Ocean energy is not a niche opportunity

Against the backdrop of 5.4 above, it is useful to 'compare' the enormous scaling-up of ocean energy forecast earlier against the projected investment in offshore wind put forward by Roland Berger[57] (see Figure 3). These consultants forecast that the annual global rate of installation of new offshore wind capacity may rise to 6.5GW p.a. with an annual investment of €20.8bn in 2020. This 'compares' with the Carbon Trust's forecast[58] of a €40bn p.a. market in ocean energy at peak, albeit many years further out.

REN21[59] (see Figure 4) shows that the total installed capacity at present in renewables from all sources in the world amounts to 657GW. *The various forecasts for the scale of the ocean energy market set out at 5.2 represent a substantial proportion of this figure.*

[57] *Offshore Wind Towards 2020 – on the pathway to cost competitiveness* op cit
[58] *Marine Renewables Green Growth Paper* op cit
[59] *Renewables 2015 Global Status Report* op cit

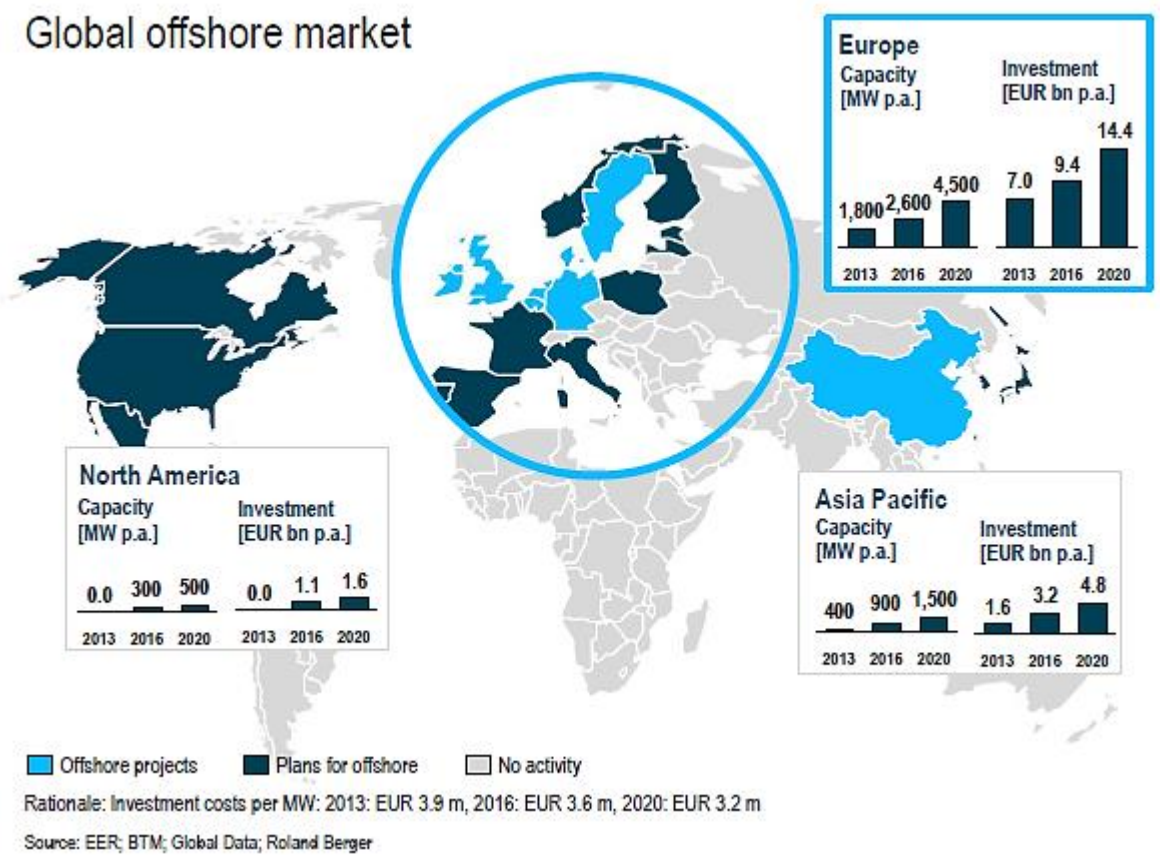


Figure 3: Global offshore wind market projections

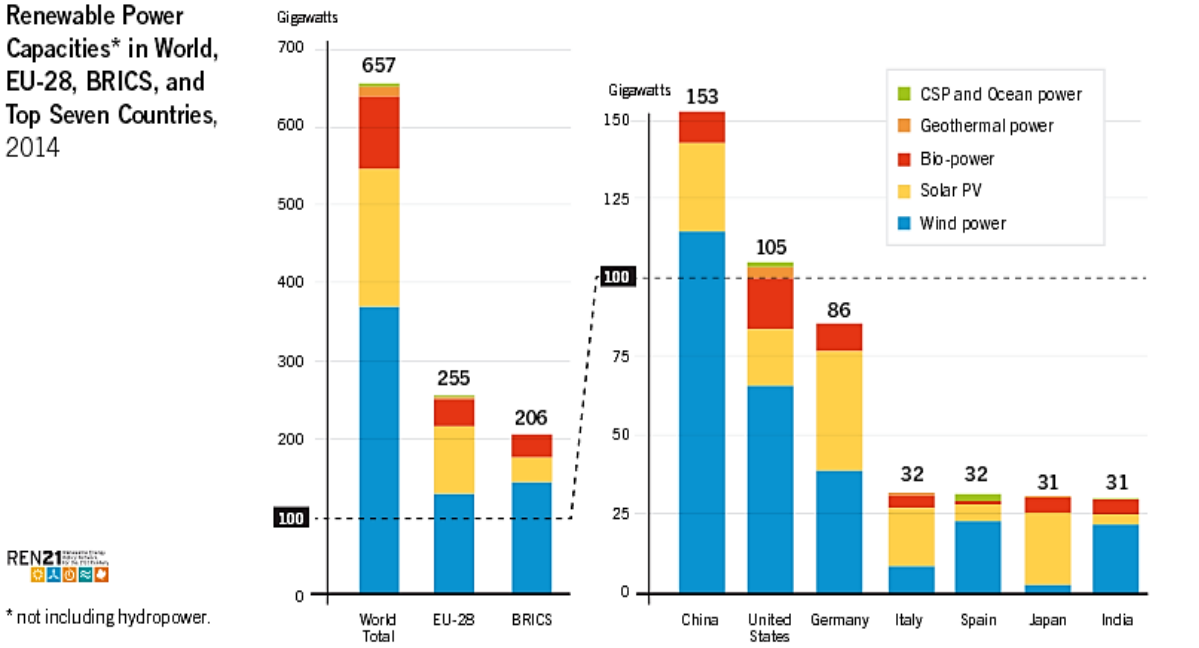


Figure 4: Renewable Power Capacities in World, EU-28, BRICS, and Top Six Countries, 2014

The reasonable conclusion that can be drawn – even though the comparisons are of different technologies at different stages of development and over different timescales – is that the opportunity for ocean energy is relatively

enormous and that the journey being taken by ocean energy is broadly parallel to that undertaken by its wind 'cousins' (albeit over perhaps a shorter period in light of the lesser technical challenges faced by wind).

5.6 Implications for Ireland

It would be easy to take a dismissive view of the argument emerging above i.e. the 'link' made between the firm, short-term forecast of investments in a maturing technology (offshore wind) and the long-term projections for a technology still at the early stages (ocean energy).

The Association believes, nonetheless, that, based on reasonably comparable development experiences so far and the long term forecasts for ocean energy by creditable sources and institutions, ocean energy will become a major enterprise opportunity, certainly from 2030 or so onwards. This is in line with the European Union approach to renewable energy today where the policy horizon is being extended out to 2030 and is reflected too in the latest Irish energy White Paper's [60] timeframe. It is also in line with other Irish policy developments where the OREDP provides a route map to 2020 and where the next challenge is to develop ambitions, targets and policies for the next phase out to 2030. Ocean energy is unlikely to be a niche opportunity as is sometimes assumed. Ocean energy could conceivably grow to a scale beyond that of offshore wind and it perhaps has the potential to generate a notable portion of the world's power requirements.

The implications for Ireland are twofold. First, Ireland's support for ocean energy should not just be about exploiting our abundant wave energy opportunity to meet domestic energy needs and, in particular, to provide for export*. It should also be about positioning the country to exploit an extraordinary opportunity for job and income creation and to become a force in the global ocean energy supply chain.*

5.7 Make-up of Opportunity

Is Ireland taking sufficient steps to address the huge strategic opportunity presented by ocean energy? The indications so far are reasonably encouraging. Against a background of a huge natural resource we are investing in the all-important R&D and test facilities and in human resources while Government policy measures have been supportive and generally appropriate to this stage of development of ocean energy although the slow trek of draft legislation to govern the 'consenting' of offshore energy efforts is a disappointment.

[60] White Paper op cit

There is a popular assumption that the bulk of the supply chain opportunity in ocean energy lies in the fabrication of the wave or tidal energy conversion devices' 'hulls'. Therefore, the popular argument goes, Ireland will lose out on the economic opportunities in ocean energy, despite it's enormous natural resource, as the country allegedly does not have a heavy engineering tradition or deep engineering base.

In fact, there is a notable and sophisticated engineering sector (e.g. to support the large pharmaceutical cluster in Cork) in the Republic of Ireland ….and, of course Northern Ireland has excellent heavy engineering capabilities highlighted by Harland and Wolff Heavy Industries.

In any event, *hull manufacture represents a relatively small proportion of overall device costs* as illustrated by Alcorn[61] in a study which broke down the cost of an *actual* full scale prototype wave energy device (name supplied to MRIA): hull manufacture accounted for under 12% of the total project cost. The elements of the project in question are shown in Table 2 while the cost is broken-down at Table 3. This example highlights the point that device development and manufacture is not solely, or even mainly, involved in heavy engineering and that there are many different activities along the value chain where Ireland has capability also.

Major Components	*Major Services*	*Major Services (cont'd)*
▪ Hull structure ▪ Foundation/moorings ▪ Primary power take off → Hydraulics → Turbo machine → Turbine ▪ Electrical Generator + Drives + protection ▪ Power cabling ▪ Onshore works	▪ Fabrication ▪ Precision engineering ▪ Heavy lifting ▪ Towage ▪ Piling ▪ Anchor handling ▪ Diving ▪ Rigging ▪ Elec/Mech ▪ Cable installation	▪ Design ▪ Naval Architecture ▪ Certification ▪ Insurance ▪ Risk Analysis ▪ Deployment planning ▪ O&M ▪ health & Safety ▪ Berthing ▪ Training

Table 2: Breakdown of elements in actual project

[61] *Supply Chain Opportunities* Dr Ray Alcorn, MaREI Research Centre, UCC 2014. Dr Alcorn was employed by the project in question.

Hull	12%
Transport	6%
Site Works	8%
Foundations/Moorings	12%
Electrical	8%
Turbomachine (PTO)	8%
Engineering Design	24%
Integration	8%
Installation	16%

Table 3: Breakdown of costs in actual project

The same point is more generally made in a recent EU-sponsored study which interestingly illustrates the high proportion of costs attributable to installation in early tidal projects as illustrated in Figure 5.

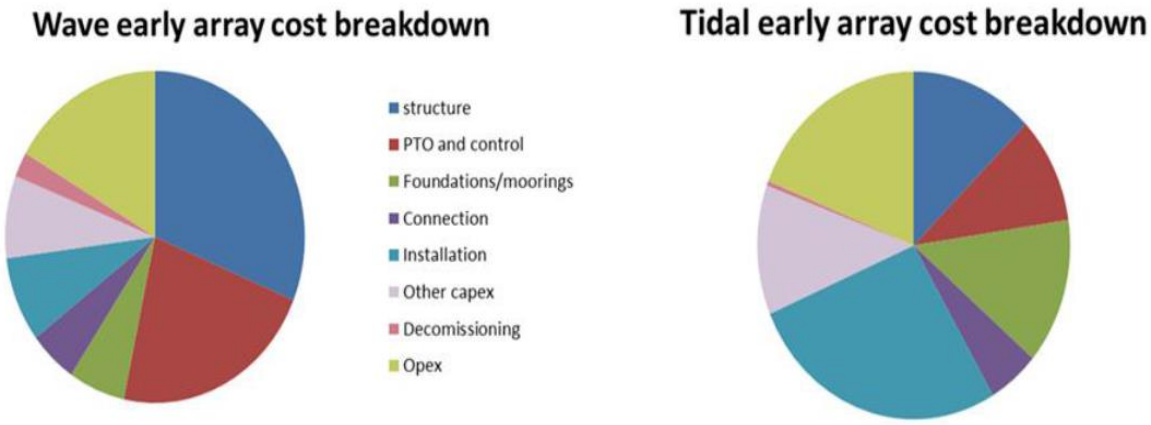


Figure 5: Wave and tidal cost breakdowns[62].

6. Engineering and Project Measures

Given that there is an enterprise opportunity for ocean energy, what measures can be used to judge the progress of energy conversion device development projects in particular?

6.1 Engineering Indicators

There are a number of technical and market indicators that can be used to judge the maturity and competitiveness of an emerging technology.

[62] *Ocean Energy: Cost of Energy and Cost Reduction Opportunities* SI Ocean 2013

On the technology side, *Technology Readiness Levels* (TRLs) have been developed[63] and adopted by the ocean energy industry and are becoming the standard in various EU and national funding programmes. These TRLs are rigorous, 'gated' development stages through which a concept may be developed and serve to reduce technical and financial risk[64]. Figure 6 below illustrates the approach for a wave device project…. and there is an equivalent protocol for tidal devices.

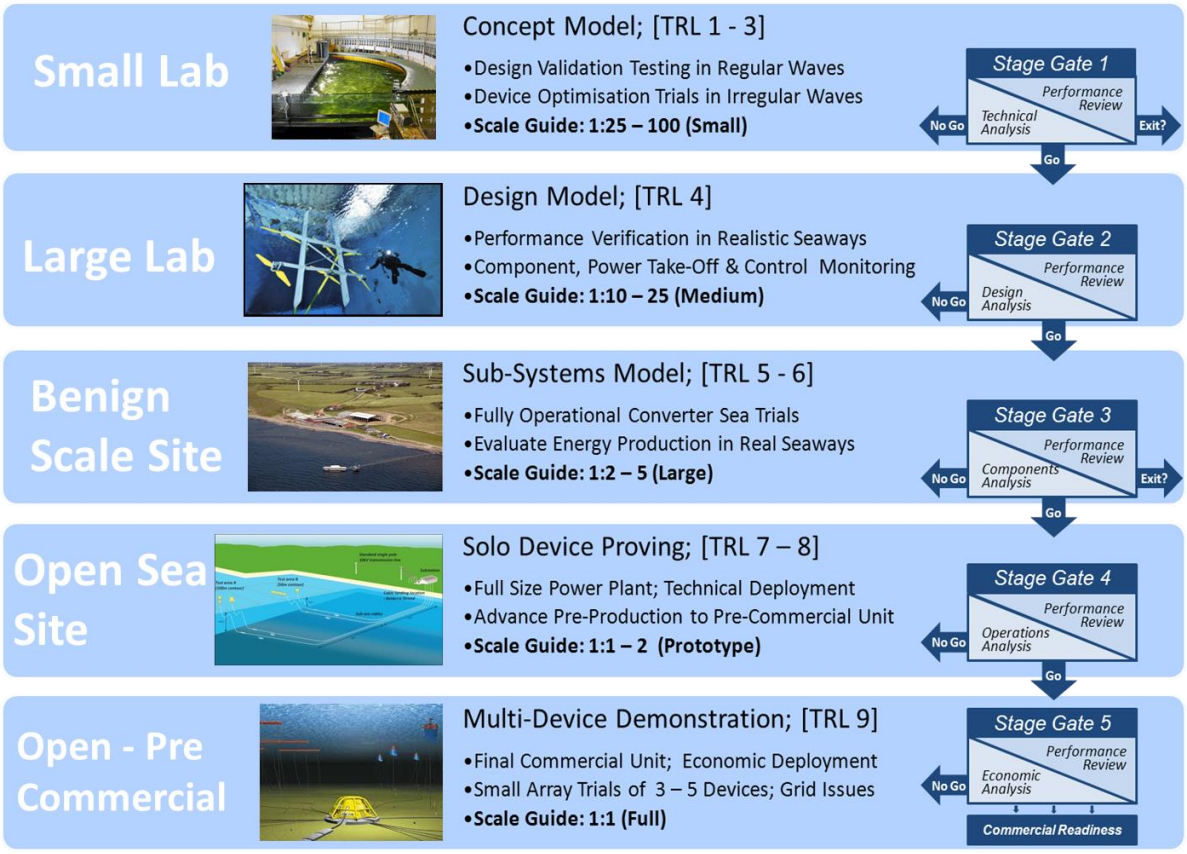


Figure 6: Technology Readiness Levels for wave energy

6.2 Project Measures

The measures or indicators dealt with at 6.1 'translate' into project terms, as follows:

Inception: *Investment in early technology validation*

There are very large numbers of inventions at an early stage of development and Ireland is no exception in this regard where there are at least twelve early stage device projects in train. These may relate to full ocean energy

[63] *Guidelines for the development and testing of wave energy systems* (2010) and *Tidal energy development protocol* (2008) International Energy Agency Ocean Energy Systems Annex 11 reports

[64] The detailed TRL system employed by ESBI and the earlier work in this field developed by the former HMRC at UCC (now part of MaREI) can be found at www.mria.ie , publications section

conversion systems or to enabling technologies related to materials, moorings, offshore electrical export systems, etc. Expert desk studies and numerical and laboratory analysis are required to identify concepts that have the potential to improve on the 'state of the art' in the field. Such activity is typically financed with a combination of inventor/angel investor funds plus, of course, Government grants.

Prototyping: *Investment in technology and product development*

Technology companies are not in a position to generate regular revenue from their activities until they develop a device or sub-system which might enable them to licence their technology or sell their intellectual property to an industrial investor or gain a major industrial partner or raise substantial funds….or some combination of these. Getting to this point is expensive in ocean energy. The verification activities required to give confidence that ocean energy products will perform as specified requires the deployment of large, bespoke offshore structures. The risks are high as are the potential rewards for successful products. This stage requires both significant private risk capital (if possible) and State development funding.

Industrialisation: *Investment in supply chain & manufacturing*

There have been some moves by large system integration companies to invest in ocean energy technologies - a major example being the DCNS investment in OpenHydro. Such companies bring with them the capacity to manufacture industrial products and provide lifecycle support services while offering the balance sheet strength and credibility to provide meaningful guarantees on their machinery specifications. Such investments are at least one avenue to the 'industrialisation' of ocean energy and, in instances where private capital invests at earlier stages, it could also provide an exit opportunity in some cases.

The End Game: *Project finance in ocean energy*

The market for ocean energy firms is perceived to lie in the generation of electricity to the grid but it may have wider applications e.g. to power platforms or enterprises (e.g. fish farms) actually at sea. The key to attracting commercial project finance is low risk technology including robust warranties and performance guarantees from device manufacturers.

Table 4 relates these measures to Technology Readiness Levels and indicates the level of total investment typically involved at each stage.

Project Development Indicators	*TRL Levels*	*Typical Investment per project*
INCEPTION	1 -4	1-2: €50-100K 3: UP TO €0.5M 4: €1.0-1.5M
PROTOTYPING	5-7	5: €2.5M- 5.0M 6: UP TO €5.0M 7: €10-15M[65]
INDUSTRIALISATION	8-9	€40-60M
END GAME	POST 9	

Table 4: Linking projects, TRLs and investment

The same points are made again, using similar staging, in figure 7 below from 2013 which illustrates the financial journey involved in developing ocean energy projects:

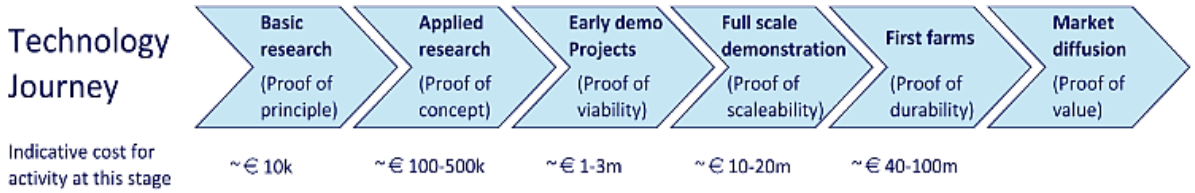


Figure 7[66]: Technology Journey 2013

While yet another, earlier take on the ocean energy 'journey' is set out at Figure 8 below from 2011

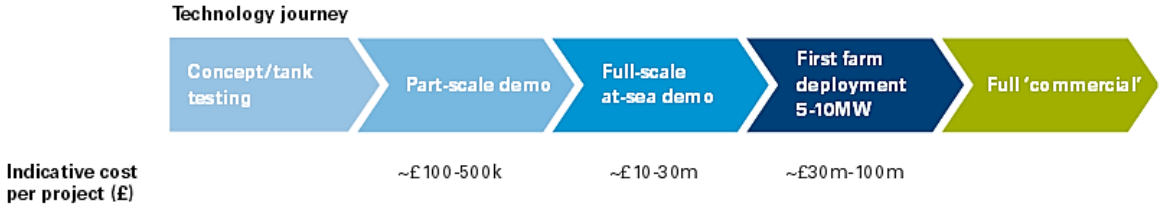


Figure 8[67] Technology journey 2011

The UK's Offshore Renewable Energy Catapult ties these stages (although with slight definitional differences) together with possible sources of finance in figure 9. This shows the position of each technology along the development pathway. It shows that there is a mix of funding sources along the pathway and each of these comes with a different quantum of funding

[65] This stage tends to be by-passed in the view of some experts

[66] *Ocean Energy State of the Art* SI Ocean 2013

[67] *Accelerating marine energy The potential for cost reduction – insights from the Carbon Trust Marine Energy Accelerator* Carbon Trust 2011

and with a different appetite for risk. It also shows that as the projects progress to full scale, the overall project costs can rapidly increase:

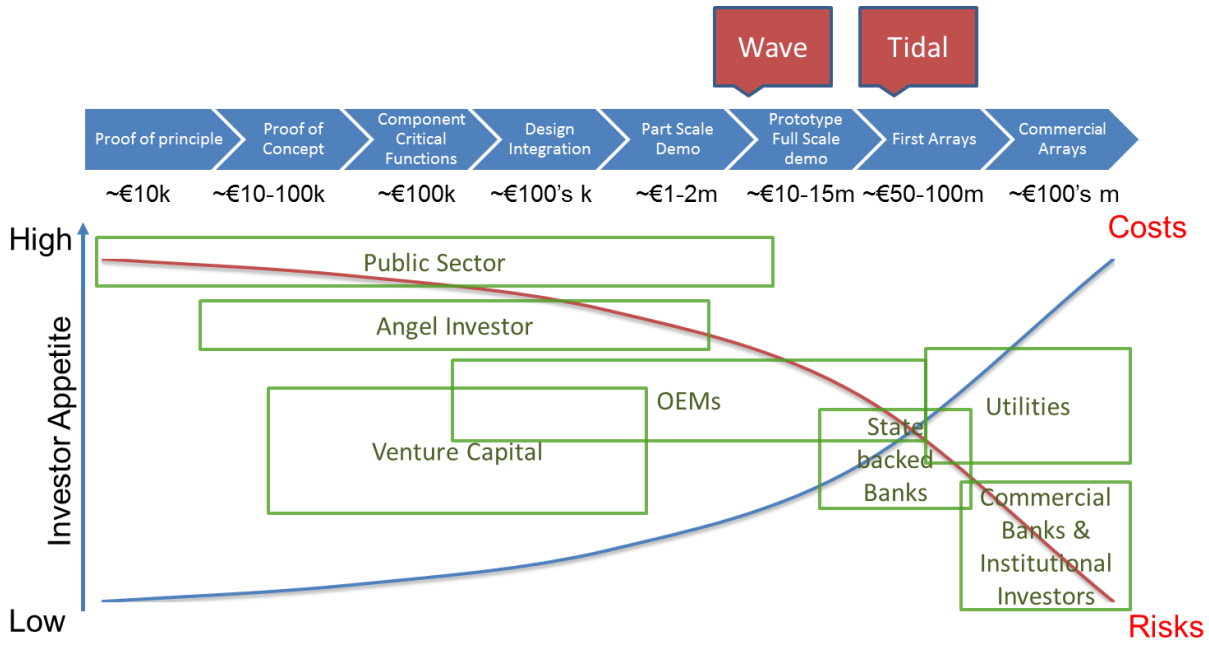


Figure 9: Funding and development roadmap. Sourced from *ORE Catapult*

One significant issue is that, even in later stage pre-commercial development, there may still be too much risk to attract significant private investment as is illustrated in Figure 10 below

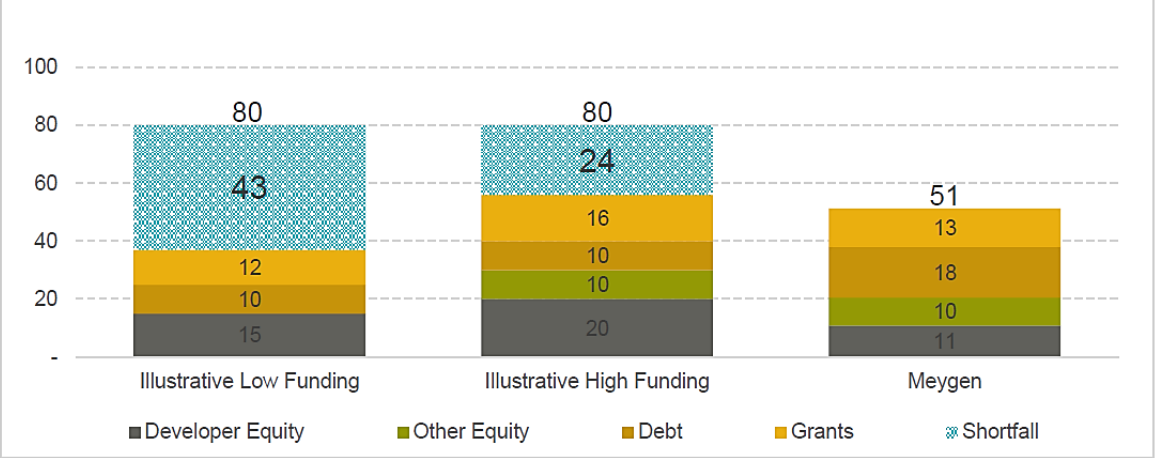


Figure 10: Illustrative project funding structure for a first demo array of 10MW. Sourced from *ORE Catapult*

7. Competitiveness of Ocean Energy

7.1 Financial Indicators

How can electricity generation options based on different sources e.g. wave, gas be compared on an objective, financial basis? How does ocean energy 'stack up' by comparison with other energy sources?

A number of different financial indicators are used to compare projects based on different resources.

Net Present Value: The Net Present Value (*NPV*) of a project is a calculation that compares the present value of the cash outflows to the present value of the future cash receipts. In other words, the amount forecast to be spent is compared to the forecast cash inflows after they are both discounted by a specified rate of return. If the NPV is greater than zero, it is expected that value will be created for the investor. If it is less than zero, it is expected that value will be destroyed for the investor.

Internal Rate of Return: The Internal Rate of Return (IRR) involves a discount rate that makes the net present value (NPV) of all cash flows from a particular project equal to zero. IRR calculations rely on the same formula as NPV does. The higher the IRR is above the discount rate used, the more desirable is the project.

Levelised Cost of Electricity: The Levelised Cost of Electricity (LCoE) is a measure of a power source which attempts to compare different methods of electricity generation on a comparable basis per KW/hr or per MW/hr. It is the key measure used in comparing different energy projects and is defined as the sum of capital and lifetime operations and maintenance costs (discounted), divided by lifetime electricity generation to grid revenue (discounted) [68] .The 'costs' include all costs such as CAPEX (capital expenditure), OPEX (operational expenditure), commissioning and decommissioning costs etc.

For renewable projects, LCoE combines a lot of information into one indicator including resource, performance and efficiency, availability, finance, discount rate, tax, inflation, revenues etc. It must be noted that the indicators should not be used in isolation. For example a project with a high LCoE may still have a reasonable IRR due to tariff or grant support. The other key points to bear in mind are, first, that power sources are sensitive to their location and this is particularly true of renewables e.g. the wave energy available to a project off the west coast of Ireland will undoubtedly exceed the potential for a similar project off the east coast. Second, depreciation

[68] *SI Ocean Report – Ocean Energy: Cost of Energy and Cost Reduction Opportunities 2013*

rates vary widely by power source: for example, the likely lifetime of a nuclear generating plant will exceed the lifetime projected for a wave array deployed in the Atlantic.

7.2 Position of Ocean Energy

The current state of the engineering art in wave energy and tidal energy conversion determines that few examples of devices have been operated at scale and connected to the electricity grid over an extended period of time.

An important EU-supported technology gap and barrier assessment [69] identified several themes and activities that require further research and development in order to allow technology progression towards a more mature ocean energy industry….in other words, the issues to be tackled are known and the pathways to dealing with them are fairly clear. The key issues in tidal and wave (where technology convergence is not apparent yet, unlike tidal) can be resolved according to expert opinion as a result of innovation, learning and deployment at scale[70].

The LCoE predicted from current ocean energy projects is too high with one authoritative report [71] indicating that, given the current state of the technology, an LCoE lying between €35-62c/kwh for early arrays is likely as seen in Figure 11 overleaf.

[69] *Ocean Energy Technology: Gaps and Barriers* SI Ocean, 2013- one of a series of key studies undertaken by the SI Ocean initiative and drawn on in this paper.

[70] *International Levelised Cost of Energy for Ocean Energy Technologies* International Energy Agency Ocean Energy Systems May 2015

[71] *Ocean Energy: Cost of Energy and Cost Reduction Opportunities* op cit

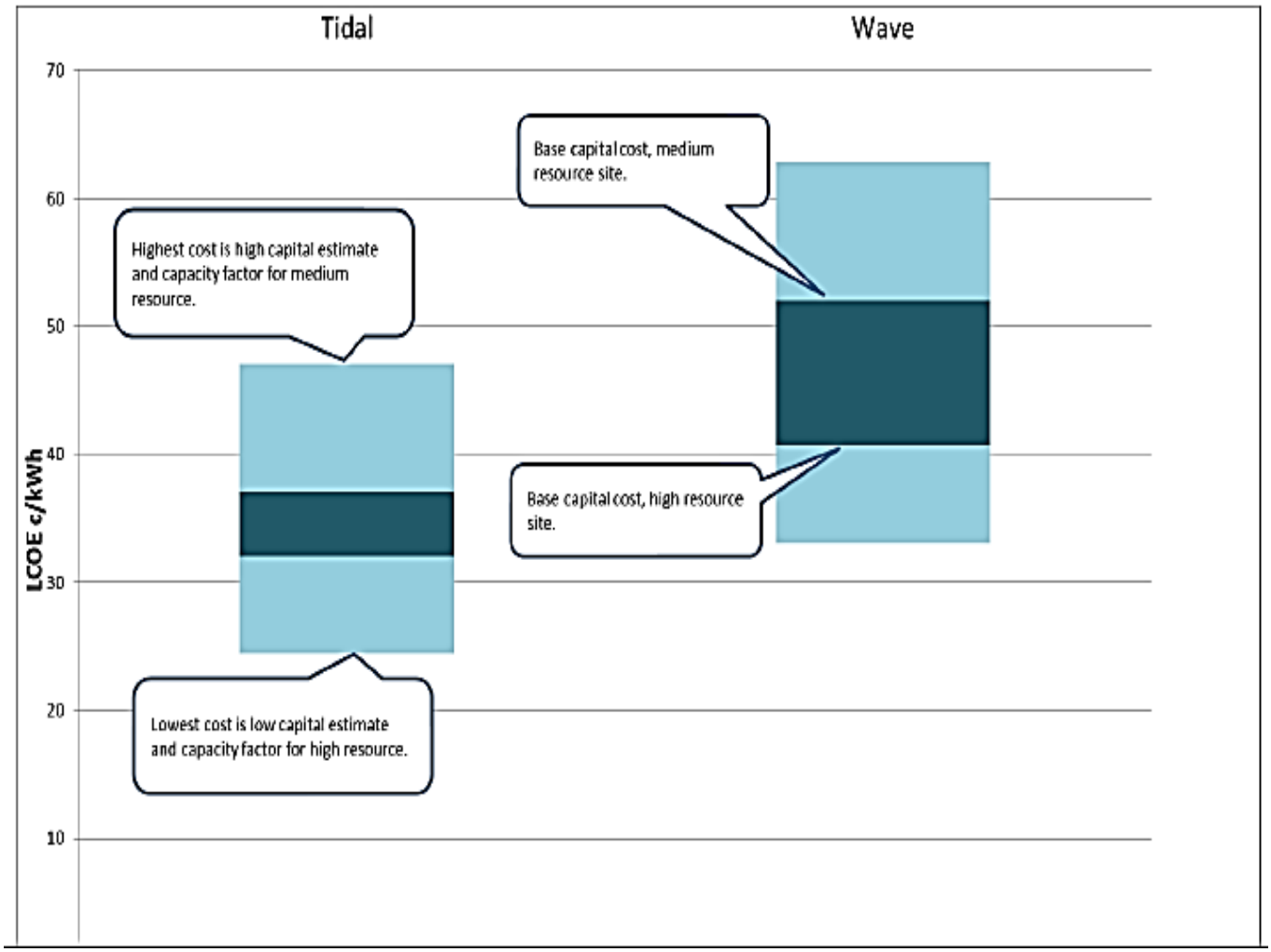


Figure 11[72] : Predictions from current ocean energy projects

However, this report also goes on to state that there are significant cost reductions still to be made by addressing each element of the technology cost base and its overall lifetime cost. The most significant of these include hull costs, power take-offs, moorings, installation and operations and maintenance ('O&M'). This is reflected in the project categorisation adopted by the recently launched *Wave Energy Scotland* initiative.

Other factors to consider are project lifetime, technology maturity and performance risk, resource risk, subsidy in the form of grants or feed-in tariffs, scale and scalability.

[72] *Ocean Energy: Cost of Energy and Cost Reduction Opportunities* op cit

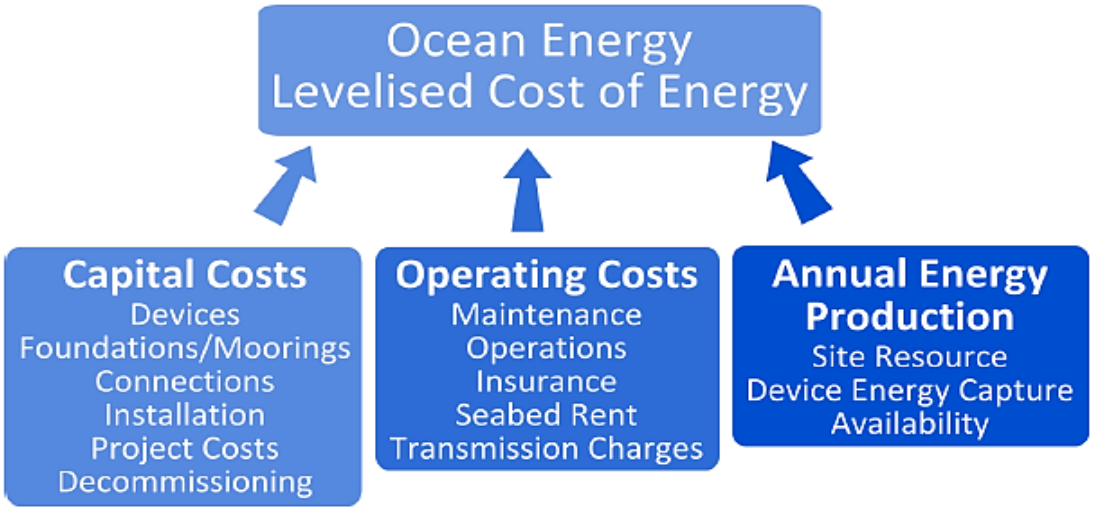


Figure 12 – Factors included in LCOE[73]

Wave Energy Scotland has recently produced a series of calls aimed at reducing LCoE. They have set a target of GB£150/MWh, (€22c/kwh at a recent exchange rate of £1: €1.46) by 1GW installed.

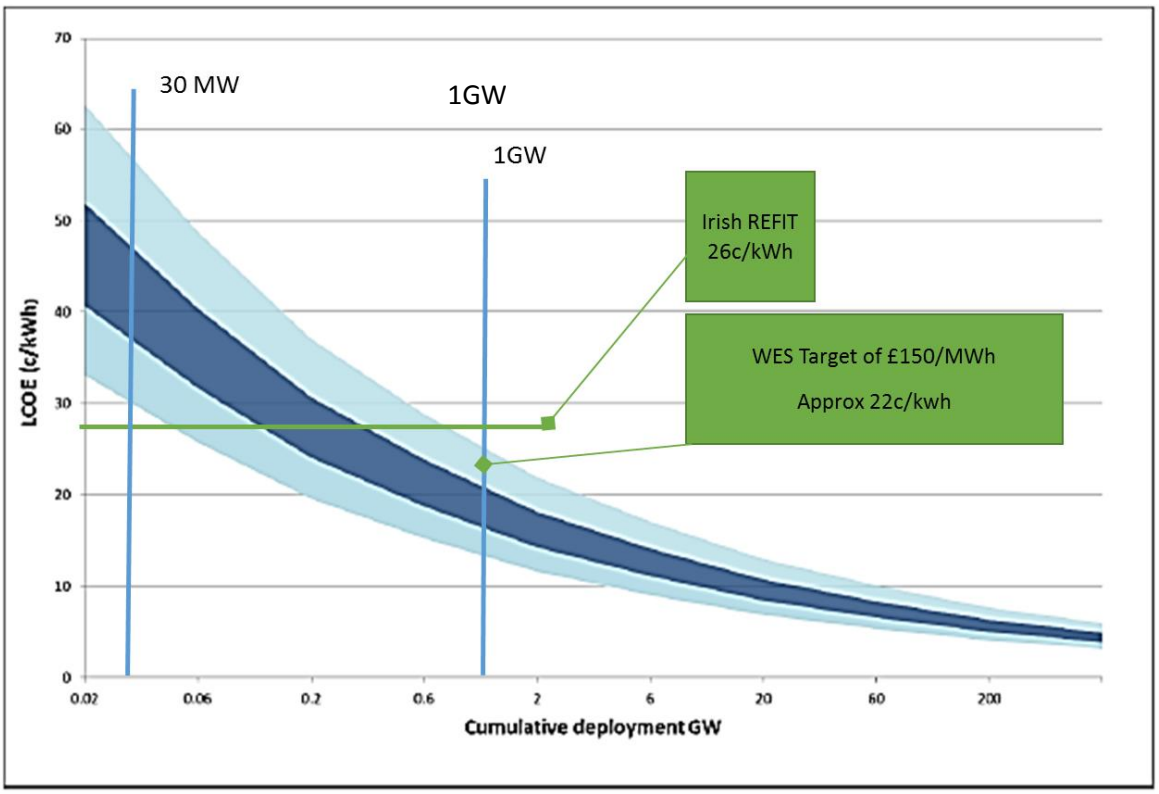


Figure 13: Wave LCOE ranges (deployment on logarithmic scale**)** over-layered in green by MRIA[74]

[73] *Ocean Energy: Cost of Energy and Cost Reduction Opportunities* op cit
[74] *Ocean Energy: Cost of Energy and Cost Reduction Opportunities* op cit

The WES target is generally regarded as being realistic and it 'maps' to costs of between €10-20c/kWh for arrays of devices which is in line with the SI Ocean forecasts.

The generation cost targets deemed realistic for ocean energy by both WES and by SI Ocean must be judged by comparison with other technologies on an LCoE basis. This is done in figure 14. A point to bear in mind here is that the application of a balanced carbon price to both renewables and non-renewables would notably improve the standing of wave and tidal!

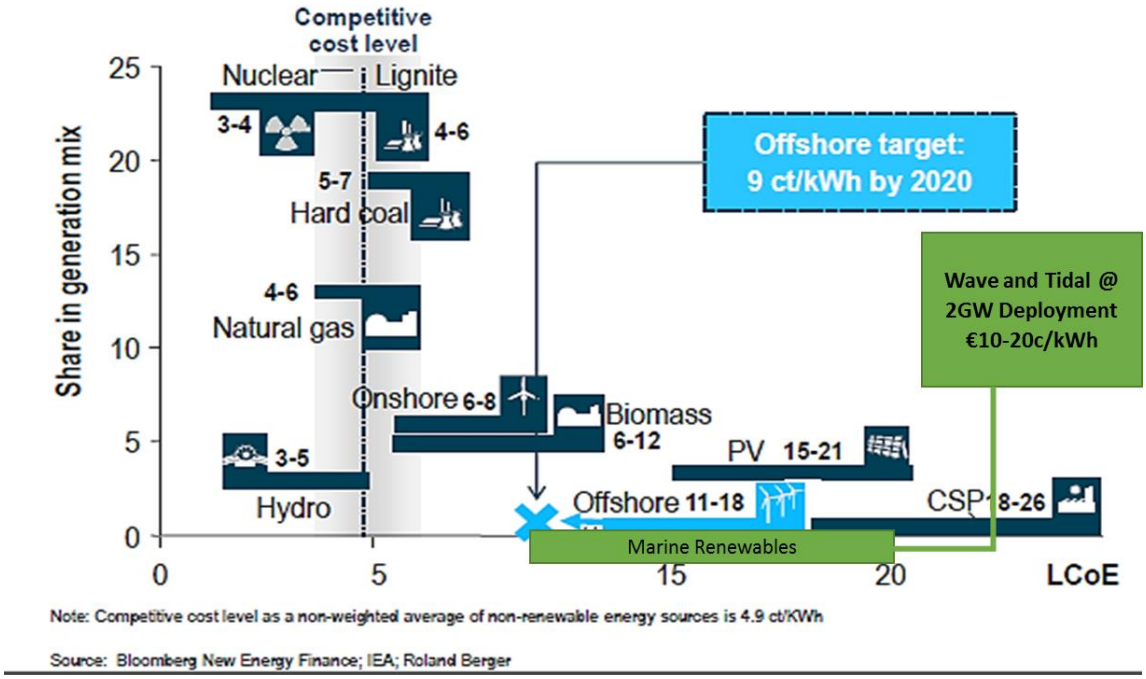


Figure 14: LCoE 2012 European Generation Mix (€c/Kwh)[75]

Finally, Figure 15 shows the view of the Ocean Industry Forum on the journey ahead and the LCoEs envisaged. The Ocean Industry Forum comprises of a series of expert groups in environment and consenting, finance and technology established with EU Commission support. The groups provided Ministers and official with an update on their progress at the Ministerial meeting organised around the Ocean Energy Europe Annual Conference held in Dublin in late October 2015. For more detail, please see 11.2.7.

[75] Roland Berger op cit

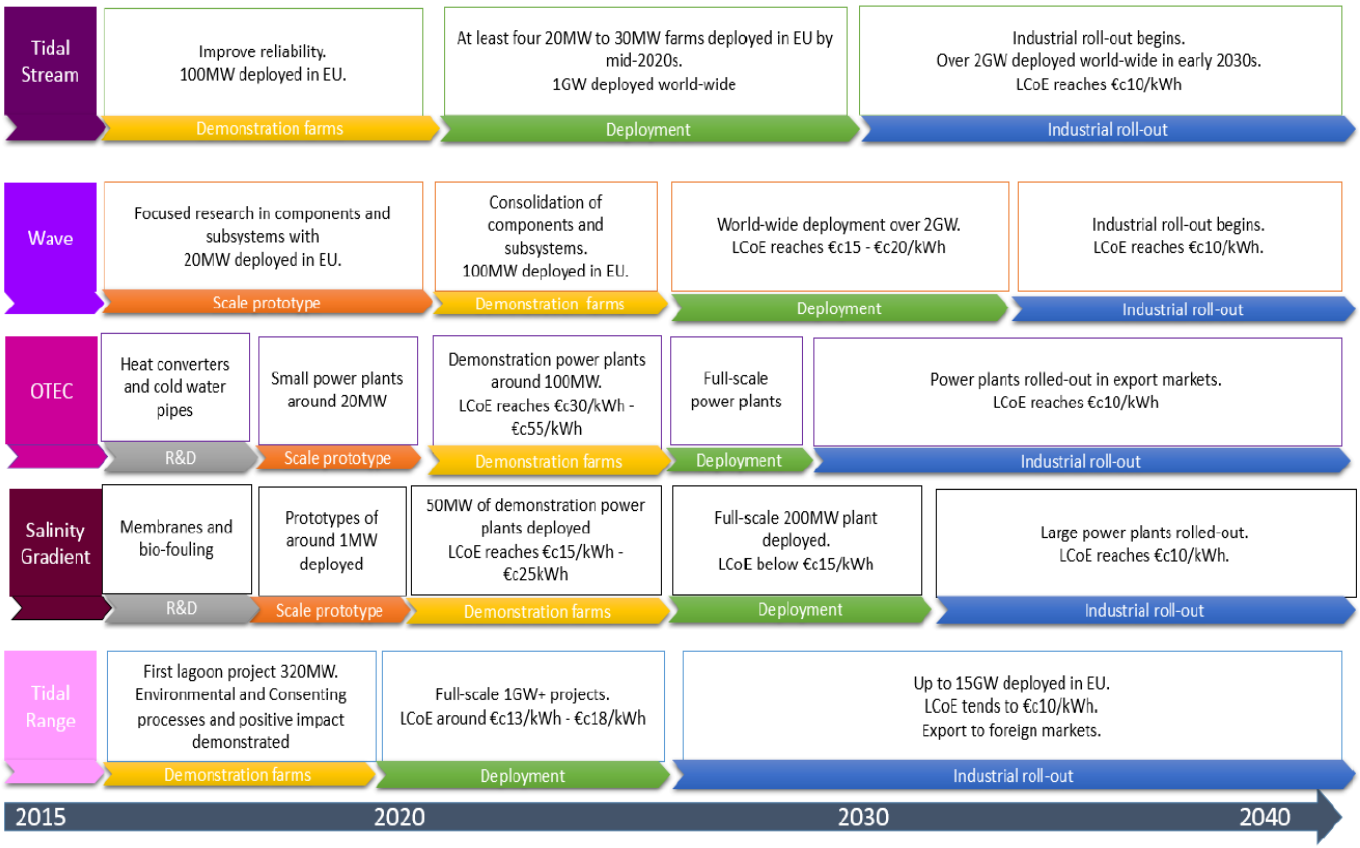
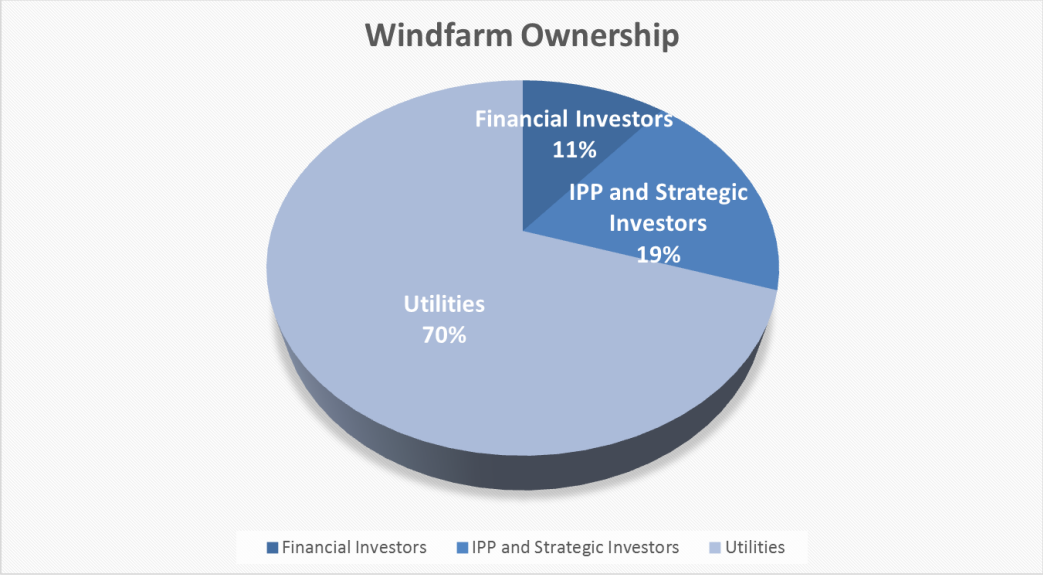


Figure15: Path to industrial roll-out (source: Ocean Energy Forum- see 11.2.7)

The MRIA concludes that ocean energy is seeking to achieve cost levels that will put it on a competitive basis with other renewable technologies. This suggests that, in due course, ocean energy can be financed in a conventional manner akin to offshore wind and other technologies – figure16 [76] shows the ownership of 3.6GW of a recently- maturing technology, offshore wind

[76] Roland Berger op cit



Source: Roland Berger

Figure 16: Offshore wind ownership source

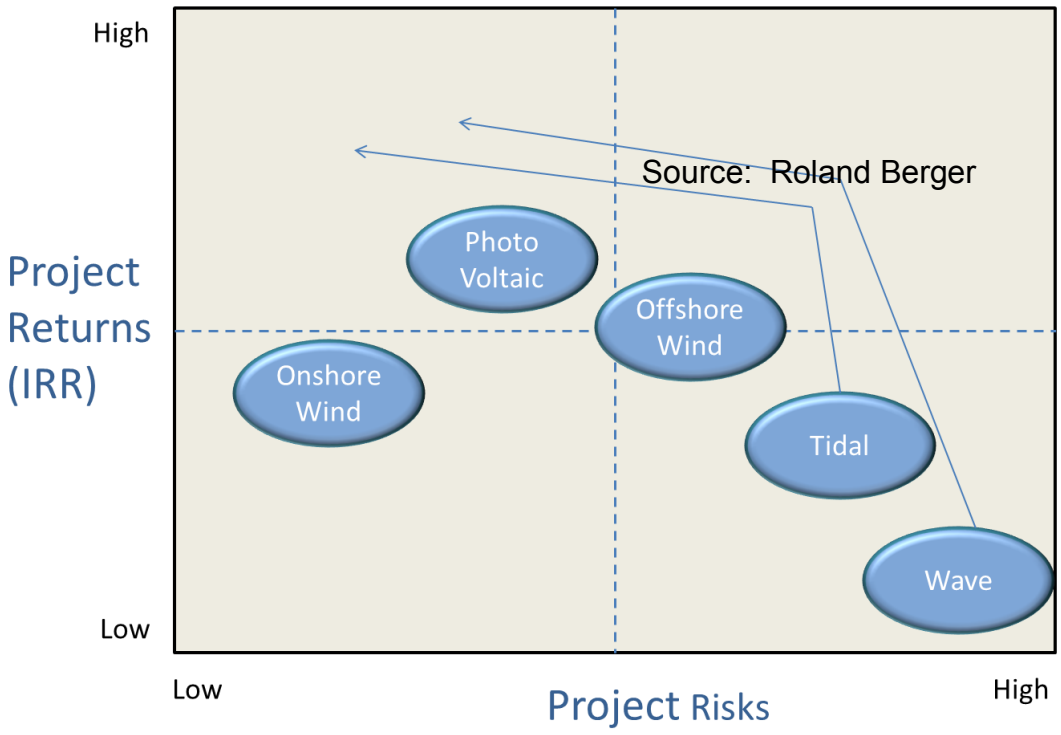


Figure 17: Project Risk/ Return for renewables[77]

[77] Derived from an illustration in Roland Berger op cit

The MRIA's view is captured in Figure 17 above which shows that wave and tidal energy are currently both high risk and low return but the argument made in section 5 of this paper suggests that ocean energy technology has the capability to move into a much more competitive space as shown by the trajectory.

7.3 Funding of Ocean Energy to Date

Much of the pioneering work into investment levels in ocean energy has been driven by Dr Gordon Dalton[78] of University College Cork who estimates that a total of €708m was invested in wave and tidal energy in the period 2010-2014 with the UK (including Scotland) being the single most important source of investment.

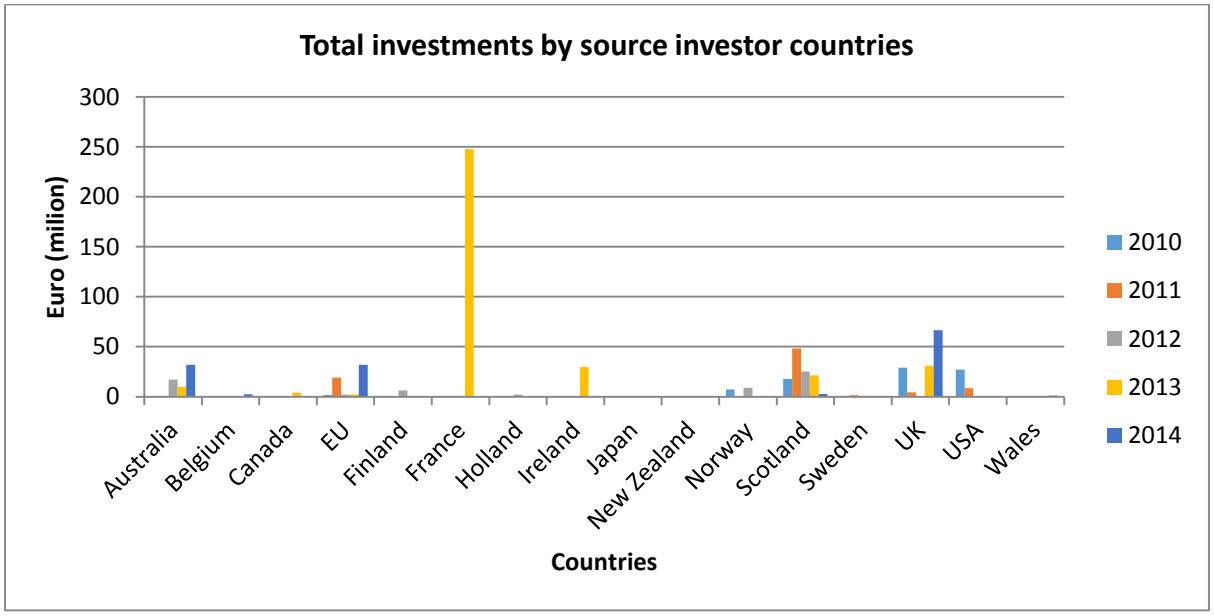


Figure 18: Investment by country

Ireland accounted for £29.6m of the global investment in the same period.

There are several actors providing financial support to ocean energy e.g. Department of Communications, Energy and Natural Resources, SEAI, Science Foundation Ireland (R&D), Higher Education Authority (contributor to the Beaufort facility) etc. The agency which directly 'faces' device and component developers at this stage of ocean energy is SEAI and their

[78] See Dalton GJ. (2014) *Investments in Ocean Energy A review of the global market*: ICOE 2014, Halifax, Nova Scotia. http://www.icoe2014canada.org/wp-content/uploads/2014/11/1-ICOE2014-Gordon-Dalton-53e23ba6c76748.10106971-8.pdf ;and
Dalton GJ. (2011) *"Why wave energy"*. OES IA Annual Report 2010 - *Implementing agreement on ocean energy systems*.pg 93-110. http://www.ocean-energy-systems.org/library/oes-reports/annual-reports/document/oes-annual-report-2010/ ;and
Neumann F, Dalton GJ. (2009) *Non-technological barriers to wave energy implementation* in: Waveplam
http://www.waveplam.eu/files/downloads/Waveplam_Del_2-2_Non-technological-barriers.pdf

contribution shows a healthy upturn in resources and growth in activity recently as shown in the Tables below

Year	***2009 €***	***2010€***	***2011€***	***2012€***	***2013€***	***2014€***	***2015€***[79]
Total allocation for Ocean Energy	3,833,320	1,710,587	3,896,505	2,544,000	1,862,000	3,700,000	
Grants awarded	2,614,233	779,830	1474487	90,652	498,565	2,085,943	c€4.5m
Grant payments	1,272,818	244,989	2,056,272	1,189,669	404,289	607,775	c€2m
Number of projects	12	7	12	4	9	10	c15

Table 5: SEAI Prototype Development Fund grant awards- source SEAI[80].

Projects at TRL stages:	***1*** ***€***	***2*** ***€***	***3*** ***€***	***4*** ***€***	***5*** ***€***	***Feasibility*** ***€***	***Total*** ***€***
Grant award	716,001	958,612	873,007	3,112,455	NA	2,152,023	7,812,907
Number of projects	18	14	9	7	0	11	
Average grant per project	39,778	68,472	97,001	444,636	0	195,638	

Table 6: SEIA Prototype Development Fund amounts awarded by TRL stage[81] – source SEAI

[79] SEAI informal forecasts at late Autumn 2015

[80] Grant awards extend over several years and thus only part of an annual award might be paid out in the year in the year of award.

[81] TRL definitions used here are based on:
http://www.seai.ie/Renewables/Ocean_Energy/Prototype_Development_Fund/HMRC-Protocall.pdf

8. Strategic Topics Explored

A wide range of interests in Ireland and the UK in academia, finance, government and finance was interviewed for this Paper–a list is contained in Appendix 1. A series of four issues identified by MRIA was explored with these stakeholders.

First, the interviews sought to establish the views of interested parties on renewables generally and the position and prospects of ocean energy in particular.

Second, views were sought on how much investment is needed to advance the 'industry' to the point where projects can raise finance in the commercial markets.

Third, interviewees were asked about the potential scope for Europe to participate in the development of ocean energy and, in particular, the scope for co-operation with Scotland[82].

Finally, the opinion of stakeholders was sought about the 'whole device v technology challenges' quandary: should limited State resources be focused on supporting proposals to develop individual energy conversion devices or, at least for the time being, for the time being, focus them on solving specific technology issues and sub-system development?

In line with the normal practice in MRIA Papers, direct quotes are given anonymously. However, only a representative selection of views is provided – over 250 substantial views were recorded by the Association in the course of preparing this Paper – at Appendix 3. Typically, just a handful of 'voices' is quoted under each heading in 9 below.

9. Funding Ocean Energy Development: the Issues

9.1 Overview

The interviews with the various parties listed in Appendix 1 generated comments which fell under two headings: the issues surrounding the funding of ocean energy development and, second, the features which must be addressed in any national policy solution.

There was a positive view of renewables in general while ocean energy was seen as an emerging technology with technical challenges still to be resolved particularly in wave energy. The rapid emergence of solar energy as a

[82] See also *The Opportunity for Co-Operation and Collaboration between Ireland and Scotland in Ocean Energy.* Discussion Paper published by MRIA 2013. Available at www.mria.ie

competitive, but probably complementary, renewables source was widely commented on.

There was (perhaps) a surprising sense among several commentators that ocean energy is within financial grasp but, even with an improving investment climate, it is unattractive to private capital at present due to its emerging technology status. There were strong views expressed about the unrealistic expectations imposed internationally on ocean energy and the damage this is perceived to have done. Moreover, the global pressure on device developers to become actual *site* developers as well was criticised.

A recent interview with the head of Wave Energy Scotland captures many of the points made in an eloquent and apt manner:

'Now that we know how difficult it is to devise a viable wave energy device why does he (Head of WES) wish to persevere? And why have our hopes not been realised so far?

"It's very easy to look back and say in hindsight that we were doing the technology at full scale too soon. People are saying that now, but it wasn't immediately apparent at the time, because the scale of the technical challenge of putting a wave device in a high energy wave energy environment was not fully apparent'

We should have built at a small scale and built up to it. That's obvious now, but it wasn't obvious then. The challenge of what we were trying to do was not fully apparent''

That rise-and-fall pattern, he suggests, was also caused by the nature of the funding landscape in the UK: "The kind of VC finance that supported those technology pilots… they want an exit, they want to see a product and want to see it sold on. They don't want you to spend too long in a test tank, they want to see something credible out there bobbing around in the ocean delivering energy.

"Also the public sector was saying we will give you money for full scale [prototypes] they were pushing the industry, and with the Renewable Obligation Certificates the more electricity you generated, the more money you made, so potentially the bigger the device you made, the more you make. All of those factors were pushing technology companies to go large too quickly"

Hurst also thinks that there was a certain amount of wishful thinking on the part of the early proponents of wave power: "There is an element of you don't know what you don't know. When you look at the engineering challenge, you see it's about reciprocating motion and converting it into electrical generation, it shouldn't be that difficult. We've seen similar things in other industries, it's a technical problem we can solve.

And it's when you get into to the sea that you realise that we want to make a device that is sensitive enough to capture the energy from a 1m wave, but that also has to survive a 24m wave. The amount of energy is 1000 times greater. There is a 1000 times between the energy you want to capture normally and……and what you want to survive."

The thinking behind the establishment of WES was a response to the exodus of confidence, and investment by the private sector, which meant that public sector bodies like the Marine Renewables Commercialisation Fund, which were based on a match-funding model, had no more funding to match.

"When you get to the point where no-one is investing, then that kind of programme doesn't work anymore. So you have to do something different." [83]

9.2 Views on Renewables in General

There was a consensus across the board, as might be expected, that renewable energy is here to stay. Interestingly, the interviewees had a strong sense of the fundamental change, indeed volatility, underway in energy markets and, also, a clear view of the impact of solar energy. Three voices among the many - see also Appendix 2 for a much wider range of opinions (under all headings):

'…we are at an inflexion point in energy: not sure how a system with significant renewables is going to work in the long term'

'Solar PV is a challenge to everything else in renewables. The world could look like a combined technology platform. Storage in conjunction with a night technology is a key. There is, for example, a 6 hour gap with tidal devices which is 'better' than the diurnal. Tidal is very predictable and has a short span. The other thing is that the solar capacity factor is nothing compared to wind. Hydro storage could also play a part. We need to look at a balanced portfolio of sources: solar, wind, wave, tide'

'With our facilities and resource in Ireland, we have the opportunity to dominate this energy technology and become a big energy exporter'

9.3 Opinions of Ocean Energy

There were strong views expressed on ocean energy! It is recognised as an emerging technology with tough technical and economic issues still to be resolved. However, optimism about the future of the industry, particularly from experienced Scottish sources, was encouraging and the strong economic development arguments for ocean energy were noted.

'The key issue is how is the industry to be funded for the next five years because there won't be an industry unless a solution is found'

'We are turning the ship around; the Scottish Government is very optimistic. ….. Aim in tidal is to get a demonstration array and in wave it is to bottom out the (technology) issues. Horizon 2020 (H2020)/TINA are all applicable. There have to

[83] Interview with Head of Wave Energy Scotland in *Sunday Herald* Scotland 6 September 2015

be better opportunities to access better funding, develop common technologies across countries'.

'The UK as a whole has committed £400m to ocean energy and just under half of this has been drawn down and there is ongoing political commitment to ocean energy although there has been a crisis (of confidence) among private investors in renewables, not just marine renewables although it has been hit hardest'

9.4 Funding Needed to Bring Ocean Energy to Maturity?

The Association sought general views on how much investment is needed globally to get over the various technology hurdles and to enable technically mature wave and tidal devices to emerge. The opinions expressed were surprising insofar as the sums projected are, in relative terms, modest. In the view of some experts at least, the ocean energy prize is within reasonable financial grasp.

'Important thing to remember is that a typical US software start up requires about €90m in investment to achieve commercial viability…there is a parallel there with ocean energy'

'About an extra £100m is needed to bring tidal energy to maturity and about an extra £200m to do the same with wave energy'

'Need another €100m to get wave technology to maturity'

9.5 Investment Climate

The investment climate generally in the Republic of Ireland has improved as the economy has recovered- Ireland was the fastest growing economy in the Eurozone in 2015. However, there are, at best, only modest signs of interest by mainstream financial institutions in young companies in marine renewables. A selection of views:

'*Based on experience of (*company name supplied to MRIA*), not just the technology, not the lack of funding, not just the people….funding supply in Ireland is too short-term…..finance houses in Ireland don't have deep pockets'*

'Need long-term capital across the board in Ireland…don't have solution to long term capital …perhaps NTMA can do something?'

'Deeper pockets are needed (for ocean energy) than those available to date in Ireland…but the prize is great'

9.6 Current Private Investment Prospects of Ocean Energy

The interview process for this Paper confirmed what is already informally assumed throughout the ocean energy domain across all sectors and all

interests: ocean energy is an emerging technology, not a business sector, at present and it will not attract private capital until various conditions are met.

'Only way to support ocean energy is on an 'uneconomic basis'. Not time yet or perhaps for 5 years to pick a winner'

'*The whole ocean energy industry is oversold and has thus underperformed. There is not proper recognition that wave and tidal are new, developing technologies'*

'We spoke to potential customers three years ago and asked them to take stakes in our company as it is always useful if the utilities are involved for both technical feedback and financial reasons…there response was 'come back to us when you have a full scale device working with good power generation numbers'

9.7 Unrealistic Expectations for Ocean Energy

A perhaps unexpected feature of a number of the interviews held was the strong opinions expressed, and not just in Scotland (with its then recent experience with Pelamis and Aquamarine Power), about the unrealistic pace at which wave and tidal device developers had been 'pushed' by public policy, promoters and investors alike to raise private finance and the damage that this has done. In particular, the requirement to bring commercial capital into an emerging technology at an early stage was critically commented on.

'The problem is that the industry/emerging technology has been pushed too hard and overpromised all over the place'

'Up to 300 wave developers out there – lots of ideas on paper, most are entrepreneur or engineer-driven, focused on just one element. Funding calls: projects are chasing calls; under pressure to go 'in the water' at far too early a stage; they are under-resourced and under pressure from shareholders seeking a return.'

'…the collapse of Pelamis and the challenges faced by Aquamarine were not their fault, it was the fault of the funding regime which was not performance oriented'

9.8 Pressure of Site Development Requirement

A number of interviewees commented on the pressure that some *device* developers faced to become *site* developers as well due to market pressures to assure investors via practical commercial site developments. It is illustrative of the fragile 'fast track' development model taken on by this currently technically challenging field, ocean energy.

'Big challenge to go from a prototype to a commercial product- OpenHydro had to develop sites at €3-4m a pop'

'Lots of people got into ocean energy with a view to selling out once TRL 4 achieved- didn't work and, indeed, Pelamis, Aquamarine Power and OpenHydro all had to become site developers as well in order to advance'

'We (company name supplied to MRIA) *are an OEM and do not wish to become a project developer but for our first projects we have effectively been forced into this'*

10. Features of a Funding Solution

10.1 Overview

Not unexpectedly, interviewees for this Paper did not have any 'magic wands' solution to the financial issues surrounding ocean energy although it is clear that all interests believe that Government financial support will be key for years to come. Nonetheless, some other key features of a solution emerged. The warranties and guarantees issue must be addressed. There is no role for at least 5 years and probably a lot more for public capital markets such as the Irish Stock Exchange in supporting ocean energy. *Wave Energy Scotland* has prompted a lot of interest and the model it presents, and the lessons of its experience so far, are seen as desirable ingredients in any overall settlement of Irish ocean energy finance. The importance of industrial partners and the ability to scale up device developers' enterprises also prompted comment.

Other topics raised included technology convergence (not there yet for wave; in sight for tidal); a national funding roadmap (critical); funding models; the role of EU (more engagement needed); co-operation with Scotland ('desirable'); and the 'support devices v sub-systems' conundrum was of great interest.

10.2 Warranties and Performance Guarantees

The provision of warranties and performance guarantees acceptable to end-customers and, thus to the investment community, is deemed a vital part of the future funding and development solution for ocean energy.

'Big issues for small device developers are power curve availability; parent company guarantees; and warranties. Government should provide guarantees. The other issue is weather-risk. All of these things bear on IRR'

'Finding a solution to the warranties issue is critical because neither investors nor site developers want risk'

10.3 A Role for Public Capital Markets?

The use of the Irish Stock Exchange or other public markets as a source of funds for ocean energy was firmly ruled out at this stage but, intriguingly, the example of the large Malin [84] biotech fund was raised on several occasions as an example of what might be possible when ocean energy matures.

'There is no significant capital available in Ireland for companies listed on the Irish Stock Exchange …they use the ISE to list'

'An Irish company – a biotech fund, Malin – listed simultaneously on the ISE and the NASDAQ recently. This IPO was pre-revenue etc. Irish Strategic Investment Fund was a cornerstone investor with an investment of €50m'

10.4 Pre-Commercial Funding Model Sought

There was a lot of support for a pre-commercial funding model. The 100% funding aspect and the rigorous engineering review process associated with Wave Energy Scotland were deemed particularly attractive. Irish companies have featured among the winners in the latest competitive round of WES funding.

'We need to look at the Wave Energy Scotland model……Under WES, the call is open around the EU; solutions must be tested in Scotland; and solutions must be available for licensing. Gets around EU rules concerning 100% grant aid'

'WES is not about a company development focus, it is about furthering the industry. We are looking for game-changing technologies. We need convergence on components. People are spending money on the same issues cover and over and companies are secretive about the outcome – there isn't even standardisation over cable sizes!'

'Public procurement commercial approach a la WES is the way to go'

10.5 Role of Industrial Partners

Industrial partners (DCNS's participation in OpenHydro is the best known example to date) are deemed a vital part of the ocean energy path to technical maturity and the scaling up of entrepreneurial start-ups.

'Having an industrial partner with a strong balance sheet a la DCNS is key…cost of putting devices in the water is challenging and ocean energy device developers need a strong balance sheet to fall back on when problems arise as they inevitably do….need trials in the water for credibility'

[84] See www.malinplc.com

'Journey from an experimental 'widget' to a big lump of iron such as an ocean energy device is a long one and a lot of investors don't want to make the journey…requires really patient capital….corporate VCs are a better bet in this regard'

10.6 Technology Convergence a Pre-Condition for Investor Interest?

There are at present many types of devices and technology solutions being proffered in both wave and tidal. It is clear that private capital will be slow to invest in the 'industry' until the field of solutions has been narrowed, particularly through successful trials in harsh environmental conditions.

'Private investment at scale will start when there is a convergence in technology and costs reduce, when everyone is working on the same technology'

'OEMs won't invest until there is a convergence in the technical approach to Wave; they don't really have an interest in early project development…and there won't be private investment until then e.g. by utilities'

10.7 National Funding Roadmap Critical

The need for a 'roadmap' which provides attainable sources of funds at various stages in ocean energy development was highlighted. Clearly, this relates not only to the provision of information but more importantly to the design and implementation of effective funding mechanisms for projects, particularly at the higher TRL levels.

'Device developers need a road map from their current start-up position to the point where they can attract private finance'

'(SEAI?) Should work with prototype developers to attract investors…but a road map is needed'

'As a country we should put our ocean energy prospectus together and go out and sell to international capital- there is so much money around the world looking for an opportunity. Don't be precious about 'invented in Ireland', don't give way to academic people'

10.8 Capacity to Scale

An interesting feature of a number of interviews was the comments made on the need for promoters to address company-development from the earliest stage, particularly the development of a team covering both the commercial as well as the engineering aspects to projects. The ability 'to scale' has been a feature of relatively successful ocean energy companies.

'People will back early stage technology provided there is a good management team to back and export potential e.g. in medtech'

'The challenge will be to combine a business plan plus management team with the ability to carry it through. Most investors will assume that the technology (in a specific project) will work……the key is the management team'

10.9 Funding Models

There were various suggestions about appropriate funding models but one common thread was an enhanced role for Government funding.

'Biggest issue for the industry is the relationship between generating capacity and capital cost….the wave industry has been featured by strong leadership of a small number of device companies which have gotten ahead of the real TRLs…these strong leaders have mopped up most of the money and left everyone else floundering'

'Concern about the State trying to pick winners by directing investment to specific technology solutions. Perhaps (State) should give money to companies only if it leverages co-operation between companies…(don't) put money into different companies with similar approaches and problems…should copy the EU's Horizon 2020 model which requires companies to work with partners to gain grant support'

'The Government's approach of splitting the cake (the SEAI Prototype Development Fund) does not solve the problem. Bearing in mind that ocean energy is a technology that will turn into an investable class of infrastructure, then you need to support a top idea with perhaps €100m and it will take 7-10 years; 6- 7000 hours in the water; in 2 or 3 jurisdictions; and in lots of bad weather ….to get an investable device. It is only at that stage that soft loans etc will emerge from the private sector to roll out (ocean energy) and be able, like offshore wind today, to stand on its own two feet'

10.10 A Role for EU Funding?

Europe has played an important role in ocean energy development to date (e.g. Structural Funds support for SEAI's aid schemes) and interviewees were keen to see the EU play a bigger role in funding particularly but also in policy and practical project co-ordination in future.

'Co-funding with Europe is desirable alongside SEAI'

'*Europe is the way to go…that is the generic wish in the industry. We should all act together on generic issues such as moorings and collaborate on test centres'*

'We don't need competition between nations at this stage but rather to see an industry emerge'

10.11 Co-Operation with Scotland Important

Greater co-operation between two of the most important ocean energy nations, perhaps the most important nations in this field, Ireland and Scotland, has been a central theme of MRIA work[85] and this was supported by a wide range of expert 'voices' on both sides.

'We need to hold joint calls with Scotland to deal with technology issues- Wave Energy Scotland will cover 5 areas in line with the SI Oceans Report …we are in danger of duplication'

'Like the Wave Energy Scotland approach which deals with the fundamentals. But it should add on (certainly if copied in Ireland) with a 'Chief Engineer's Review' process which all projects should be required to pass. Alternative opportunity cost of failed projects is too high at present. Should Ireland have a joint Review process with Scotland?'

'Collaboration with Scotland is a really smart idea- let's share the costs'

10.12 Investment in Specific Technology Solutions or Sub-Systems?

This important issue on which there were many comments was prompted by the impression (correct or otherwise) that Wave Energy Scotland is focused on sub-systems. Essentially, the view of industry and experts was that a twin-track approach (including a more rigorous engineering review effort) to develop both sub-systems and components as well as devices is needed.

'The problem with the focus on sub systems or components approach is that you have to have a WEC industry to supply in to…..we must focus on generation grid connected wave farms'

'Ireland has developed a research industry in ocean energy, we must now concentrate on developing a wave (in particular) device industry'

'Small companies with limited capital access should focus on components'

'The (State funded) pot is small, don't spread it around…make the tough choices and focus the funds on singular projects including components'

[85] *The Opportunity for Co-Operation and Collaboration between Ireland and Scotland in Ocean Energy* op cit

11. Conclusions and Recommendations

11.1 Conclusions

This Paper was originally conceived as a study of the perceived funding 'gap' which arises as ocean energy conversion devices approach the middle part of the TRL ladder (many Irish and international device solutions are currently 'bunched' at present around TRL 3/4). *None of the solutions and initiatives to this problem suggested by interviewees will, in Ireland's case, stretch the immediate State funding envelope for ocean energy beyond that already suggested in the Government's anchor ocean energy policy document, the Offshore Renewable Energy Development Plan*[86].

Notable funding has been injected into the sector during a difficult time for the broader Irish economy. Major technical issues have been encountered and technology convergence has not occurred so far in wave (unlike tidal, where it is emerging). Even so, there is a pathway to technical solutions but it will need Government and international funding and it will probably take another 10-15 years before reliable ocean energy engineering solutions are able to generate electricity at scale and large-scale commercial development can begin.

Even against this backdrop, the MRIA has concluded that there is a remarkable economic opportunity ahead in ocean energy. It is important here, however, to distinguish between ocean energy as a *new source of local electricity generation* (and, very likely, of electricity exports in Ireland's case) and ocean energy as a *new global supply chain or enterprise opportunity*.

Ireland[87] may need substantial ocean energy in the future for domestic needs. This will depend on the extent to which mature ocean energy technology can provide a competitive LCoE; security of supply issues arising from international political developments[88]; etc. The export market for Irish electricity may develop over the next 15 years and there may be a place for wave energy in it.

However, the key point is that the substantial local wave energy resource can be exploited for both domestic and export purposes with foreign developed and supplied technology and services i.e. *the bulk of the supply chain jobs and income potential may go elsewhere (as happened with wind*

[86] *Offshore Renewable Energy Development Plan* op cit. See p21 where reference is made to an extra €30m for capital investment in 2016-18. Latest indications are that this may slip to 2017 or even 2018 based on perceived demand at present.

[87] Both Northern Ireland and Republic of Ireland; the island operates a common electricity market

[88] A recent *Economic and Social Research Institute* www.esri.ie report on the implications for Ireland if the UK exits the EU suggested that such an event would adversely affect Ireland's energy security.

power which in practice arrived in Ireland after the technology had matured) unless there is a firm national ambition to capitalise on our strengths in ocean energy and grasp the economic opportunity they present.

The OREDP maps out Ireland's ambitions and tasks to 2020. In line with the 'timetable' outlined earlier for ocean energy and in keeping with the trend in EU and national energy policy generally, there is need to start work on developing a strong national ambition for post-2020 and out to 2030, perhaps an ambition to become the global powerhouse in ocean energy, possibly in conjunction with our neighbours in Scotland. The inspiration for Ireland's ocean energy ambitions might be Denmark who built and exploited an early-mover advantage in wind power into a major industry which now employs 24,000 people[89].

The enterprise opportunity is significant regardless of what happens on the domestic and export electricity supply fronts. There are many sources of wealth and employment in ocean energy including R&D, testing, education, design and engineering services, installation, O&M, financial and legal services…… and there is plenty of scope for subsystem and component manufacture and hull fabrication and assembly as well, particularly in the extensive facilities of Harland and Wolff Heavy Industries in Belfast.

'A total of 90% of the world's offshore wind turbines are either Danish produced or have Danish developed foundations and components. The leading global companies all have R&D activities in Denmark'

The Irish national interests in ocean energy have tended to divide into two groups: those, such as researchers in the field, who believe passionately in the Irish ocean energy future and those who view it solely through the prism of its perceived (potentially negative) impact on local electricity costs because of the REFIT mechanism. But the real opportunity may well lie in the scope to develop a global supply chain and this has not yet received sufficient attention. The focus to date, and perhaps correctly so, has been to build up the policy framework e.g. OREDP and the network of R&D and test facilities.

The next conclusion drawn by the Association from the research behind this Paper is that, despite an improved national investment climate, there is no private capital market open to ocean energy in light of the early development stage of the technology and this is despite the informed and supportive views encountered in the financial institutions. Moreover, damage has been done

[89] *New Offshore Wind Tenders in Denmark* Danish Energy Agency

by an international funding environment which de facto 'forced' ocean energy device projects to raise substantial private capital to finance what in essence was early 'public good' type R&D- a point made strongly by Scottish interviewees in particular and reflected in *Renews*, the influential industry newspaper, recently in commenting on the collapse of Aquamarine Power:

> *'A lack of new private finance was a key element in the company's downfall……the technology is simply not ready for primetime. Observers will point to the UK's finance-focused system of developing early stage technology, putting pressure on Aquamarine and before it Pelamis to get kit in the water and earning revenue too soon'*[90]

Promoters worldwide have had to push out the technical boundaries too fast in order to raise private money and the consequent failure of their projects has hurt ocean energy in the eyes of the financial world[91].

There are a variety of players involved in the funding of Irish ocean energy including DCENR, SEAI, Science Foundation Ireland, IDA Ireland and Enterprise Ireland, universities, individual investors and promoters… among others. The most important source of State funding for those developing devices or sub-systems is the Sustainable Energy Authority of Ireland's *Prototype Development Fund* (PDF) which will approve c€4.5m in grants of up to 70% of costs to promoters in 2015 – a record annual amount. Most recently, Apple announced[92] a €1m fund to support developers who receive a PDF grant and wish to test their devices at SmartBay. In addition, the OREDP seeks further Exchequer support of €30m for ocean energy in 2016-2018 although this may slip principally because of concerns about the timing of demand for this funding. An early task will be to establish targets etc for this substantial block of extra funding.

The current PDF is an appropriate, flexible, demand-driven and well established scheme which caters for the needs of projects, particularly at the inception and early prototyping stages. It supports feasibility studies, very early stage projects and it serves to inform both promoters and the Authority about the merits of various technical approaches. It might also be called into use as the platform needed to support major *prototype* projects e.g. WestWave which would lie outside the boundaries of the pre-commercial financing initiative proposed at 11.2.1. TRL boundaries to the tried and

[90] *Renews* editorial, 3 December 2015

[91] A view endorsed by the key stakeholders attending a private Ireland/Scotland *High Level Ocean Energy Co-operation Workshop* organised by MRIA and Scottish Renewables in September 2015.

[92] See *Minister White welcomes Apple's commitment to ocean energy in Ireland* media release on 11 November 2015, Department of Communications, Energy and Natural Resources.

trusted PDF system should not be set at this stage particularly as it will take time to establish the new initiatives suggested later on in this Paper.

The PDF does not, however, easily meet the needs of promoters in the middle ground i.e. from the upper end of TRL 3 to cTRL6 where, for example, the requirement for a promoter to fund (e.g. to provide 'matching' or 'part-matching' funding to State support) a substantial proportion of a project's cost is beyond the means of most start-up and early R&D focused companies…….and this funding gap gets even tougher to bridge as the TRL ladder is ascended. The new Apple fund will ease this issue in the short-term but it amounts only to €1m at this stage. There is clearly a need for a next, pre-commercial stage to the financial roadmap for this nascent industry to follow i.e. a route which if successfully navigated will open up appropriate funding at various stages to qualified projects. Moreover, once 'pre-commercial' funding is dealt with, the roadway on to a final financial destination must be laid i.e. how to fund the early commercial arrays using TRL 8 + technology.

In the view of at least some experts, TRL 7 tends to be bypassed i.e. it is not relevant. Thus, there is consistency in the suggestion here that the *PDF deals with TRL 1-3/early 4, the pre-commercial initiative proposed at 11.2.1 deals with the space up to TRLc6, the early commercial financing proposal (dealt with at 11.2.4) deals with early arrays at TRL8+….and that the PDF mechanism be held in readiness to deal with e.g. a TRL 8 prototype which should be expected to be partly private-financed but which may be premature and, indeed, too small to be dealt with under the financing model suggested at 11.2.4*

The views of a wide range of stakeholders (met in the course of preparing this Paper in Ireland and elsewhere) as to what needs to be done to fund ocean energy's immediate next steps are practical and attainable within existing State budget outlines and plans.

The current position is captured in Figure 19 below:

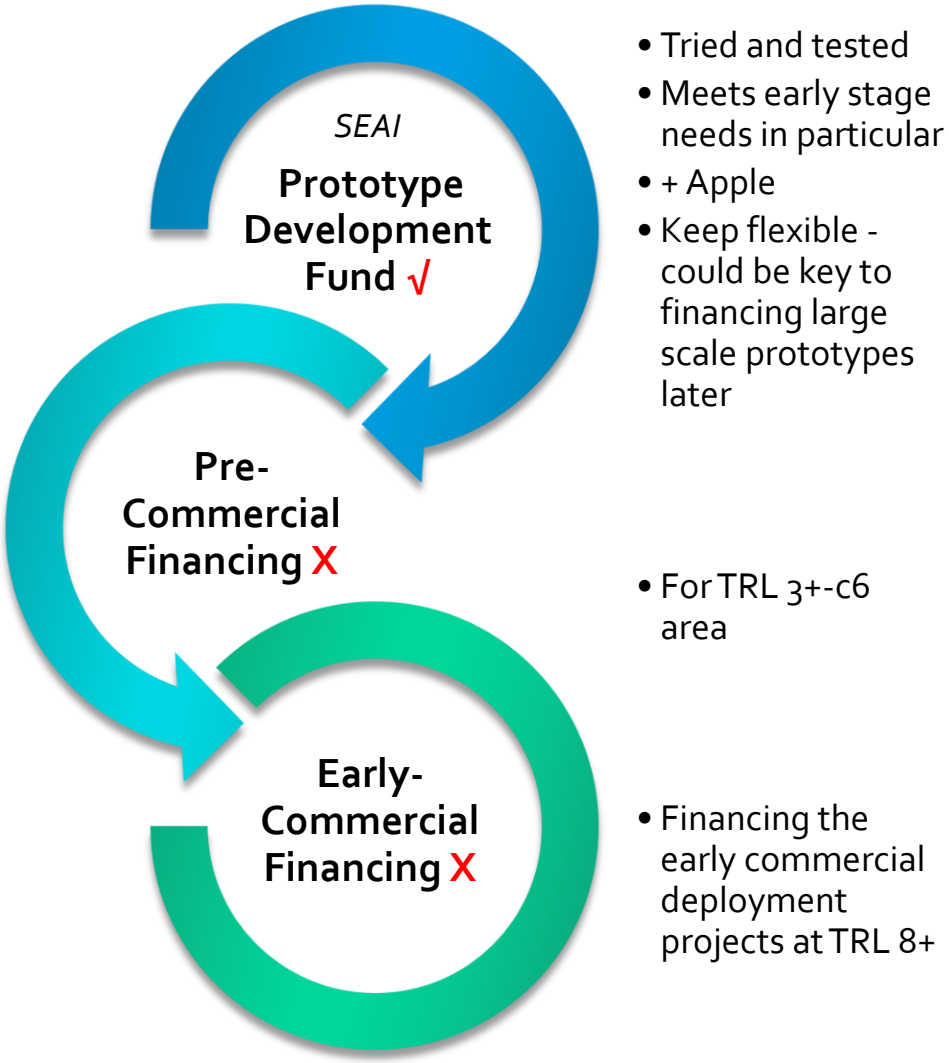


Figure 19: Hierarchy of ocean energy funding needs

Wave Energy Scotland is one exemplar to address the pre-commercial funding gap within the hierarchy of needs illustrated above, although it deals with wave only. WES is currently focused on developing solutions to particular issues i.e. power take offs via a competitive process which provides 100% funding on condition that inter alia various requirements for IPR exploitation are met. WES partly overlaps with the SEAI Prototype Development Fund as well as with the new Fund recommended below.

> *'WES will take innovative technologies from concept to being ready for private sector investment…..WES will award contracts for wave energy until the technical and commercial risks are low enough for the private sector to re-enter. It is anticipated that this will take up to 10 years using*

a technology development process that focuses on proving technology and engineering quality'[93]

However, the Wave Energy Scotland model is not a 'silver bullet'. It is, in the view of some promoters, a programme suited to established concerns who want to pursue an emerging new opportunity. It is more challenging, in their view, for young companies who must provide finance for projects themselves initially and then be reimbursed later: such working capital can often be difficult for small companies to arrange.

Other renewable energy sources enjoyed enormous Government aid globally e.g. in the UK and the US at a similar stage of development. For example, nuclear energy was the preserve of military funded R&D projects and activities long before it became a commercial energy source while solar enjoyed bountiful support from the various space exploration programmes which commenced in the 1950's; solar energy as a commercial energy source is largely a feature of the past few years i.e. over 50 years later!

Some sets of figure illustrate the general point. In the period 1990-2002 when the Non Fossil Fuel Obligation (NFFO) was in place in the UK, the Fossil Fuel Levy provided £800m support to renewables and £7.8bn to nuclear[94]. An IMF survey, 'How Large Are Global Energy Subsidies?, shows that the UK's fossil fuel sector will have received subsidies of more than £26 billion in 2015 - more than £400 per person living in the UK. The IMF states that this is 1.4% of UK GDP. For comparison, UK spending on defence is c2% of GDP. The cost of supporting all renewable energy technologies in the UK during 2014/15 will be £3.5 billion according to figures from the Department of Energy and Climate Change[95]. These figures for the UK reflect the situation across the globe.

Finally, the Association is somewhat agnostic about the issue of whether financial support should be focused on sub-systems and components and/or on the development of devices with perhaps a slight tilt in favour of the latter! Insofar as a consensus can be identified, it appears to want priority to be given to the former on the general grounds that it's a waste of time building devices if the components are not proven while, of course, others point out the need to provide funding models for devices and that this must be tackled on the grounds that 'aeroplanes would never have been taken off

[93] *Wave Energy Scotland* Highlands and Islands Enterprise 2015

[94] U*K Energy Policy 1980-2010 – A history and lessons to be learnt* The Institution of Engineering and Technology and the Parliamentary Group for Energy Studies 2012

[95] RenewableUK media release – 4th August 2015

if the Wright brother's first aircraft had been grounded in 1903 while awaiting the first jet engine which was developed in 1941!'[96]

11.2 Recommendations

11.2.1 Establish an SEAI *Pre-Commercial Technology Fund* to meet the 'funding gap' which is at the heart of this Paper and complement the *Prototype Development Fund*

It is recommended that a *Pre-Commercial Technology Fund* (PCTF) be designed and launched. The case in favour of this State initiative is that it would leverage Ireland's investment in ocean energy R&D, test facilities, policy developments etc. It would also represent a major step towards securing a global supply chain position for Ireland and, indeed, give IDA and Enterprise Ireland extra tools with which to 'sell' the country as an ocean energy hub[97]. It is feasible to support an initial PCTF from within the extra funding envisaged for ocean energy in the OREDP. For industry, the new Fund should help to bridge the 'valley of death' encountered by many promoters and to provide the immediately needed next steps along the financial roadmap. But there will be a 'tough love' element involved too, notably in the rigorous engineering reviews envisaged.

The PCTF should have the following features:

- Design to address funding needs from about late-TRL 3 up to early Prototyping (say, TRL 6)
- Provides 100% funding broadly utilizing the SBIR model[98]
- Open to all relevant promoters in Ireland and overseas but work must be undertaken in Ireland primarily. Promoted internationally by IDA Ireland and Enterprise Ireland with support from SEAI
- A competitive process focused on specific topics (ideally complementary) to the Wave Energy Scotland agenda but Ireland should also allow for tidal energy
- Extra points for collaborative (between companies etc) applications

[96] View of an interviewee for this paper

[97] An interesting trend lies in the interest shown by start-ups elsewhere (notably the US) in establishing an Irish location e.g. www.orpc.co

[98] Small Business Innovation Research. This has already been applied by SEAI to an Electric Vehicle Smart Charging scheme. It involves what is essentially Pre Commercial Procurement (PCP). PCP, as defined by the European Union, involves the purchase of research by a Government entity which is undertaken with the objective of stimulating innovation that the contracting authority or some other party may benefit from at a later stage when goods or services not currently available are developed from the outcomes of the research - see more at: http://www.seai.ie/SBIR

- All applications subject to strict engineering reviews by a panel of internationally regarded experts at the commencement and completion of projects…. with pre-determined metrics of success
- Designed to generate solutions - projects cannot proceed to any further rounds of funding without success at this stage
- Intellectual Property Rights must be commercially exploited in a pre-defined fashion by a specified date
- But….deal in an innovative way with the IPR issue where the central point is to share learning in an 'open book' fashion and to ensure that IPR created under the PCTF is commercially exploited
- Focus should probably be directed in the early years to sub-systems, components, technical roadblocks rather than devices but the latter should be given attention too.
- Perhaps two calls annually worth c€2.5m in total each…it may be necessary to start with smaller calls to gauge demand
- The final call should involve a Prize for developers of small output working devices in both the tidal and wave fields. Ideally, this might be linked in to a wider project e.g. it could serve as a power source for activities in SmartBay in Galway.
- Comply with EU State Aids requirements
- See also 11.2.2 about recommended State agency partners

The PCTF would be operated by SEAI (who will need some extra staff resources to run the scheme) - the agency also operates the PDF and is well geared and experienced in operating complex funding schemes as well as being knowledgeable about ocean energy.

Figure 20 below summarises the position that would ensue after the inauguration of a pre-commercial funding arrangement.

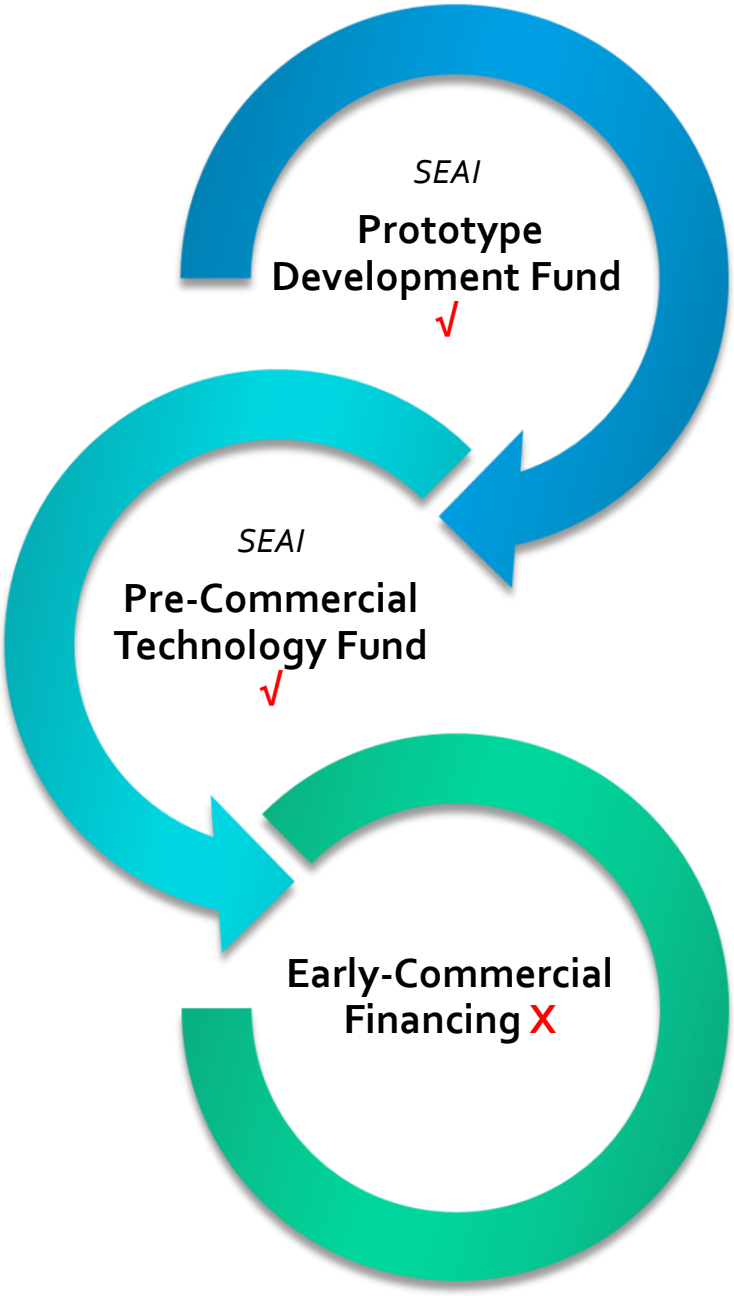


Figure 20: The most pressing funding need addressed by PCTF

The Pre-Commercial Technology Fund would represent a major step forward in both resources for ocean energy and in 'TRL coverage'. It would be a natural partner to the Prototype Development Fund. It would go a long way to bridging the immediate 'funding gap'. The two funds, PDF (at about €5m pa) and PCTF (again at c€5m pa) plus whatever ongoing investment

may be required in the research and testing infrastructure, will readily account for the €30m envisaged over 3 years for device and sub- system development by the OREDP. *It will be important for policy-makers to view the PDF, PCTF and infrastructure etc as flexible and complementary and not to become a 'prisoner' of a pre-determined split of the €30m pot.* Note also that WES has a budget of Stg£10m in 2015-2016 and is slated to have Stg£13.5m annually thereafter.

11.2.2 INVOLVE ENTERPRISE IRELAND, IDA AND NTMA'S STRATEGIC INVESTMENT FUND AS PARTNERS IN THE PCTF. THE PARTNERS SHOULD BE ENGAGED IN THE DESIGN OF THE FUND AND IN ITS DECISION-TAKING BODY.

Availability of appropriate funding will not in itself bring the ocean energy industry to maturity. Nor can the task be accomplished by SEAI alone. As companies move up the TRL ladder, they will need commercial development advice and support and this means that Enterprise Ireland and IDA must play a part in designing and operating the new Fund. Equally, the NTMA's Strategic Investment Fund (SIF) should have a part to play in the early commercial financing (see 11.2.4 below). All three agencies would gain useful early exposure and experience through involvement with the PCTF and could be major contributors to it although it is unlikely that they will do so in a financial capacity. They should all be represented on the PCTF design and project decision bodies.

11.2.3 ESTABLISH METRICS OF SUCCESS FOR PCTF AND PROVIDE FOR A FURTHER ROUND OF FUNDING IN C2020.

The proposed PCTF will not solve the problems of ocean energy in, say, three years with a total budget allocation of, say, €15m (out of the proposed extra €30m referred to in the OREDP)! Nonetheless, a key task will be to set realistic but robust metrics which will enable policy makers to make an informed judgement about the PCTF model and which will serve, if the experience of the initial PCTF is successful, to justify a further round of funding for the post-OREDP era in the early 2020s.

11.2.4 DEVELOP A SOLUTION FOR FINANCING NEEDS AT THE EARLY COMMERCIAL STAGE OF OCEAN ENERGY.

The funding roadmap for ocean energy must be rounded out……promoters of devices and deployments at sea of early arrays must be able to see a route to substantial funding when devices and sub systems reach the later development stages i.e. TRLs 8-9. There must be a final financial destination.

There should be a role here for the Strategic Investment Fund (SIF) which is run by the National Treasury Management Agency and has €8bn at its

disposal[99]. It has a unique mandate: it must generate commercial returns for its shareholder, the State, but it must also make a social impact – the latter is a particular challenge for a financial institution with commercially oriented staff! The SIF has invested in a number of commercial wind projects and, indeed, has invested €50m in the €300m biotech investment fund, Malin, which was listed recently on the Irish Stock Exchange. However, direct investments by the SIF in ocean energy projects is unlikely at this point in the technology development cycle due to the developmental nature, small scale and high risk of projects.

One role model to draw on in the future might be the Scottish Investment Bank's *Renewable Energy Investment Fund* which provided a bedrock investment of £103m to the 398MW Maygen tidal stream project in Scotland recently. The tough nature of funding a major project in an emerging industry is illustrated by the fact that there are 4 separate State strands (i.e. funding sources) to the overall Maygen funding package.

As work underway at European level at present points out, a further point to bear in mind is that:

> '*Ocean energies, like most renewables are CAPEX-intensive, the cost of the device infrastructure and installation represent a very high share of the kW cost. This contrasts with gas-fired stations, for example, where the plant itself represents just 25% of the electricity cost, the remainder coming mostly from gas purchases. Whilst different for each ocean energy technology, total CAPEX (including costs of capital) is estimated at 60-80% of the final cost of energy. This means that developers need access to high levels of funding upfront before electricity- and therefore revenue – is generated. Support schemes for the first arrays must, therefore, include a high proportion of upfront finance whether debt, grant or equity-based'*[100]

The immediate task is to commence a review of the funding needs of early commercial projects and identify options to meet those needs. This work might be carried out under the aegis of the Offshore Renewable Energy Steering Group. No boundaries should be set at this stage i.e. all options should be considered. For instance, is there a role for the WestWave project here? e.g. could it be involved in an initial funding pot of cash and assets (roughly along the lines of the Malin project referred to earlier) or, perhaps,

[99] See http://www.ntma.ie/business-areas/ireland-strategic-investment-fund/ for more details

[100] *Ocean Energy Forum Draft Ocean Energy Strategic Roadmap Building Ocean Energy for Europe* Autumn 2015, p28 http://oceanenergy-europe.eu/images/Documents/Ocean_Energy_Forum_Roadmap.pdf

could it be a cornerstone of a new State company for ocean energy, a new State sponsored body, to develop early offshore ocean energy arrays? Regardless of the ultimate answer to these questions, the SIF seem to be an appropriate lead institution for early commercial finance and their staff would gain valuable early experience through involvement in the design and operation of the PCTF (see 11.2.1) and could make a valuable contribution to developing a commercial dimension to ocean energy generally.

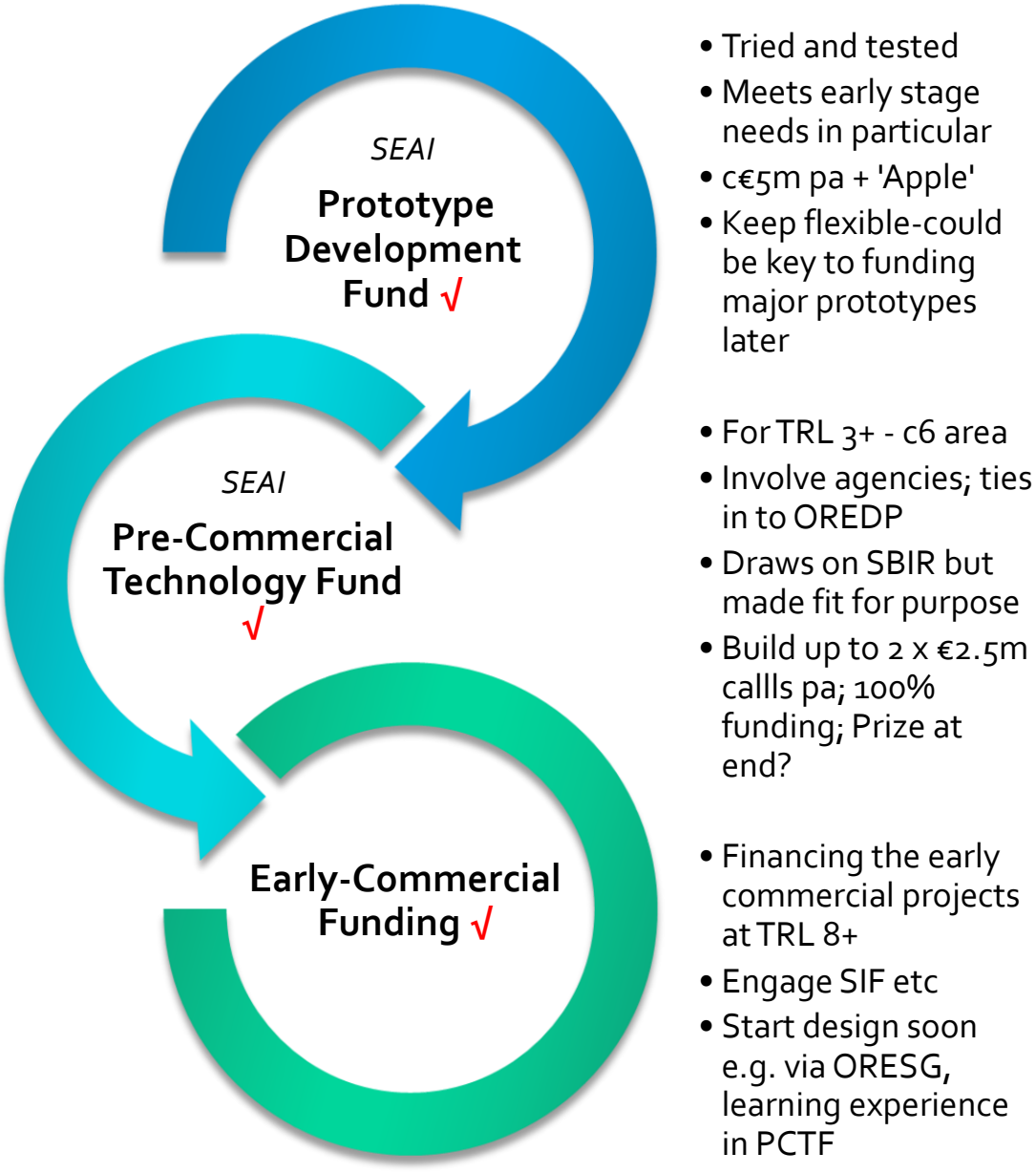


Figure 21: the ocean energy financial roadmap

11.2.5 THE OFFSHORE RENEWABLE ENERGY STEERING GROUP[101] SHOULD INITIATE A DEBATE ON A *NATIONAL OCEAN ENERGY AMBITION (NOEA)* FOR THE PERIOD 2020-2030 TO GUIDE AND TO SUPPORT IRELAND'S DRIVE TO BECOME A MAJOR GLOBAL SUPPLIER TO THE OCEAN ENERGY INDUSTRY.

This recommendation may appear at first sight to be a candidate for the empty rhetoric division of public policy! Nonetheless, National Ambitions can be vital ingredients in shaping policy and priorities and in marshalling resources for particular purposes. President Kennedy's eloquent call[102] for 'a man on the moon by 1970' played a huge part in promoting the US space programme and the ultimate achievement of his goal. More prosaically, the ambitions set by Ireland, and particularly by the development agencies, to become a global force in select, job rich areas of finance, software and social media were all deemed overstretching at their outset…but the early commitment to sectoral ambitions played an important, if somewhat unrecognised, role in mobilising resources and in the later success of those initiatives. The NOEA could be a key contributor to the official goal of doubling the contribution of all marine efforts to the economy to 2.4% of GDP by 2030[103] set by the landmark *Harvesting Our Ocean Wealth* policy and would be a key ingredient to a follow-on policy to the OREDP when the latter expires around 2020.

Alongside the NOEA, institutional arrangements must be put in place to promote Ireland as an ocean energy location to firms involved in the sector throughout the world. This is an issue under consideration by the ORESG.

11.2.6 DEVELOP AN INFORMAL FRAMEWORK FOR CO-OPERATION AND COLLABORATION WITH SCOTLAND TO ADVANCE OCEAN ENERGY WITHOUT UNNECESSARY DUPLICATION[104].

Ireland and Scotland have joint political arrangements (n.b. *The British Irish Council* which has a Marine Energy Committee); control much of Europe's most productive wave resources and have a share of the exploitable tidal resource[105]; provide between them perhaps the bulk of the important R&D and test facilities (e.g. EMEC, LIR national ocean energy test facility, SmartBay) in Europe; and have generated or house many of the world's leading early ocean energy companies.

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[101] An inter-departmental and agency group (with some industry involvement) charged with implementation of the OREDP

[102] See www.history.nasa.gov/moondec.html

[103] *Harvesting Our Ocean Wealth – an integrated marine plan for Ireland* Government of Ireland July 2012

[104] This is an ongoing feature of MRIA policy – see *The Opportunity for Co-Operation and Collaboration between Ireland and Scotland in Ocean Energy – Discussion Paper* MRIA 2013 available at www.mria.ie

[105] www.orecca.eu illustrates just how resource rich Ireland is.

The experience to date suggests that a series of informal agreements between the two Administrations, companies and researchers on both sides would be the quickest way forward. For example, in the event of an Irish pre-commercial fund (see11.2.1), it would make sense to 'split', even informally, the agenda of topics to be researched in the wave field between the two countries i.e. between the Irish fund and Wave Energy Scotland, thus avoiding duplication while stepping up the pace of development of the sector globally. This is the approach endorsed by the recent workshop between all of the key 'players' in ocean energy in Ireland and Scotland[106]. Clearly, neither country can specialise in every link on the supply chain. This implies that policy choices must be made in both jurisdictions on the basis of perceived national competitive advantage and, in turn, this could lead to overlap and competition in certain fields between the two countries. Nonetheless, an informal framework and collaborative working relationship could, at a minimum, avoid much overlap and duplication.

11.2.7 MAKE EVERY EFFORT TO DRIVE EUROPEAN SUPPORT FOR THE SECTOR PARTICULARLY IN FINANCE AND IN RELATED AREAS SUCH AS WARRANTIES, PERFORMANCE GUARANTEES AND INSURANCE.

Europe has played an important support role in ocean energy by supporting R&D, pilot projects etc. However, the EU Commission has not been central to the effort so far to drive ocean energy projects to commercial scale e.g. by reducing costs to developers.

There are signs, however, that the Commission wants to step up the effort. *Ocean Energy Europe*, the trade association, prompted the establishment of the Ocean Energy Forum which is drawing up a roadmap in the areas of environment and consenting, finance and technology via a number of expert working groups. This work is scheduled to be finished in 2016 and, hopefully, it will in time be endorsed by the European Commission (who support the initiative) and by national governments. A number of Ministers and officials received a briefing on the progress of the roadmap at their meeting during the Ocean Energy Europe conference in Dublin in October 2015.

Another positive progress indicator lies in an announcement made by the European Investment Bank in autumn 2015 that it will provide loans of up to €75m to pre-commercial renewable energy projects for up to 15 years under its InnoFin Energy Demonstration Projects initiative although this has

[106] See footnote 39

drawn adverse comment in the (fifth!) draft of the Ocean Energy Forum's Roadmap[107] which states (p28) that:

> *'The new InnoFin scheme, with an initial envelope of €100m for all renewables…….budgets are clearly misaligned with the financial needs of the demonstration and pre-commercial phase: ocean energy projects in those phases are likely to cost each in the range of €40-100m'*

The Irish Government should actively promote the forthcoming Ocean Energy Forum Roadmap[108] particularly in areas which are roadblocks to early ocean energy development such as capital finance, insurance against business interruption and provision of guarantees[109] and warranties…..each of which should be solved on pan-European basis. It is believed that these specific issues are already under discussion by the Ocean Energy Forum.

11.2.8 Develop an innovation learning and support scheme during 2016

Help will be needed, over and above that normally available from Enterprise Ireland and IDA, in the business development of ocean energy companies with an emphasis on R&D and innovation management. The Industrial Research & Development Group[110] approach is one way forward and the design of an appropriate path in this area for ocean energy should be investigated during 2016. The tentative proposal put forward at the MRIA Council in December 2015 for an Ocean Power Innovation Network is a significant step in the right direction and is under active consideration.

[107] *Ocean Energy Forum Draft Ocean Energy Strategic Roadmap Building Ocean Energy for Europe* op cit p23

[108] The Department of Communications, Energy and Natural Resources is involved with the Roadmap preparation

[109] The EU is moving in this direction with 'first loss protection', for example, featured as an integral part of the new *European Fund for Strategic Investment*. See europa.eu/rapid/press-release_MEMO-15-3223_en.htm

[110] See www.irdg.ie

Appendix 1: List of Bodies Interviewed

FINANCE:

BVP (venture capital)
AIB
National Treasury Management Agency (NTMA)
New Era
Greencoat (venture capital)
Davy
Goodbody
BDO Ireland
Irish Stock Exchange
Enterprise Ireland

INDUSTRY:

Electroroute
ESBI
Jospa
Blue Power Energy/IWEDA
Open Hydro
Aquamarine Power
NOW Ireland
DP Energy
Open Ocean Energy
Ocean Energy
SmartBay
Verdant
Black and Veatch
Arthur Cox
Prof Tony Lewis
SEAI
Schottel Hydro GmbH

OVERSEAS STATE AGENCIES:

Scottish Renewables
Scottish Enterprise
Scottish Government
Marine Energy Catapult UK

Appendix 2: A Selection of Opinions of Stakeholders

VIEWS ON RENEWABLES IN GENERAL

'There is no energy market in Europe and this will get worse as we move to the 50% renewables target: half the sources of supply are subsidised and the other half are facing distorted market prices as a consequence'

'…we are at an inflexion point in energy: not sure how a system with significant renewables is going to work in the long term'

'Solar PV is a challenge to everything else in renewables. The world could look like a combined technology platform. Storage in conjunction with a night technology is a key. There is, for example, a 6 hour gap with tidal devices which is 'better' than the diurnal. Tidal is very predictable and has a short span. The other thing is that the solar capacity factor is nothing compared to wind. Hydro storage could also play a part. We need to look at a balanced portfolio of sources: solar, wind, wave, tide'

'Solar: can't rely in renewables on just one solution- back up is needed as there are large swings in solar due to cloud cover and this impacts on the stability of the overall system. While solar is cheap, can't see it being added to the grid to the exclusion of other renewables e.g. wave energy which is more predictable and consistent than wind energy'

OPINIONS OF OCEAN ENERGY

'The key issue is how is the industry to be funded for the next five years because there won't be an industry unless a solution is found'

'Don't underestimate the cost and timelines involved in ocean energy – OpenHydro in operation for ten years in May 2015'

'Key criteria: is there a real market for wave? There is none at current LCOE…even if the technology works, is the world ready for wave energy? There will be a wave sector…but will it be in 10 or 20 or 30 years' time?'

'…we need a big project for wave, this is where Government leadership comes in…strategic is the key word'

'This needs real leadership, Ireland needs to get off the fence like France has done with OpenHydro who are taking the risk in tidal and consequently we know where the future tidal jobs are going to be - France!'

'We are turning the ship around; the Scottish Government is very optimistic. ….. Aim in tidal is to get a demonstration array and in wave it is to bottom out the (technology) issues. Horizon 2020 (H2020)/TINA are all applicable. There have to

be better opportunities to access better funding, develop common technologies across countries'.

'We are starting to see interest (by investors) in Scotland and in diversification into wave and tidal- people recognise them as a long-term play. Experience of Marine Energy Advisory Board is that companies are interested in becoming involved or re-involved in ocean energy when progress is made with the technology'

'…..The arguments for wave and tidal are the potential economic benefit e.g. jobs, community support…'

'Marine renewables in Ireland are unique because of the resource….PV is not unique. Ocean energy should be about projects, about economic activity and not just about investing in full scale project ….get activity going'

'*Tidal is beginning to be credible…it's not that hard…the important thing is to do it the right price including installation and servicing. It starts with the technology- get it right'*

'Problem with wave is the bad fundamentals. Pelamis- how could it work on a tons/kw basis although it had lots of good stuff e.g. the power take-off. I have a lot of time for lots of the floating solutions e.g. Scotrenewables and Seagen both have a 'lot of legs'; pitching solutions are interesting because it means that you can do a lot of active things e.g. in the event of wave surge. But I struggle with the tiny e.g. 50kw machines'

'The big issues in ocean energy are the uncompetitive scale to output ratio at present (e.g. Pelamis at 750KW); the large number of moving parts in devices and their lack of resilience in the harsh marine environment. The devices that locate the generating side of things ashore are interesting'

'Funding is the greatest road block to developing this industry- there is no tariff; foreshore law not yet sorted out; grid is hard to access etc'

'With our facilities and resource in Ireland, we have the opportunity to dominate this energy technology and become a big energy exporter'

'There is a growing interest in Scotland in solar energy. Wave is still at the research and innovation stage and must be thought of in this way for funding purposes. Tidal will have three arrays by 2020 and the focus must be on cost reduction and funding there should be on the basis of tidal as another, emerging, source of electricity. Wave and tidal are not REFIT qualified in the UK but they do fall within CfD – 100MW is ring fenced but there are issues to do with how to

shift between years (within a 15 years contract), provision of higher rate of support for wave etc see notes'

'Without a bold move, ocean energy will wither on the vine'

'Irish policy environment is not attractive (consenting issues?) but it has the graduates, the grey matter and you can find 'metal-bashers' anywhere'

FUNDING NEEDED TO BRING OCEAN ENERGY TO MATURITY?

'Important thing to remember is that a typical US software start up requires about €90m investment to achieve commercial viability…there is a parallel there with ocean energy'

'The UK as a whole has committed £400m to ocean energy and just under half of this has been drawn down and there is ongoing political commitment to ocean energy although there has been a crisis (of confidence) among private investors in renewables, not just marine renewables although it has been hit hardest'

'About an extra £100m is needed to bring tidal energy to maturity and about an extra £200m to do the same with wave energy'

'Need another €100m to get wave technology to maturity'

'Estimate that 20-30MW arrays will come in late 2020s/2030'

'2-3 companies globally at TRL 8 in wave WECs. We won't support anything under TRL8 e.g. for Horizon 2020. We reckon that it takes something in the region of €70-100m to get individual WEC designs to TRL 8 and this is borne out by the experiences of Aquamarine, Pelamis'

INVESTMENT CLIMATE

'There is no shortage of capital but a shortage of opportunity in recent years. Investors invested in lower return categories in 2008-14 as projects in mature/ traditional areas (e.g. infrastructure) didn't come to market and some capital went into earlier-stage developments. In the last 12-18 months, there is evidence of capital investing outside of traditional areas. Evidence of increased competition for projects e.g. reportedly 40+ competitors for recent Schools PPP'

'Funds with renewable aims can't always get in to onshore opportunities and thus are looking at early-stage offshore projects'

'Little bit of a move away from private equity with their 5-7 year exit horizon and 'disruptive' approach. Investors tending to prefer transparent public companies to opaque private equity which in any event is looking for established companies who want to scale up'

'Investors are exiting utilities because the market has been disrupted with e.g. subsidies setting a floor price for renewables……market disruption will continue for several years'

'It's very hard to raise capital for Irish SMEs. The 'bite sizes' are too small and there is concern about governance issues'

'*(Based on experience of Wavebob) Not just the technology, not the lack of funding, not just the people….funding supply in Ireland is too short-term…..finance houses in Ireland don't have deep pockets'*

'Apart from Novus Modus ('Greencoat'), there is no other clean tech fund but we would consider investment if one were established…but cleantech venture capital funds internationally have been washed out, they struggle'

'Need long-term capital across the board in Ireland…don't have solution to long term capital …perhaps NTMA can do something?'

'Interestingly, Silicon Valley investors turned tap off for a long time for 'cleantech' but that has changed in the past 12-18 months'

'Deeper pockets are needed (for ocean energy) than those available to date in Ireland…but the prize is great'

CURRENT PRIVATE INVESTMENT PROSPECTS OF OCEAN ENERGY

'Ocean energy is an un-investable sector at present while there are many other less risky investments in renewable energy'

'Ocean energy companies have no source of revenue except for grants; no capacity for debt because they can't show any ability to pay back loans; have no deposits- no interest income; promoters are usually not high net worth individuals. Only early interaction between typical ocean energy promoters and banks relates to car loans, basic bank accounts for the business and personal credit cards. Banks seek to stay close to start-up companies in all sectors to spot and back emerging winners'

'Have never seen Irish investors invest in an IPR 'play' e.g. invest at, say, TRL 4 with a view to selling out at TRL8'

'We are so far away from the commercial stage with ocean energy at present that we can't creditably go near the banks'

'Timescales in this sector are too long…investors have a 5-7 year time horizon. In 1980, the three-blade approach to wind turbines had not been settled on…look how long it has taken since then for wind to approach grid parity. Ocean energy is further behind than wind was in 1980'

'Ocean energy device developers feel that no commercial investment is possible for their firms at present- they are a million miles away from standard utility EPC gas turbine-type supply contracts!'

'Can think of very few examples since DCNS went into Open Hydro where a pure private capital investment was made in an ocean energy project'

'Limited support so far due to state of the technology. OEMs such as Ahlstrom, DCNS have become involved. ESBI through Novus Modus has engaged with ocean energy, Fortnum, the biggest utilities fund in Finland, has backed three technology efforts including Seabase and the Danfoss brothers invested personally in the Danish Wavestar device while Dresser Rand are providing the turbine for Ocean Energy Limited …..and that is more or less it'

'…unless technology is proven, can't get there (technology maturity) by adding to natural return on projects via REFIT e.g. wave projects will move from a 'naturally required' return of c15% to 20% with REFIT. Bear in mind that the market place is seeking 20-30% pa return i.e. two or three times money for low level risk technology'

'Our view is that the industry suffers from 'TRL'itis' and should really focus on getting to TRL 4 and debug the device thoroughly……a debugged TRL 4 device has commercial value…ships are sold on the basis of tank tests'

'Ocean energy needs to 'force the market'. Getting companies to raise 30/40% of capital needed is a good test in the market. People need to be focused on commercialisation and you have to be concerned about keeping projects on life support too long'

'Only way to support ocean energy is on an 'uneconomic basis'. Not time yet or perhaps for 5 years to pick a winner'

'*The whole ocean energy industry is oversold and has thus underperformed. There is not proper recognition that wave and tidal are new, developing technologies'*

'We spoke to potential customers three years ago and asked them to take stakes in our company as it is always useful if the utilities are involved for both technical feedback and financial reasons…there response was 'come back to us when you have a full scale device working with good power generation numbers'

'*We have turned wave promoters away as they were at too early a stage and they need 10year money (perhaps €8-10m in total) and we can only offer 3-5 year money'*

UNREALISTIC EXPECTATIONS FOR OCEAN ENERGY

'The failure of Pelamis has shaken confidence…although there are still 'players' in the industry. Pelamis came a long way but the expectations were too high and it was pushed too fast and everything e.g. public sector funding was pushed their way'

'The problem is that the industry/emerging technology has been pushed too hard and overpromised all over the place'

'The Pelamis experience pushed the funding models – public and private – too far, too quickly. A heavy dose of realism was needed but we are now in a better place (in Scotland), doing things right, good things are underway'

'Up to 300 wave developers out there – lots of ideas on paper, most are entrepreneur or engineer-driven, focused on just one element. Funding calls: projects are chasing calls; under pressure to go 'in the water' at far too early a stage; they are under resourced and under pressure from shareholders seeking a return.'

'Last major private sector investment in ocean energy was in 2007, largely in OPT. Wind energy took 40 years to develop while we expect wave and tidal to make a more difficult journey in 20 years!'

'…the collapse of Pelamis and the challenges faced by Aquamarine were not their fault, it was the fault of the funding regime which was not performance oriented'

'This is not a sector for private equity and probably not for individual promoters at present'

PRESSURE OF SITE DEVELOPMENT REQUIREMENT

'Big challenge to go from a prototype to a commercial product- OpenHydro had to develop sites at €3-4m a pop'

'A further important point ultimately is that device developers who want to attract investors must have working projects along the lines originally planned by Pelamis and Aquamarine. But…it is very hard see SMEs such as Pelamis doing everything including site development'

'Lots of people got into ocean energy with a view selling out once TRL 4 achieved- didn't work and, indeed, Pelamis, Aquamarine Power and OpenHydro all had to become site developers as well in order to advance'

'We (company name supplied to MRIA) *are an OEM and do not wish to become a project developer but for our first projects we have effectively been forced into this'*

Warranties and Performance Guarantees

'Big issues for small device developers are power curve availability; parent company guarantees; and warranties. Government should provide guarantees. The other issue is weather-risk. All of these things bear on IRR'

'Finding a solution to the warranties issue is critical because neither investors nor site developers want risk'

'Public funding is needed for high risk emerging technologies like ocean energy. Ocean energy needs new types of project consortia (not just utilities or utilities at all) and then the industry can tackle issues like warranties etc –the sector needs a certification process re performance and underwriters for warranties'

'It's a pity that private money went into wave at such an early stage; it was too early. Wave is not that hard – need to get the cost of the devices and the cost of installation down. But remember that the ultimate customers will look for credible warranties'

A Role for Public Capital Markets?

'Room for public markets to cater for more high risk projects with revenues in the €10-30m range'

'There is no significant capital available in Ireland for companies listed on the Irish Stock Exchange …they use the ISE to list'

'An Irish company – a biotech fund, Malin – listed simultaneously on the ISE and the NASDAQ recently. This IPO was pre-revenue etc. Irish Strategic Investment Fund was a cornerstone investor with an investment of €50m'

'Is there a possibility at some time of a publicly floated venture fund for ocean energy a la Malin recently floated to invest in the Biotech industry with eight pre identified investment projects'

An Irish Equivalent to *Wave Energy Scotland?*

'SEAI's 70% funding is not enough. Device developers need an Enterprise Ireland approach i.e. investment in the form of preference shares or a WES SBIR approach

'We need to look at the Wave Energy Scotland model; too much money put into elaborate R and D facilities. Under WES, the call is open around the EU; solutions must be tested in Scotland; and solutions must be available for licensing. Gets around EU rules concerning 100% grant aid'

'WES is not about a company development focus, it is about furthering the industry. We are looking for game-changing technologies. We need convergence on components. People are spending money on the same issues over and over and companies are secretive about the outcome – there isn't even standardisation over cable sizes!'

'Need strong technical assessment at the centre of the allocation of resources'

'WES is getting the focus back on fundamentals because we know from the Pelamis and the AMP experiences that there is a need to drive down costs, actually get the devices to produce electricity etc. But there is a place for 'getting wet', so we need test tanks etc'

'WES – the positives: for the first time we have a structure to develop a technology. The negatives - the timescale is out to 2020; everyone is given an equal opportunity-you have to enter WES at stage 1 as they want companies to build a track record and that is a problem although a company may be able to enter the WES system at a later stage if you can 'prove' that you would have passed the previous stages; WES is another quango and that weighs a company down'

'The WES funding model is very positive as it provides 100% funding but there isn't enough money to go around. It is better for an early stage project than for more mature enterprises (well up the TRL scale)'

'WES is fundamentally good because it is competitive; has 'learnings' from industry and effectively leaves the IP with pre-industry as long as it is exploited'

'Public procurement commercial approach a la WES is the way to go'

'Wave Energy Scotland (WES) has generated hundreds of applications. Their schemes involve 100% funding. The basic challenges facing ocean energy cannot be met without Government support. The contracts with promoters allow them to hold the Intellectual Property created but they must commercialise within a fixed period or otherwise it passes to WES'

ROLE OF INDUSTRIAL PARTNERS

'Having an industrial partner with a strong balance sheet a la DCNS is key…cost of putting devices in the water is challenging and ocean energy device developers need a strong balance sheet to fall back on when problems arise as they inevitably do….need trials in the water for credibility'

'Encourage ocean energy device developers to partner with multinational OEMs'

'Who takes a long term view on the private investment side? Industry players on the global stage. Ocean Energy device developers should go for partnerships/investment with large international engineering companies'

'Journey from an experimental 'widget' to a big lump of iron such as an ocean energy device is a long one and a lot of investors don't want to make the journey…requires really patient capital….corporate VCs are a better bet in this regard'

'Not clear what TRL level is minimum required to spark private finance interest…clearly, projects need a revenue stream, partnership of an OEM or industrial partner (e.g. DCNS with OpenHydro) is an advantage'

'Key is to get OEMs involved with device developers but give them an incentive for taking a large risk e.g. a development site at sea'

TECHNOLOGY CONVERGENCE A PRE-CONDITION FOR INVESTOR INTEREST?

'Critical need is for consensus on what the technology approach should be in ocean energy. Ocean is 20 years away and (finance industry) can't interest individual investors who, say, have €5-10m to invest in this industry when most of them (investors) are in their 50's and 60's! The only possible private investors now are large private OEMs'

'Private investment at scale will start when there is a convergence in technology and costs reduce, when everyone is working on the same technology'

'OEMs won't invest until there is a convergence in the technical approach to Wave; they don't really have an interest in early project development…and there won't be private investment until then e.g. by utilities'

'In wave, many ideas should still be considered and an approach like WES or the US DoE competition with stage gates. The process is difficult as you may miss a good idea. Balance between good ideas and a good development team(s) is difficult to get right as it must change during the staged development….tidal is a much more mature technology and there is convergence here'

'Device developers need a road map from their current start-up position to the point where they can attract private finance'

'…interestingly, our clear technical and commercial roadmaps were important to (name supplied to MRIA) because they showed a viable business without unknowns'

'(SEAI?) Should work with prototype developers to attract investors…but a road map is needed'

'Only Ocean Energy Ltd is near to technical maturity in Irish wave energy devices. We need to get 'small guys' into the water in Galway Bay. We need to have imaginative funding models to do this e.g. the Danish model whereby they aim to use their funds to get two or three devices to quarter scale. Invest €1.5m (including time in the test facilities at MarEI) and/or go for the European SBIR model'

'The collapse of Pelamis caused a big slide in confidence in Scotland and there is a lack of a roadmap for wave'

'Need to have rewards for attaining/following a TRL path. At TRL 6 get an investor in and go global---- original promoters will still have a lot of equity at the end of TRL 6 development. Serious investment need during TRL 5-6 journey and promoters must be open to sharing IPR'

'As a country we should put our ocean energy prospectus together and go out and sell to international capital- there is so much money around the world looking for an opportunity. Don't be precious about 'invented in Ireland', don't give way to academic people'

'*Private sector has depended in Ocean Energy on a public sector due diligence which has been poor'*

CAPACITY TO SCALE

'OpenHydro are well networked, lots of key people are not engineers and have a commercial team who understand investors. Other companies are different and haven't rolled forward to how they will take their project commercial. Private capital want a commercial return as well as an asset class spread'

'(Ocean energy has) lots of early stage competing technologies….look at how the wind turbine manufacturers have consolidated into a small number of low margin companies with the capacity to deliver…investors in Ocean want to see the ability to scale'

'People will back early stage technology provided there is a good management team to back and export potential e.g. in medtech'

'The challenge will be to combine a business plan plus management team with the ability to carry it through. Most investors will assume that the technology (in a specific project) will work……the key is the management team'

FUNDING MODELS

'Strategic Investment Fund amounts to €8bn and has two mandates: invest in commercial opportunities (typically alongside the private sector) – there is no 'benchmarking' of the forms of investment: they can take form of equity, senior debt etc; second, invest in opportunities which will have an economic impact on Ireland- a new role for most staff who come from the private sector. We need to be careful that we don't crowd out the private sector'

'Biggest issue for the industry is the relationship between generating capacity and capital cost….the wave industry has been featured by strong leadership of a small number of device companies which have gotten ahead of the real TRLs…these strong leaders have mopped up most of the money and left everyone else floundering'

'Concern about the State trying to pick winners by directing investment to specific technology solutions. Perhaps (State) should give money to companies only if it leverages co-operation between companies…absolute insanity to put money into different companies with similar approaches and problems…should copy the EU's Horizon 2020 model which requires companies it work with partners to gain grant support'

'*EIS scheme involves wind farms, so why not extend it to wave developments; give bigger tax breaks for support to lower TRL projects e.g. wind is at TRL 10; wave at TRL 4- investors might be interested in a spread'*

'Need to widen the argument i.e. seek overseas companies to locate in Ireland, have companies compete for the money'

'We need to spend at least €10-15m to get a demonstrator to prove technology at large scale e.g. 0.5MW. It will take another €100m to get to 'commercial device' level'

'The matched funding approach is irrelevant- Government must pick winners….look at the approach taken by US State which is putting $1bn + into supporting a revolutionary-battery factory project for Tesla'

'The Government's approach of splitting the cake (the SEAI Prototype Fund) does not solve the problem. Bearing in mind that ocean energy is a technology that will turn into an investable class of infrastructure, then you need to support a top idea with perhaps €100m and it will take 7-10 years; 6- 7000 hours in the water; in 2 or 3 jurisdictions; and in lots of bad weather ….to get an investable device. It is only at that stage that soft loans etc from the private sector will emerge from the private sector to roll out the sector and be able, like offshore wind today, to stand on its own two feet'

'Commercial investors don't easily buy into a 5-7 year's timeframe…but there is massive interest in technology and deals that get done are a long time'

'Focus on early stage device developers in wave. State to retain a 'golden share' in the IP'

'Money is needed for soft support, early stage developers need handholding'

'To make a device developer attractive to private investors, they must have a device working in the water'

A Role for Europe

'*There is no ocean energy profile in the EU's ocean energy plans'*

'Europe thinks that ocean energy is advanced. The H2020 call in September will concern devices in arrays and the EU contribution will amount to €15m. Only one company, Wello of Finland, has won significant EU funding so far'

'Co-funding with Europe is desirable alongside SEAI'

'We need the European Investment Bank to come to the 'game' which the commercial banks are not at e.g. EIB to ring fence €200m to loan to this industry. Moreover, Europe needs to look at the infrastructure needs to support ocean energy on a Europe wide-scale'

'*Europe is the way to go…that is the generic wish in the industry. We should all act together on generic issues such as moorings and collaborate on test centres'*

'We don't need competition between nations at this stage but rather to see an industry emerge

'The key role for Ocean Energy Europe and for the EU Ministerial Forum is to develop a roadmap for the industry'

'Project developers do not want to take technical risk. Technical and operations and maintenance risk is the biggest item the EU could help with. These EU projects need to involve more project developers as opposed to product developers'

Co-Operation with Scotland important

'(Scottish Government) are reviewing the R and D fund. Also we want to do something on tidal, e.g. foundations. There must be scope for collaboration (with Ireland). Looking at next call for co-fund ERANET. Lots of funds look for matched funds. Lots of private enterprise interest in funding tidal'

'Co-operation with Scotland could play a part but inventors (e.g. those who work on early-stage ocean energy devices) don't want to share the spoils and this syndrome is at work all over Europe

'We need to hold joint calls with Scotland to deal with technology issues- Wave Energy Scotland will cover 5 areas in line with the SI Oceans Report …we are in danger of duplication'

'Ireland needs to be competitive with research sites (and associated costs) and REFIT etc – Nova Scotia, Scotland etc all offer great packages….£0.5bn spent in Scotland in past ten years on ocean energy and only a fraction of that was in the form of grants'

'In favour of co-operation'

'Scotland gives us a site to test devices along with Wavehub and Northern Spain

'Scotland can't do this (development of ocean energy) alone…want a UK wide strategy, want DECC to provide financial support….the Maygen project shows how a variety of 'pots' can be tapped to support a project'

'All on for collaboration in Scotland as the Scottish Government feel themselves to be out on a limb regarding ocean energy. There are structural changes underway in innovation in Scotland- look at the SNP Election Manifesto which fails to mention wave and tidal'

'Collaboration with Scotland is a really smart idea- let's share the costs'

'There should be a joint effort to push the ISLES project which has now been published and ought to attract support from InterReg. Do it now, not in 2020! It will take 3-4 years to organise and only then can the 'wires' be tackled so don't start the planning in 2020'

'Like the Wave Energy Scotland approach which deals with the fundamentals. But it should add on (certainly if copied in Ireland) with a 'Chief Engineer's Review' process which all projects should be required to pass. Alternative opportunity cost of failed projects is too high at present. Should Ireland have a joint Review process with Scotland?'

INVESTMENT IN SPECIFIC TECHNOLOGY SOLUTIONS OR SUB-SYSTEMS?

'No reason why sub-systems should succeed rather than full devices'

'Bear in mind that the measurement of output from small devices is very difficult and this makes scaling up very challenging'

'Role of SFI should be reviewed insofar as its approach does not encourage inter-company co-operation- doesn't breed collaboration; does breed networks. SEAI now gives grant 'bonuses' for projects in which companies collaborate'

'Run a competition for companies to use AMETS with provision of cash, cable etc – make it contingent on TRL level already attained'

'The problem with the focus on sub systems or components approach is that you have to have a WEC industry to supply in to…..we must focus on generation grid connected wave farms'

'Ireland has developed a research industry in ocean energy, we must now concentrate on developing a wave (in particular) device industry'

'Blades/coils/magnets are our key components…. We are looking at making them in-house to reduce our supply chain'

'Small companies with limited capital access should focus on components'

'The (State funded) pot is small, don't spread it around…make the tough choices and focus the funds on singular projects including components'

'Intellectual property is the only value a device or component developer has'

'*Wave Energy Scotland is looking at the supply chain and components. This is like asking Frank Whittle to develop the jet engine while telling the Wright brothers in Kittyhawk, North Carolina not to bother taking man's first flight*'

'We need components but we also need devices. Was Pelamis's problem solely one of PTO? If not makes the case for supporting both WEC and sub system development'

'Discussion did take place when WES set up about whether sub systems and components should be supported separately to devices or as an alternative to devices. WES is about reducing duplication – we had three or four different teams all working on the same sub-system's issues, there was no joined up thinking.'

'There are two responses to the components v devices argument. First, there will be an Industry Advisory Board set up and each WES-like project will be stage-gated. Second, we need to do something about device developers but no initiatives so far'

'WES own Pelamis but teams who win WES competitions can lose (to WES) ownership of the IPR if it is not commercialised in a certain way'

'*In the next five years, we want to scale back on wave devices until problems with subsystems solved…….it will be 5-10 years before further substantial support for*

full scale devices needed. In tidal, that element of the industry has 4-5 years to prove their technology…Government support will particularly help support efforts to reduce the 'cost of energy' and to help to get final technology challenges sorted'

'The problem with individual developers is that if someone 'gets in the water' and fails, then that is bad for all developers and impacts on all of them. There needs to be a process, an Engineering Review Board approach for all projects seeking Government aid'

'Both components and systems are important to fund provided that the subsystems are truly reusable'