Non-Financial and Non-Technical Barriers to the Development of the Ocean Energy Sector in Ireland

Discussion Paper

February 2017

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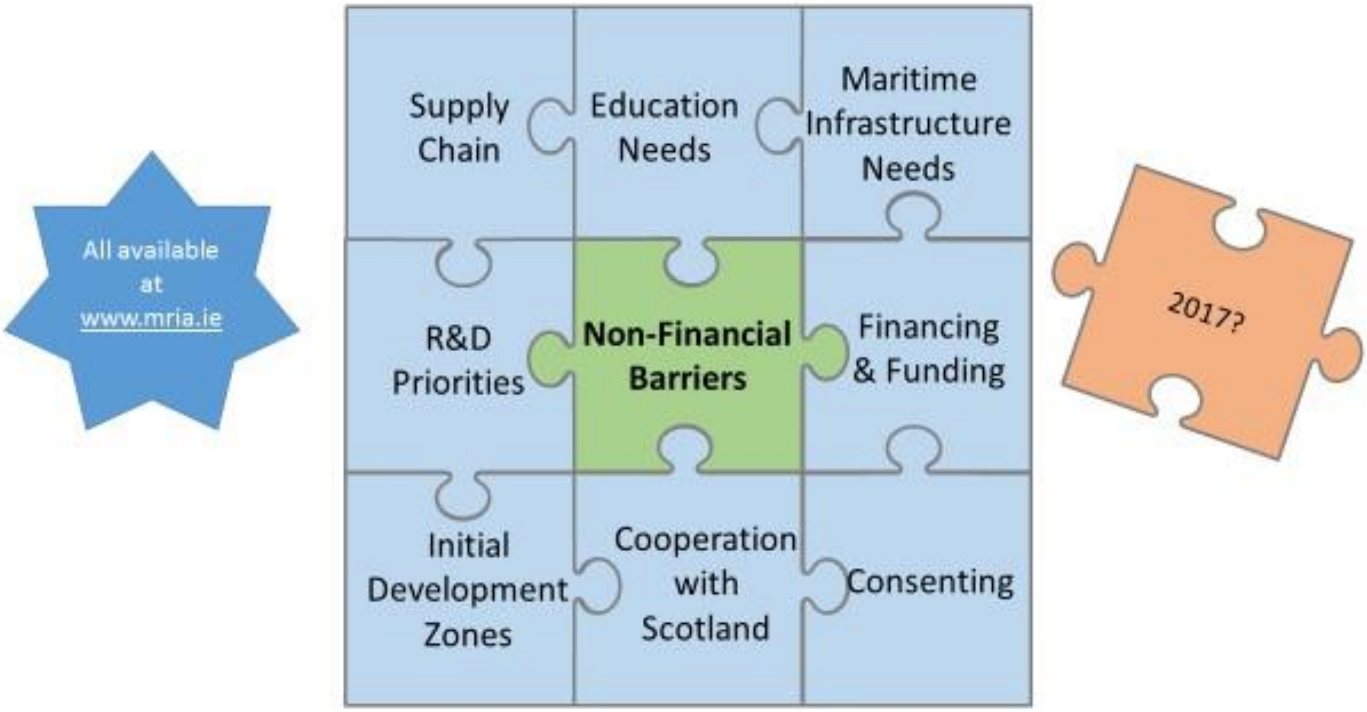
MRIA's Policy Publications



Preface

This is the latest in a series of Discussion Papers prepared and published by the Marine Renewables Industry Association (MRIA) with the generous support and encouragement of the Sustainable Energy Authority of Ireland (SEAI). The illustration on the preceding page indicates the wide range of topics covered in recent years.

Ocean energy can be a major source of jobs and income in Ireland from around the late 2020's onwards as the tough engineering challenges involved in generating electricity reliably (and at a competitive cost) from wave and tidal energy convertor devices are overcome. Ireland has a substantial wave resource (and a tidal one too, in Northern Ireland),

excellent R&D facilities and supportive Government policies. We can become a global supply chain hub for ocean energy and a major exporter of offshore-generated electricity too.

The current challenge is to sustain policy-makers interest and support in this 'industry of tomorrow'. One key to this for the MRIA is to help lay down the policy infrastructure to support and exploit the almost unique Irish opportunity in the future in ocean energy. Thus, the MRIA has dealt with the most obvious policy needs – finance, R&D, educational requirements etc – in our range of Discussion Papers to date.

This Paper deals with the non-engineering and technology and non-financial roadblocks to ocean energy. In particular, it focuses on the important area of insurance which we believe can be both an issue and an opportunity for Ireland. It seeks to raise awareness also of issues in areas as diverse as marine vessel operations and health and safety. Moreover, we update in this Paper, as has been the practice in recent Papers, the evidence for ocean energy's claim to be a major economic development opportunity.

Summary of Recommendations

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

1. The Sustainable Energy Authority of Ireland (SEAI) should allow insurance costs to become both an eligible cost (important when reckoning overall grant aid) and become eligible for grant aid under the SEAI Prototype Development Fund.

2. A working party be established involving Sustainable Nation Ireland, MRIA, SEAI and other relevant parties to:

    - Inform the insurance industry world-wide about the ocean energy opportunity and about Ireland's resources and expertise in this area
    - Inform the ocean energy industry about the insurance industry's needs
    - In particular, develop and support insurance product ideas for ocean energy globally thus giving Ireland scope to win global ownership in this field

3. The Government should support at Government-to-Commission level, and also via the European Transport, Telecommunications and Energy Council, the Ocean Energy Forum initiative on insurance while being cognitive of the likelihood that the initiative will not impact on the bulk of Irish ocean energy enterprises' needs in the short term and that it will also be complementary to recommendation 2. Ireland should also lobby hard to include an instrument designed specifically to support early stage device and sub-

system developers in any insurance package determined by the Commission for ocean energy.

4. The current pioneering founders of the Ocean Power Innovation Network (OPIN) should continue to run the initiative pro-tem until an appropriate funding source can be identified and the initiative scaled up to include a full–time secretariat spanning the member jurisdictions

5. SEAI should review the consultancy fee caps set for the Prototype Development Fund and consider pilot exercise (with clear measures of success) with a small group of companies to ascertain whether the extra cost involved would be more than offset by measurable positive impacts on companies.

6 Ocean energy interests should open a dialogue with the Marine Survey Office (already agreed in principle by the Department of Transport, Tourism and Sport) and separately with the Health and Safety Authority. The lead for this can be taken by MRIA and involve other relevant bodies such as SEAI

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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 renewable 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 non-financial, non-technical barriers to ocean energy in Ireland with a particular emphasis on insurance issues. The terms of reference are dealt with in more detail at 5.

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]*.'*

Another authoritative source, the European Commission-prompted Ocean Energy Roadmap[4], takes an ambitious stance:

'Ocean energy is abundant, geographically diverse and renewable. Under favourable regulatory and economic conditions, ocean energy could meet 10% of the European Union's (EU) power demand by 2050….. Ocean energy can be an EU industrial success story. With favourable support over the coming decade, Europe will obtain leadership in a global market, worth a potential €653bn between 2010 and 2050 and an annual market of up to €53bn,

[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 (EU-OEA)

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

[4] *Ocean Energy Strategic Roadmap Building Ocean Energy for Europe.* Prepared for the European Commission, 2016. Available at https://webgate.ec.europa.eu/maritimeforum/en/frontpage/1036.

significantly benefiting the European economy. The successful development of a competitive European ocean energy industry would also place the European industry in a prime position to seize export opportunities in the global market…Today, 45% of wave energy companies and 50% of tidal energy companies are from the EU…. The global market for ocean energy could see 337GW of installed capacity by 2050, a third of this would be in Europe' p.7, 13.

The opportunity 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 Offshore 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 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 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 limited resource in tidal in the Republic, although not in Northern Ireland where substantial tidal projects are already 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 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 arrangements sought then may be revived in time due to UK generation-capacity constraints although the impact of Brexit on this and other aspects of energy is unknown at present. Recently, a Memorandum of Understanding between EirGrid and RTE (Réseau de Transport d'Electricité, the French transmission operator) was signed[5]. The Memorandum of Understanding is an agreement between the two transmission operators to move to the next phase of development of the Celtic Interconnector Project. This phase, which will take

[5] On 21 July 2016 on the occasion of the visit of President Hollande of France to Dublin

two years to complete, will comprise initial design and pre-consultation for an electricity interconnector between Ireland and France.

In time, large scale deployment of ocean energy devices should 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. A lot of technical issues could be resolved in ocean energy over the next ten years; the intermittency of renewables will be addressed by new electricity storage solutions, particularly in the field of batteries; there may be technical breakthroughs which make ocean energy competitive with traditional energy feedstocks; etc. One emerging element that may have a positive impact are 'hybrids': devices that combine (floating) offshore wind and wave energy devices.

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 contrariness of the sea which impose great challenges across the spectrum from sheer survivability (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 to components and 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 (30 MW+)
By 2050 – **Mainstream**	Rapid-cost reduction- volume production	Supply up to 100 GW 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 in Europe. The consensus appears to be that tidal energy technology is ahead of wave energy technology in development terms[6].

Ireland (specifically, the ESB) may have the pioneering 5 MW WestWave wave project up and running by c2020 and there is a possibility of 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

[6] 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

that ocean energy (wave) array deployment of scale off the West coast will not occur until the latter part of the 2020s at the 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[7].

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[8]. Supporting the emergence of this industry was set as one of a handful of strategic goals fixed for national energy policy to 2020[9]. The policy statement on the Green Economy, published in November 2012, also highlighted the potential importance of the sector and pledged support.[10]

The huge UCC Beaufort building, part of University College Cork and headquarters of the SFI-funded MaREI Centre, was opened in 2015 and houses the *LiR* national ocean energy tank testing facilities. The new complex and MaREI Centre itself are in receipt of substantial financial support from the Department of Communications, Climate Action and Environment (DCCAE, previously the Department of Communications, Energy and Natural Resources-DCENR), Sustainable Energy Authority of Ireland (SEAI) and Science Foundation Ireland (SFI) with cash or contributions in kind from around 50 industry partners.

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 secured significant capital investment support from industry, SEAI and SFI. A total of 35 different projects have been supported to use the facility under a special access programme[11] since 2012 with another 9 projects approved from industry and related activities to aid sensors to 'move up' the TRL[12] ladder. In May 2016, a National Infrastructure Access Call funded by the Marine Institute was launched with successful projects expected to commence by December of this year. Irish SME *SeaPower* has been awarded funding from SEAI to test their device at the SmartBay test site and it was successfully deployed in October 2016. In addition, SmartBay has

[7] Siemen's presentation

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

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

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

[11] National Infrastructure Access Programme

[12] Technology Readiness Level

been successful in EU funding applications, with 7 projects already funded, 1 in contract negotiation stage, 2 proposals under evaluation by the European Commission and 2 more being prepared.

SmartBay is providing test site access and marine science support in the following projects: RECODE (to assist in the development and testing of an umbilical cable monitoring system); FORESEA (to support testing and validation of low carbon technologies in marine test centres); MARINA (to promote responsible research and innovation in Europe's R&D); COLUMBUS (to improve the dissemination and exploitation of EU funded R&D outputs); JERICO-NEXT (involves harmonization and improvement of ocean observation and R&D through facilitated access to research infrastructures); and MARIABOX (development, testing and validation of a multi-parameter autonomous marine bio-chemical sensor). MARINET2 (free access to test sites for marine renewable energy technologies) held a 'kick-off' meeting in conjunction with the MRIA Forum in February 2017.

SmartBay is a partner in the €11m FORESEA project which opened its first call for support package applications in July 2016 and a second call in November 2016. Successful applicants receive free access to test ocean energy technologies in real-sea conditions at the project's network of open sea test centres. The project is funded through the Interreg new programme, part of the European Regional Development Fund. The project aims to encourage longer term testing and technology de-risking, thereby leveraging further investment and enabling progression towards the marketplace.

Through the project, the performance of innovative ocean renewable energy technologies is demonstrated in real sea conditions, helping to leverage the investment needed to take new products to market. Access to test sites will be provided through a programme of competitive calls, run by the project's consortium.

To the north of SmartBay, work by SEAI is in hand to develop, on a phased basis, a full-scale test site (Atlantic Marine Energy Test Site, AMETS) at Belmullet in County Mayo. Although there is no device at present which could survive at AMETS in winter (at least!), it is a smart investment in the future and 'successfully tested at AMETS' could well become a vital marketing tool in ocean energy globally.

The most important contemporary policy development in Irish ocean energy was the publication of the *Offshore Renewable Energy Development Plan*[13]

[13] 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

(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 consultations on tariff supports[14] and guidance on environmental assessments[15], respectively. A mid-term of the OREDP is envisaged for later in 2017.

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 (probably DCCAE) should act as 'landlord' for the seabed and operate a 'one stop shop', concerning licenses and leases, for potential developers must be sorted out. The timing and terms of reference for 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 activity such as ocean energy must be updated via *the Maritime Area and Foreshore (Amendment) Bill* which is reportedly imminent (as it was when the last study undertaken by the Association was completed in 2015!) and which, once more, is on the Government's legislative programme for this session.

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

3.4 MRIA Policy Studies

This paper is the seventh 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[16] 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 - UCC) 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, 27 students have completed the MEngSc programme and

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

[15] *Draft Guidance on EIS and NIS, Draft Guidance on Monitoring Part 1, Draft Guidance on Monitoring Part 2* – Department of Communications, Climate Action and Environment, September 2016

[16] *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

have been employed by companies and organisations such as Wavepower Technologies, Kite Power Solutions, MaREI and Mainstream. In addition, MaREI has also introduced the *OceanEd* training seminar for industry with over 20 attendees at two seminar and wave tank session held at LiR in late 2016.

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.

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 fifth 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.

The sixth paper, was published in February 2016 and covered Funding the Development of the Ocean Energy Industry in Ireland and its core recommendation, the creation of a Pre-Commercial Technology Fund, has prompted interest in official circles.

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. The Ocean Energy Opportunity[21]

Ocean energy has the potential to make a significant contribution to the world's energy supply[22]; indeed, the theoretical potential easily exceeds human energy requirements. It could provide 'winning' countries – those

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

[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] This section is drawn from *Funding the Development of the Ocean Energy Industry in Ireland* www.mria.ie and has been updated and placed here again to drive home the point that ocean energy is a real and enormous economic opportunity

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

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 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[23] stated in 2010 that:

There is currently sound quantitative evidence that by 2030 a fully developed island of Ireland OE sector providing a home market and feeding a global market for Renewable Energy could produce a total Net Present Value (NPV) of around €9billion and many thousands of jobs....It is possible that an island of Ireland wave energy industry ……. 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[24] since has underpinned the broad thrust of the SQW study although it is generally regarded today as being somewhat optimistic in terms of its forecasts of when job creation etc. might occur.

4.1 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)[25]. Undeniably, over-ambitious (with the benefit of hindsight) targets were fixed in early years for installed capacity. Ireland, for example, set a target of 500 MW of ocean energy 'in the water' by 2020[26]. 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[25] 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 10 MW each with some leading players installing up to 50 MW

[23] *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 latter's near term predictions won't be achieved.

[24] Referenced later in this section 4

[25] *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*

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

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

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 as recent as 2013 as likely to happen in the UK out to 2020.

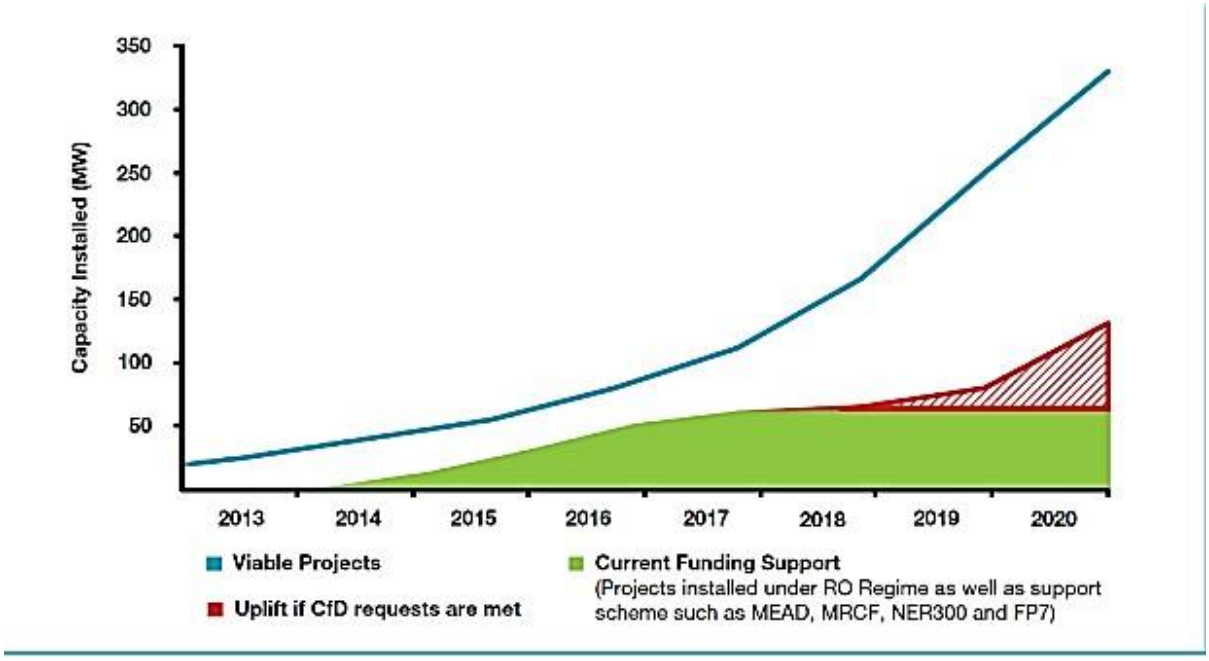
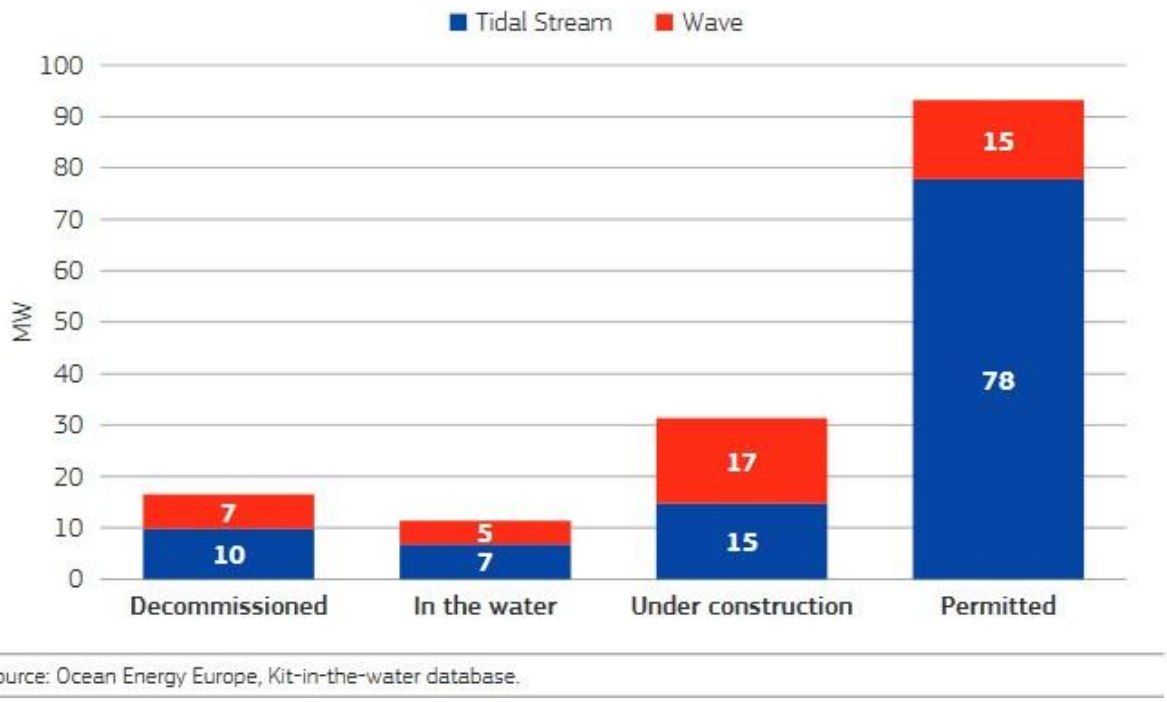


Figure 1: Likely deployment for UK wave and tidal energy 2013[27]

The latest European view is set out in Figure 2 below which shows the position at June 2016 and is tied into a forecast deployment of 850 MW by 2020.[28]



[27] *Ocean Energy Technology: Gaps and Barriers* SI Ocean 2013

[28] Ocean Energy Strategic Roadmap op cit p16-17

Figure 2: Europe deployed tidal stream and wave capacity, under construction and permitted capacity (MW) situation at June 2016

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'[29] 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' [30]

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

> *'.... first pilot arrays – consisting of three or more devices with a maximum installed capacity of 10 MW – 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 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.'*[31] .

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 5-10 MW) 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'* [31]

[29] This approach is illustrated by the pragmatic *Offshore Renewable Energy Development Plan* op cit.

[30] *Offshore Renewable Energy Development Plan* op cit.

[31] *Wave and Tidal Energy Market Deployment Strategy for Europe* SI Ocean June 2014

[31] *Accelerating Marine Energy* Carbon Trust 2011

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. This issue is tackled in the next sections.

4.2 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 100 GW of ocean energy could be installed in Europe by 2050[32]. The Carbon Trust[33] 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 189 GW of wave and 52 GW 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. The latest, Ocean Energy Strategic Roadmap[34], forecasts are similar

The International Energy Agency[35] estimates a worldwide potential of up to 200 GW of wave (65%) and tidal energy capacity, again by 2050.

The global firm EY[36] 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'* [37].

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

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

[33] *Marine Renewables Green Growth Paper* Carbon Trust 2011

[34] *Ocean Energy Strategic Roadmap Building Ocean Energy for Europe* op cit. p.7

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

[36] Formerly Ernst and Young, then EY

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

62% of their supply chain is Scottish. They forecast over 10,000 jobs, direct and indirect, in tidal in Scotland by 2030.[38]

Regardless of source, expert opinion believes that the ocean energy market will be enormous in 20+ years' time.

4.3 Development Volumes and Costs

How many MWs must be deployed at the prototype/demonstration/precommercial stages of ocean energy development before industrial roll-out is feasible? A provisional estimate is 520 MW for wave at a cost of €4.3bn and 400 MW for tidal at a cost of €3bn[39]. The bulk of the volumes (300 MW each in both wave and tidal) and costs (67% of a total of €7.3bn) is attributable to still distant pre-commercial arrays involving TRL 8+ devices. Neither sets of financial 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 – a real opportunity in this area arises for the three jurisdictions of Ireland, Northern Ireland and Scotland.

4.4 Comparative Experience

The long term projections cited at 4.2 appear remarkable in the light of the current stage of development of what is an emerging technology. However, wind energy may be an illustrative and broadly comparative development experience for ocean energy.

Onshore wind energy is not an overnight phenomenon. 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 well over 100 GW.[40] In modern times, the first significant wind turbine was a three-bladed 200 kW device installed in Denmark in 1956[40], 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 1980s ….and yet Growian is commonly regarded as the kernel of the modern German wind industry.

Growian –derived from the German word for 'wind-powered device' – was a pioneering 3 MW wind turbine built by MAN in the early 1980s. It had a 100m tower, a 100m rotor diameter, a nacelle that weighed as much as a jumbo jet and cost €75m! Growian worked

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

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

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

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

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 450 kW array was slightly smaller than the 5 MW now envisaged for the ESB's WestWave wave energy project anticipated for c2020. The first *commercial* offshore wind farm was opened at Middelgrunden, Denmark only in 2000 (just seventeen years ago) with a total capacity of only 40 MW[41]. *Windeurope* has reported[42] that in 2016 there were 3,589 wind turbines, with a total combined capacity of over 12.6 GW, fully grid connected in European waters across 10 countries……and that a further 4,948 MW, worth €18.9bn, in 11 projects have reached 'final investment decision'.

The jobs and wealth creation associated with renewable energy are remarkable: a total of 8.079 million people were employed directly and indirectly in renewable energy globally in 2015 .This is up from 2.2 million jobs worldwide in 2007[44]. Global new investment[45] in renewables in 2015 is estimated at $286bn.

The UK envisages £6.1bn added to the UK economy by ocean energy by 2035, creating 20,000 jobs[43]. Scottish Enterprise forecast that Scotland could secure up to 30% of all wave projects going forward and 15% of all tidal projects.[47] SQW forecast a transformational impact by ocean energy on the all-island of Ireland economy by 2050.[48] 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.'* [44]

As an illustrative aside, the long-term nature and complexity of offshore projects is illustrated in Figure 3 [45] below setting out the time-scale

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

[42] *The European offshore wind industry - key trends and statistics 2016* https://windeurope.org [44] *Renewables 2007 Global Status Report* REN 21 Renewable Policy Network for the 21ST century 2007

[45] *Renewables 2016 Global Status Report* op cit.

[43] *Wave and Tidal Energy in the UK- conquering challenges, generating growth* Renewables UK 2013 [47] MRIA/Scottish Renewables Workshop op cit. [48] SQW op cit.

[44] *The State of Renewable Energies in Europe* EurObservER, 2013 Edition

[45] *Offshore Wind Towards 2020 – on the pathway to cost competitiveness* Roland Berger April 2013

[51] *Offshore Wind Towards 2020 – on the pathway to cost competitiveness* op cit.

associated with a typical (and roughly comparable to ocean energy) offshore wind project.

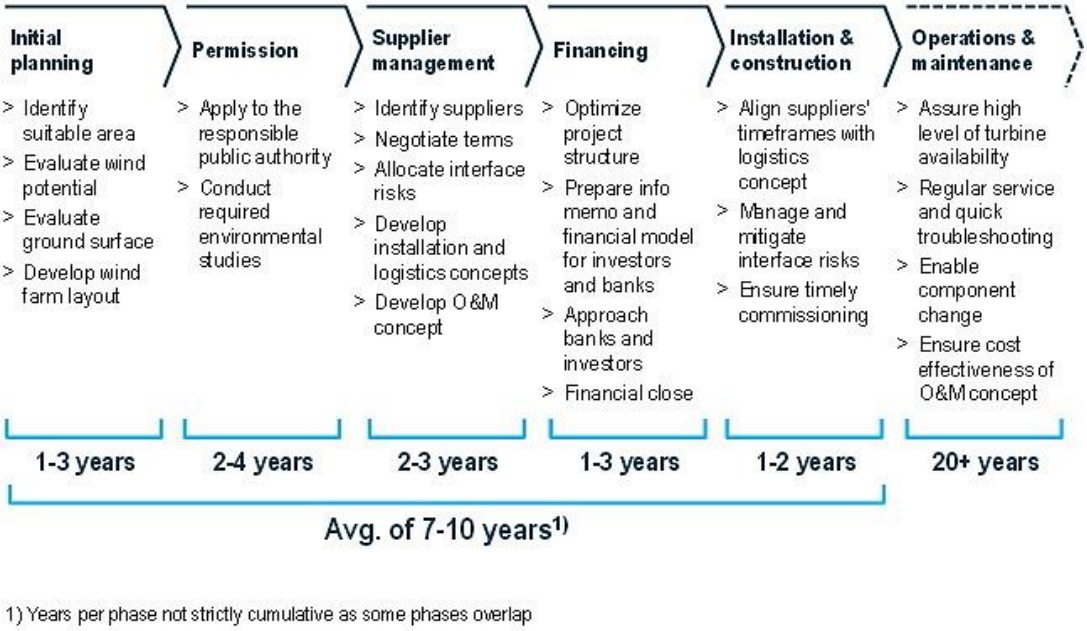


Figure 3: Timescale of typical offshore wind project

Overall, the argument here is that the precedent set for ocean energy by other renewable technologies, and 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, particularly to the benefit of Ireland, once engineering stability and basic competitiveness are attained.

4.5 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[51] (see Figure 3). These consultants forecast that the annual global rate of installation of new offshore wind capacity may rise to 6.5 GW p.a. with an annual investment of €20.8bn in 2020. This 'compares' with the Carbon Trust's forecast[46] of a €40bn p.a. market in ocean energy at peak, albeit many years further out.

REN21[47] (see Figure 4) shows that the total installed capacity at present in renewables from all sources in the world amounts to over 750GW*. The various forecasts for the scale of the ocean energy market set out at 4.2 represent a substantial proportion of this figure.*

[46] *Marine Renewables Green Growth Paper* op cit.

[47] *REN 21 Renewables 2016 Global Status Report* op cit.

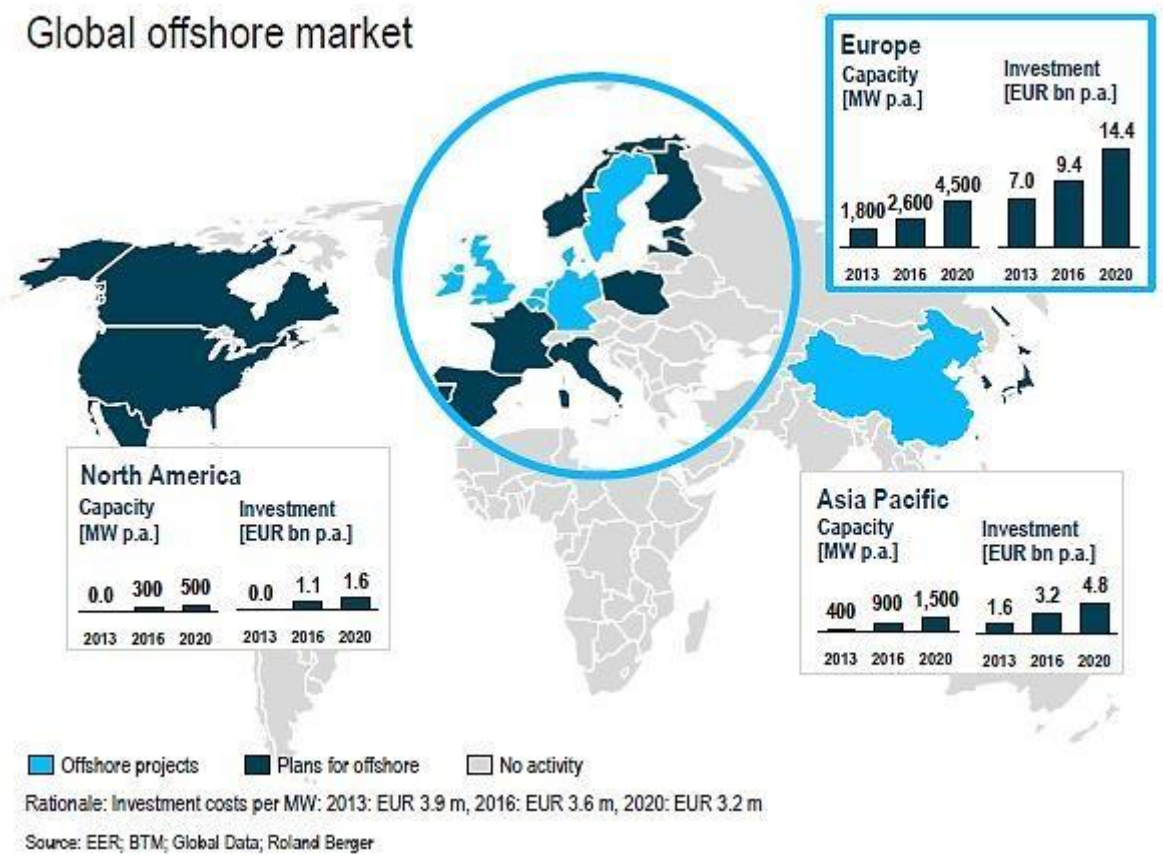


Figure 4: Global offshore wind market projections

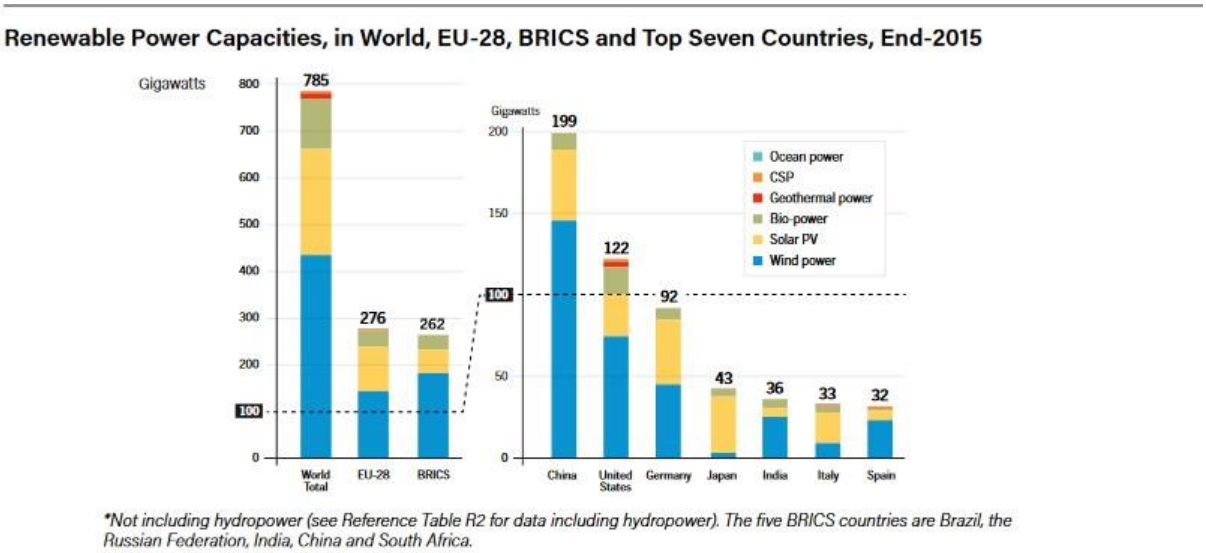


Figure 5: Renewable Power Capacities in World, EU-28, BRICS, and Top Six Countries, 2015[48]

The general 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

[48] *REN 21 Renewables 2016 Global Status Report* op cit.

[55] White Paper op cit.

parallel to that undertaken by its wind 'cousins' (albeit over perhaps a shorter period by the latter in light of the lesser technical challenges faced by wind).

4.6 Implications for Ireland

It would be easy to take a dismissive view of the argument emerging above e.g. 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 also in the latest Irish energy White Paper's [55]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. Terms of Reference

The MRIA put forward, in 2016, a proposal to the Sustainable Energy Authority of Ireland (SEAI) to examine the non-technical, non-direct funding barriers to the development of ocean energy in Ireland with an emphasis on insurance related issues.

This issue arose from an informal but widespread view that an active intervention in the market would be required if prototype devices and particularly early arrays are to be properly insured and if the associated performance guarantees, warranties and other (mainly) regulatory matters required by utilities etc. are to be met. In other words, these side-issues, as they are typically regarded, may have the capacity to be 'show stoppers' for ocean energy. They emerged also as a concern in the various surveys

undertaken in Ireland, Northern Ireland and Scotland recently in regard to the OPIN project[49].

The challenges to both our basic knowledge of the problem and in the formulation of solutions to it include:

1. What form and type of e.g. insurance is required and by whom? How is risk perceived and determined in the marine area? What is deemed an acceptable level of performance-guarantee and warranty provision for new technology developments? What is required and by whom? What other (principally) regulatory requirements will be faced by prototype device and early array developers? Are they possible blockages to development?

2. How were these issues dealt with in other renewable energy fields, notably wind? What are the lessons for ocean energy? Is there scope for the arrangements in those areas to extend into ocean energy?

3. What initiatives are underway elsewhere e.g. at the European Union's *Ocean Energy Forum*, at the European Investment Bank etc. to tackle these issues and how can Ireland link in to them?

4. What form should a cost-effective public policy initiative take in this area if needed to de-risk prototype devices and notably early stage arrays, thus increasing the international appeal of Ireland as a location for this future industry?

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 emphasis to it. However, it should be noted that the Association is an allisland one and this is reflected in the make-up of MRIA's membership.

6. Strategic Topics Explored

The Association undertook a review of the issues outlined at 5 during 2016 in interviews, on a face to face basis in most instances, with a wide spread of interests in Ireland, the United Kingdom and elsewhere in Europe. A list of those companies and institutions interviewed for this paper is contained in Appendix 1.

Interviewees were presented with a list, drawn up by the Association (and not claimed by us as being exhaustive!) of possible obstacles to the development of ocean energy. Challenges as diverse as consenting, initial development zones and health and safety were all set out alongside insurance

[49] *Ocean Power Innovation Network* established by Ireland, Northern Ireland and Scotland as founder members in 2016 with support from MRIA and ESB

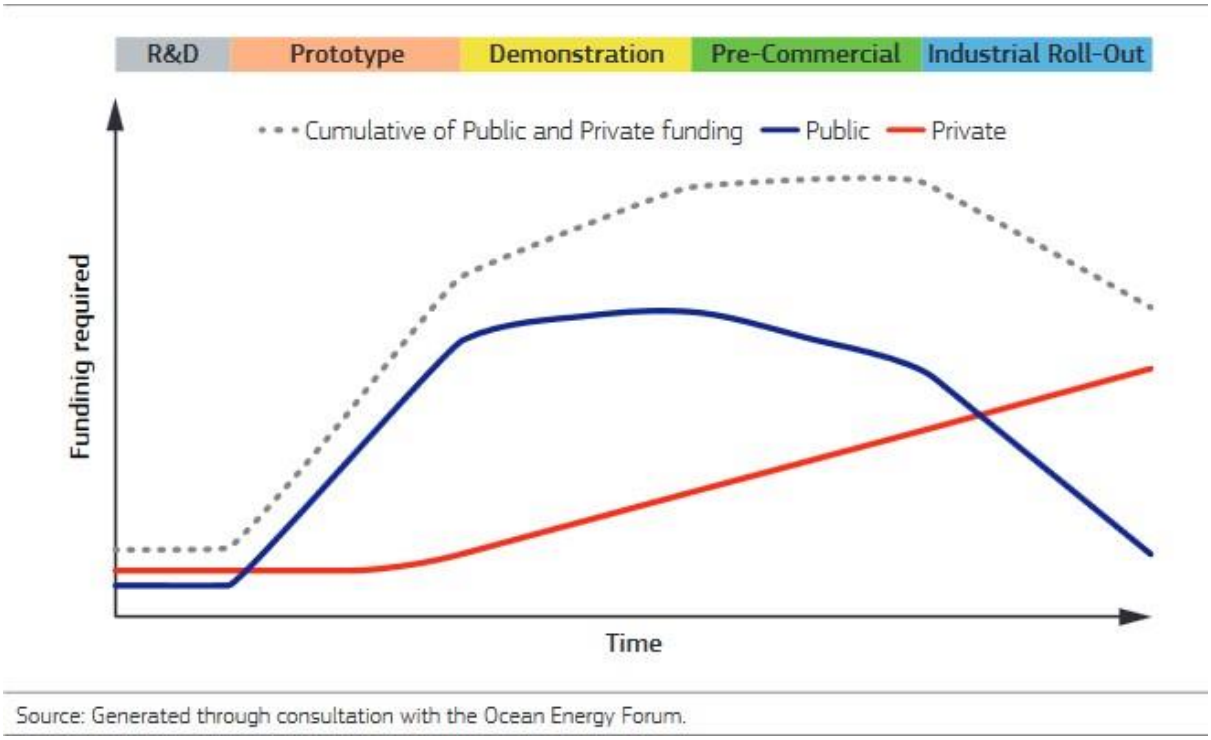
i.e. the discussions were not 'stacked in favour' of insurance as being the principal obstacle. The topics raised all lay outside of the technical (e.g. engineering problems) and direct financial fields (e.g. raising equity, loans and grants). The exception to this rule lay in discussions with topic experts (e.g. in insurance) whose interest lay in tightly defined domains.

In line with the normal practice in MRIA Papers, direct quotes are given anonymously. However, a record of most views – about 300 substantial views were recorded by the Association in the course of preparing this Paper – is set out at Appendix 2. Typically, just a handful of 'voices' is quoted under each heading in the main body of the Paper below.

7. The Issues

7.1 State of The Industry

The great conundrum of ocean energy is that, on the one hand, there is widespread recognition of the potential of the sector in terms of both the scope to generate electricity from those locations (including Ireland) with a resource (principally a wave resource in Ireland's case) and, to create a jobsrich supply chain, and, on the other hand, the relative lack of investment in ocean energy by Governments. Ocean energy's challenge stands in stark contrast to the experience of other forms of energy generation which were lavishly supported during their period of trial and error, prototype iterations and so on. Solar, for example, benefited from the 'space race' while gas turbines and nuclear power are both offspring of military R&D. Wind has benefited from the heavily State-supported progress made in composite materials, particularly in aerospace, which has spilled over into wind turbine blades. Figure 6 gives an indicative share of private and public funding for an ocean energy concept per development phase:



Source: Generated through consultation with the Ocean Energy Forum.

Figure 6. From *Ocean Energy Strategic Roadmap Building Ocean Energy for Europe* p31

Nonetheless, progress is being made in ocean energy: new start-up companies in wave and tidal continue to emerge around the world but particularly in Western Europe; the European Commission is working on plans to support ocean energy e.g. through the Ocean Energy Forum [50] initiative; Governments in the ocean energy lead-nations – arguably Ireland, France and Scotland – continue to support the industry despite the lack of a defence or other major imperative to drive funding; and test facilities and programmes are growing e.g. the LiR facility, SmartBay and MaREI Centre in Ireland.

However, there is a 'political' need to get devices 'wet' i.e. in to the water and generating electricity at experimental levels at the various facilities. Policymakers need to see progress and one possibility that has emerged is to concentrate on achievable, kW-scale, applications in the immediate future e.g. to provide electricity to island communities. The one dampener to the generally cautious optimism encountered during the course of this study relates to the unknown impact of Brexit on ocean energy and the general difficulty surrounding tariff supports and policy generally for renewable energy in the UK.

[50] This is an initiative driven jointly by the European Commission and the private sector to develop a road map for European ocean energy and has led to the report already referred to: *Ocean Energy Strategic Roadmap Building Ocean Energy for Europe* 2016 available at https://webgate.ec.europa.eu/maritime forum/en/frontpage/1036

These points are illustrated by the selection of quotes from interviewees below (and more quotes are contained at Appendix 2).

'Looking at the industry generally, everyone is looking at Carnegie with great interest- will this be the first device in wave to work well? The wave jury is still out. Can anyone get a 1 MW device to work, to survive the ocean? Scottish Enterprise is looking at other options/markets for wave – did a niche market study which looked at fish farms, islands- new customers and new problems – which do not requires large (i.e. output) devices. On the tidal side, we are close to saying that tidal is close to the cusp of success and close to the line of success. On large scale, Atlantis dominates tidal and there are other contenders such as Scotrenewables'

'Wave will emerge in the next ten years but we do need to see success a lot earlier, need something over the line in the next five or six years'

'Wave should focus on small niches, particularly fish farming, islands and the military'

'Wave and tidal generally have to be optimistic –there is a SET plan now, resources are becoming available etc.'

'Everything is on pause, policy-wise, regarding energy in the UK and chances of this being sorted out in the short-medium term are low'

7.2 Insurance

Insurance will be a major non-technical and non-directly financial barrier to ocean energy for some time to come. The issue breaks down into several fairly discrete elements: conventional insurance e.g. wreck insurance for devices; construction insurance (likely to be a challenge given the precedents set by offshore wind energy); cabling (an issue shared with offshore wind); and, particularly, performance guarantees and warranties.

> *… the currently higher risk inherent to innovative technologies cannot be fully borne by either device or project developer, nor insured commercially as insurers lack knowledge of the sector and appetite for high risk/low premium insurance schemes* Ocean Energy Strategic Roadmap P9

Obviously, the insurance 'obstacle' is to some degree a problem for the future as insurance solutions can be found to cover early, low-TRL, projects where performance guarantees usually don't arise. Discouragingly, pioneering device developers (Pelamis, Aquamarine Power) also tried to become site developers in part because of insurance (performance guarantees etc.) issues…with disastrous business results. Our interviewees were eloquent on this topic:

'Ocean energy faces an insurance triple whammy – it is in the sea; at the product development stage; and customers will require a performance guarantee'

'Insurance is a massive issue for ocean energy. There is no way that an SME can provide warranties and performance guarantees. Indeed, there is a need for specialist insurers to deal with the 'conventional' aspects e.g. wreck insurance for ocean energy….in offshore wind, the well-established manufacturers provide warranties etc. but that doesn't apply in ocean energy'

'There should be no insurance problems at the experimental stage (i.e. sub TRL 4). But everyone needs a 'line of sight' to an insurance solution and if more mature/big projects can't start because of insurance issues, then there is a problem for everyone in ocean energy'

'Ocean energy is at too early a stage for insurance to be an issue although it is very expensive. Problems concerning insuring performance guarantees are way down the line'

'There will be no acceptable warranties in ocean energy even from big companies'

'Warranties are a 'big company' issue but can be solved for early companies by some form of partnership with big companies'

'(Ocean energy device developers) have to become site developers in order to create the market as independent site developers will put the risk on to the technology developers who self-insured for stuff which is outside of normal insurance boundaries such as warranties and guarantees for 20 years'

'…the biggest single insurance problem with offshore wind (and this may well apply to ocean energy too as there are great similarities in terms of multi turbine fields etc.) is cabling and a particular issue is the quality of cable'

7.3 SCALING

Ocean energy encompasses a wide and long supply chain ranging from university laboratories through to law firms, mechanical engineering enterprises, shipping and ports… and wave and tidal device developers. The companies in the wave and tidal space today are almost uniformly small and, typically, at the start-up stage. In scale terms, they are probably no further on than offshore wind firms were in 1991 when the first offshore wind farm was deployed off Denmark[51] and there were at least ten offshore turbine manufacturers seeking Danish business at that time which reduced significantly in the following decade as most early participants in the industry dropped out and consolidation occurred.

[51] See 4.4

Small, typically start-up, firms are a feature of every new technology innovation and have several barriers which are accentuated in a capitalintensive area such as ocean energy: the development cycle for devices is long and expensive; small start-ups have difficulty in attracting capital and staff; and, faced by large and technically demanding customers such as utilities, they lack credibility.

This issue is compounded in Ireland by a strong drive in many entrepreneurs to create and protect Intellectual Property e.g. though patents which precludes collaboration and sharing.

'The problem for device developers is scaling-up their businesses; they lack the funding to do so'

'Big issue for small companies is technical mentoring or rather the lack of it. Big disconnect with researchers in universities although the EI Innovation Voucher scheme works well. Perhaps form a panel of experts and SEAI provides support in similar manner to EI'

'People talk about collaboration but don't do anything about it. If the ocean energy community doesn't deal with generic issues, then there will be no industry'

'…. the challenges of being small can be insurmountable…promoters need to focus on their best features, their strengths and a partnership or relationship with a larger company can be the best route to market'

'If we can't share, we can't get devices to work and then we will have no industry'

'Focus on patents leads to silo development, I advocate open innovation so that resources can be can then be spent on products and technology and less on the protection of IP portfolios…concentrate on getting things done'

'Need to go 'open source'; anything else i.e. protection of Intellectual Property is disastrous for the industry'

'Issues of collaboration and competition are obvious issues. Lots of small companies running around after the same pots of money and there is no Intellectual Property (IP) or knowledge sharing'

7.4 CONSENTING

At this point in the sector's development, environment related issues such as consenting would not normally be to the forefront of ocean energy's collective concerns. However, the consenting environment in prospect is a tough one – the long promised overarching 'consenting' legislation[59] has yet to appear[60] and legal precedents set in related fields are a worry, particularly the *O'Grianna v An Bord Pleanála* judgement[61] which implies that offshore

projects must be consented in the round i.e. cannot 'project split' and, accordingly, must, for example, have a grid connection before applying for

[59] *The Maritime Area and Foreshore (Amendment) Bill*

[60] The Association believes from dialogue with Government that the Bill may finally appear in 2017 [61] See:
[2014] IEHC 632
http://courts.ie/Judgments.nsf/09859e7a3f34669680256ef3004a27de/71409d20df97079280257ddc004f8721?OpenDocument
[2015] IEHC 248
http://courts.ie/Judgments.nsf/09859e7a3f34669680256ef3004a27de/f143e7c97d13b14980257e31004997e9?OpenDocument

consenting. In addition, there are concerns about Environmental Impact Assessment, Appropriate Assessment and data collection e.g. related to sea birds.

'The planning etc. issues surrounding landfall will be very important for ocean energy and the O'Grianna v An Bord Pleanála *judgement will be key in that regard which deals with the whole chain from offshore power generation to the grid connection for individual projects'*

'A big issue arising in Irish planning law which will impact on ocean energy is 'project splitting' which in practice means that applicants must have grid connections arranged prior to seeking planning permission. This is not practicable'

'…another issue incidentally refers to lack of data e.g. re seabirds in Ireland – big contrast with Scotland'

'EIAs are also a big issue - the surfing community, for example, are very sensitive to locational issues as they are affected changes in the wave field arising from devices. This is going to be an issue in County Clare (the important ESB WestWave project will be located off the Clare coast)*'*

'The biggest issue in this area for Ireland is Appropriate Assessment and Ireland has been before the European courts and fined because it did not do AA properly (?) in certain cases. The issue arises from the transposition of the EU Habitats Directive into Irish law which was poorly done. As a consequence, the DAFM requires an AA for each aquaculture site in Ireland'

'Habitats Directive is the biggest barrier to development in Ireland. The interpretation by the European Courts of Justice was not helpful'

7.5 Health and Safety/Operations and Maintenance

Health and Safety and Operations and Maintenance are issues that arose regularly with interviewees and are closely linked. Two key points that arose are, first, that the regulatory authorities here (particularly the *Marine Surveyor's Office* and the *Health and Safety Authority*) will have an important part to play in the development of ocean energy but have little experience in

the traditional, carbon-based offshore industries because Ireland has seen relatively little offshore oil and gas activity unlike the UK. Thus, the counterpart agencies to the Irish bodies there have built-up a large pool of expertise in offshore energy. Second, a critical issue for the economics of ocean energy is whether or not devices can be maintained offshore or will have to be towed to port even for routine maintenance.

'The Sea is a very good system for destroying things'

'Device developers dealt with up to date display good knowledge of strictdomain issues such as anchoring, PTOs etc. but they are weak in regard to Health and Safety, platform access, Operations and Maintenance'

'Health and Safety will be an issue'

'Do we know how to maintain devices e.g. in light of weather considerations? There is likely to be no access during October - March and only for 50% of the time during the rest of the year for devices located at AMETS in Belmullet, Co Mayo. Trying to board restrained moving platforms is an act of insanity. The only practical solution is to tow devices to a harbour for maintenance'

'…… view that all ocean energy devices would have to be taken into a port for 0&M on Health and Safety grounds is unwarranted. The Wavebob device, for example, was classified as a vessel and O&M and Health and Safety followed this. A blanket ban on any O&M at sea would impose significant cost and be a true barrier to ocean energy development'

7.6 OTHER

A variety of other issues arose in the course of the extensive range of interviews. Funding, the subject of a major MRIA study in 2015[52], arose a lot but was deliberately set aside by the Association as being broadly outside of the terms of reference of this study. Suffice it to say that companies still struggle to raise *funding*. A challenge which was signalled is *decommissioning* with early companies grappling with perceived unrealistic demands by consenting authorities. The *'vessels'* issue largely reduced to a concern about the local availability of suitable craft to support operations and maintenance etc. and to concern also about the shape that any support-vessel regulatory regime might take. Apart from some other miscellaneous issues, there was a widely-held view about *engagement* at two levels. First, there is concern about engagement between the policy-makers and the industry with nostalgia expressed about the former industry liaison committee of SEAI's then Ocean Energy Development Unit; second, and quite separately, industry figures are well aware of the need to devise an effective model of public

[52] *Funding the Development of the Ocean Energy Industry in Ireland* www.mria.ie

engagement at sites encompassing test sites, prototype sites and locations for commercial arrays.

7.6.1 Funding

'The big issue isn't industry matching funds but rather the obstacle the EU's States Aids regime puts in the place of funding of what is effectively R&D'

'Device developers need to seize on something that works, get it into operation and 'bank' it as a demonstration'

7.6.2 Decommissioning

'Decommissioning could be a big issue e.g. concerning the 'abandonment' of anchor chains; breaking anchor chains with adverse impact on fisheries'

'Decommissioning bonds are in place for oil and gas offshore and will apply to ocean energy'

'An issue that is just coming into sight now is decommissioning. To get a decommissioning agreement (in the UK), you need to show that you have resources. We struggled to get an appropriate financial deal. The authorities really wanted us to have the funds on deposit and this is going to be a big struggle for small companies'

7.6.3 Vessels

'We require vessels to be fully certified. There is a unique problem in Ireland in that you have to forego your fishing licence with the Marine Survey Office when you want to use it as a workboat and then reapply for your fishing licence when you want to switch back again…and pay a fee. This is not a requirement in Scotland'

'Specialist vessels are being developed to enable boarding offshore wind devices in waves up to 2.5m in the North Sea. Concerned about the vessels which may be deployed to support wave energy. Likely to be drawn from oil and gas industry where circumstances are very different.'

'Cost of hiring in vessels for deployment and O&M is one of the top three issues for this industry and Ireland needs to look at its regulatory regime to ensure that it can line up with the emergence of ocean energy'

'Ireland doesn't have a satisfactory work boat code unlike the UK. Ireland, for example, doesn't distinguish between work boats and passenger vessels. Skippers of the latter are not necessarily familiar with dealing with offshore work e.g. civil works in heavy seas'

7.6.4 Public Engagement

'Public engagement is vital to ocean energy and good precedents lie in the work done to date with WestWave in Clare and AMETS in Mayo'

'Compensation and community gain will be issues for ocean energy with fishermen and local communities'

'Took a year to sort out compensation at AMETS with crab fishermen and private developers… will certainly face claims for compensation. Shell gave each fisherman (in regard to the Corrib project) a total of €30k in 'compensation' '

7.6.5 Miscellaneous

'Other issues in the way of ocean energy development? How to share risk means new business models are needed; the availability of personnel and deployment vessels; a pipeline of projects is needed to give the supply chain confidence in the sector and in the long-term economic opportunity'

'A big issue for Ireland (v Scotland) is how to provide a supply chain on the West coast where the wave resource is – where do we hire a really big crane, for example. No doubt that the supply chain in the West can evolve a bit but it is still very risky'

'…there is a commercialisation gap in academia: a huge amount of money is going into academic research (in ocean energy) but how do we get at the results?'

8. Features of a Solution

8.1 INSURANCE

Insurance, including performance guarantees and warranty provision, is a major issue and one where several elements in any future solution came through in interviews. There needs to be engagement with the insurance world even at this early stage in ocean energy so that knowledge is developed and interest kindled in that industry. New funding solutions are suggested e.g. via EU sources (as was discussed under the aegis of the Ocean Energy Forum referred to earlier) and even, perhaps, self-insurance for conventional (i.e. not performance related) risks may be an option in the long-term along the lines of the oil industry's OIL initiative: 'Oil Insurance Limited (OIL) is a mutual insurance company that insures close to $3 trillion of global assets for its 50+ members who are engaged in energy operations.

The company provides its members with up to $400 million of per occurrence limits which serves as "cornerstone capacity" for their global insurance programmes'[53].

'Ocean Energy is outside the knowledge of the insurance community. (For instance) … major problem in getting professional indemnity insurance for a WES project although got other forms of insurance without much difficulty. Solicitors, doctors etc. can get indemnity but not someone from a new technology. Eventually got it at disproportionate cost for one contract'

'Insurance must be looked at as part of the overall funding model. It's all about what warranties can be provided and thus ocean energy's small companies will need large partners to underwrite. Investors don't want innovation; they want something they can trust'

'Would like to see an EU fund to share the risk of insuring many different ocean energy projects'

'It took ten years from 1991 for the insurance market in offshore wind to develop expertise and to settle down'

'Ocean energy straddles the maritime and power fields and the natural starting point is the marine insurers. RSA has 80% of the market in offshore wind etc. and other big players are Allianz, Axa, Swiss Re and Munich Re. Work with insurers who now work in the offshore engineering space'

'The market is worth about stg£800m in annual premiums to the five key players – RSA (60% of the market), Swiss Re, Munich Re, Axa and Allianz'

'Insurance for performance guarantees was needed at the beginning of offshore wind (early 90s) and was gone by 2000 as the technology matured and strong companies emerged who could provide acceptable guarantees directly'

'The challenge is to get qualified (i.e. large, experienced, credible) companies (such as B&V) involved with device developers when the latter are at a low TRL level. The large company can act as independent validators of the small company's work so that the large company can stand over the guarantees of the small company if the latter has developed their device in a well organised and externally validated manner. If this approach is followed, device developers shouldn't have a problem with insurance etc.'

8.2 SCALING

A number of solutions were offered to the scaling challenge and all of them recognised the difficulty of start-ups in a capital intensive, R&D intensive and almost everything-else intensive sector! This is compounded in Ireland where a unique technology-entrepreneurial tradition has emerged in recent

[53] See https://www.oil.bm/

times: start a company and once it reaches stability and a reasonable scale - sell it. This inter alia has to do with the need for venture capital funds to cashout at an early stage, perhaps as early as five years post initial investment, as well as the issue of ambition touched on earlier[54]. These solutions commonly featured the need for collaboration and partnership – with solutions ranging from ways to involve major consultancies with small companies through to intensive engagement with State agencies such as Enterprise Ireland, InvestNI and Scottish Enterprise. There was almost universal concern about the drive deemed to exist in many (most?) ocean energy device companies to generate and defend intellectual capital as a core goal…. and this is held to be a major obstacle to company development in the sector: an 'open source' approach is advocated.

'Typical ocean energy companies are two person bands who will have to change. At least five or six companies are on this journey and they will have to recognise that they will need a partnership with a big balance sheet to survive'

'Why don't Irish companies generally grow into large firms? Probably because the ecosystem (e.g. lots of long term risk-taking patient capital) isn't there and also because a lot of company owners lack the ambition to scale: at a certain point they want to sell up'

'Seek a model which allows major engineering consultancies – who want to earn commercial level fees - to get involved with projects without raising IP issues. This is particularly important when projects reach SmartBay level i.e. cTRL 4+. This is one route to collaboration and partnership which would allow device developers to scale up'

'A marine energy entrepreneur needs a strategic partner who can provide funding, insurance experience, technical competence and a project development plan. The developer also has to deal with onshore planning, grid connection and the CER Offer'

'The Prototype Development Fund rules regarding consultant's fee rate (max of c€600 per day) is an obstacle to qualified companies engaging with early stage device developers. Providing a scope of work for a fixed fee is one way around this; another is to provide an 'average day rate' arrangements which might allow for high-rate experienced engineers to be blended in with lowerrate juniors to meet the 'average day rate' and yet meet the PDF's current rules'

'If major consultancies seek PDF grant aid as direct partners to small companies or some similar arrangement, then the level of grant aid is reduced

[54] See 7.3

down to c50% for the large firms and this becomes uncommercial for the larger firm'

'Scottish Enterprise can arrange for companies to get a skills appraisal and review of organisational development; also do advanced due diligence to flush out flaws and help companies. Also provide support for market analysis and provide Scotland stands at trade events. It all comes down to the willingness of companies to engage'

'You can become an Enterprise Ireland client in one of two ways: graduate from the Local Enterprise Office system with sales of €1M and/or ten employees or qualify for our High Potential Start-Up programme where you will have to convince us that you can achieve €1m in sales and/or ten employees in a relatively short period'

'Intellectual property is an issue insofar as entrepreneurs/start-up companies spend money on patents which should be spent on product development etc.'

'Need to go 'open source'; anything else i.e. protection of IP is disastrous for the industry'

8.3 CONSENTING

The big lacuna in the ocean energy environment and planning space is the lack of the long-promised modern legal framework, the Maritime Area and Foreshore (Amendment) Bill. The hard work on this has been done by officials, what is needed now is the political will to bring this complex and vital legislation in to the Oireachtas (Parliament) and commence the journey to the Statute Book. Many of the other suggestions concerning consenting – key examples are quoted immediately below – will hang off this legislation once it becomes law. An important issue in the practical area is the need to rationalise and turn data collection e.g. mammal and bird surveys into an 'open' issue and, so far as possible, to move them it into the realm of 'public goods'.

'Consenting legislation is critical. Where is it?'

'Initial Development Zones are an interesting notion and there has been a lot of work on this in the OREDP'

'The semi – informal Marine Licensing Vetting Committee should be placed on a statutory basis so that their scientists can make a 'call' on the data presented under EAs'.

'Should early ocean energy go to ABP as traditional Strategic Infrastructure? An application alone costs €100k and generally there are huge costs involved'

'The number one issue is the consenting authority. It must be An Bord Pleanála. Planning law had big controversies over split projects, each component of

which was sub various environmental assessment requirement-limits. The issue today is decision-splitting and the only way to avoid it is to have one decision authority for consenting'

'Data on mammals and birds in particular must be open and shared'

'We need to minimise environmental data collection. It is wrong to use early companies as pathfinders for everything, including data collection'

8.4 Health and Safety/ Operations and Maintenance

Health and Safety and Operations and Maintenance are not immediate issues for ocean energy insofar as the technology is still largely at the prototype and demonstration phase. However, they are of long-term importance and, as previously remarked, are linked issues which have the capacity to be 'showstoppers' particularly as Ireland has a very limited offshore development experience and, therefore, has limited familiarity with the regulatory world of H&S and O&M in this part of the ocean space. The key challenge for the next few years is involvement and communication with the relevant regulatory bodies.

'Ocean Energy won't make it if we cannot develop robust H&S, O&M regimes'

'Health and Safety should be top of the agenda and ocean energy has been 'lucky' so far. Health and Safety practices must be as robust as possible'

'Maintenance: need to know exactly what you are doing and need expert advice re ship hire etc. – this is especially important regarding tidal where there are limited windows of opportunity for maintenance'

'Buoys last a long time - CIL have buoys which are up to 60 years old. Over the last 15 years or so they have bought 10 buoys (from Turmec in Meath); expect to get 16 years' service from solar panels and 8-10 years from lanterns'

'Most of the conditions under which maintenance of offshore wind platforms is allowed won't work for ocean energy. How to maintain ocean energy devices on site, and the regulation of that issue, is a big concern. There may be some learnings from the 'Lean Wind' EU project concerning efficiencies in offshore wind. It will involve recommendations about how to safely deploy maintenance etc. personnel aboard offshore wind platforms'

'EMEC is a key player on developing Operations and Maintenance expertise while the Crown Estate is particularly hot on Health and Safety and this is a big issue for a lot of device developers. EMEC has developed H&S and decommissioning guidelines'

8.5 Other

Finally, turning to the Other issues category – Funding, Decommissioning, Vessels, Public Engagement and various Miscellaneous matters – it is

interesting that all of the solutions put forward (there is a small selection below, see also F in Appendix 2) again feature the need for communication and preparation in advance of the industry reaching early maturity if Ireland is to maximise its potential benefits in ocean energy.

8.5.1 Funding

'…interestingly, several companies have used public financial markets to good effect: Atlantis on the AIM; Carnegie Wave on the Sydney Stock Exchange; Minesto on the Scandinavian version of NASDAQ'

'It is dawning on the EU that it is necessary to throw shedloads of money at projects to develop ocean energy. The EU is the only body at this stage that can put significant funds (at least €10m per case)'

'Lack of any clarity about CfD is turning off investor interest in ocean energy, we need (UK) a statement about minima, strike prices and so on'

'LCoE ambitions are achievable if realistic volumes of wave and tidal – at least a GW can be deployed to build the learning experience

8.5.2 Decommissioning

'Decommissioning arrangements e.g. bonds have become an issue at EMEC- it's not compatible with SME developers in an early-stage technology. The principle of bonds is fine but must be executed via some form of sinking fund arrangement'

8.5.3 Vessels

'Looking at the need for small deployment vessels, industry needs to look at the design of specialist vessels, especially for tidal devices while special towing vessels are needed for wave devices. This could be a joint project for Ireland and Wales under Interreg'

'…. we have no problems re supply of vessels due among other things to the condition of the oil and gas industry and nor have we an issue with the supply of test instrumentation'

'It would be a huge boost if the EU were to acquire a vessel which could provide installation and O&M services to early ocean energy deployments'

8.5.4 Public Engagement

'Local consultation is a critical issue - Oriel to date has made 390 different submissions and held 90 meeting with local interests'

'A public competition in wave energy would drive excitement up (in ocean energy) and could be good for public engagement'

'Need to get all of the agencies to work together under the aegis of the OEDU to co-ordinate funding efforts (the bulk of which will arise from SEAI) and support companies – in the Wave Energy Scotland manner - through the TRL stages to achieve – with some companies dropping out or being dropped along the way – so that they can be put in front of utilities with confidence as potential suppliers or, indeed, potential investments.

'Need to establish the Marine Development Team recommended in 'Harvesting Our Ocean Wealth' – get a team of experienced executives down and dirty with the supply chain, Foreign Direct Investment. This would greatly enhance IMERC and SmartBay. We need a team along the lines of the Irish Maritime Development Office and staffed among others with Enterprise Ireland and IDA seconded staff' - this has been done since this interview.

8.5.5 Miscellaneous

'Marine Scotland is one stop shop and really important. All agencies engaged with ocean energy e.g. the Maritime and Coastguard Agency are co-ordinated by Marine Scotland'

'MaREI is really, really very positive. It has good people; the structure is going in the right direction…. overall a very positive development'

9. Overview and Conclusions

MRIA cannot express often enough its view that Ireland has two distinct, ambitions in ocean energy. First, Government recognises the enormous potential resource to generate electricity represented by the energy intensive West coast wave regime. This can be exploited to meet domestic needs (although the island of Ireland market is small and already well served for renewables by onshore wind) and, particularly, to realise export opportunities. But this electricity generation ambition can be met without any domestic participation in the provision of the necessary technology and services – all the devices, services etc. required could be imported.

Second, however, there is an ambition to build-up a global supply chain for ocean energy based in Ireland. This can include everything from financing, legal services, education and research and development to development of software to the manufacture of components all the way up to full-scale devices. In the latter regard, we are in a friendly competition with France and the UK, at least, to be to ocean energy as Greece and Norway are to shipping…. these world power houses of shipping actually build very few ships themselves…and we have realised similar ambitions before in other fields, notably aviation and software.

Ireland's complex range of ambitions and possibilities in ocean energy is reflected in the array of targets and policies entered into by Government (see

3.3 earlier) and emphasises that ocean energy in Ireland is not solely about device or major component manufacture although public discourse might at times suggest otherwise! We are, course, fortunate to host eminent device firms, notably OpenHydro and Ocean Energy Limited, as well as promising emerging enterprises such as Open Ocean, Wavepower Technologies, SeaPower and Blue Power Energy. It is essential to the health of the Irish ocean energy world that they grow and thrive but, equally, public policy must recognise and support the complex economic development model required here: it must encompass the growth of a wide supply chain.

The Association has sought to play a positive and supportive part in the development of ocean energy. MRIA has published Papers on topics as diverse as Initial Development Zones to options for funding the industry. This Paper set out to identify other obstacles not yet identified (or, more likely, not so far dealt with in any depth) to the development of the industry.

Our work in researching this Paper has identified four substantial areas of early concern which are outstanding for policy-makers. First, the original presumption that insurance would prove to be a major issue turned out to be a prescient choice. We are convinced that it is both an obstacle (but perhaps only for the early stages –perhaps the next 10 years - of the industry, particularly the early arrays) but also an opportunity as, hopefully, the next section will demonstrate. An important study, not published at the time of writing, captured this issue succinctly:

As a consequence of the lack of understanding of total costs and technological reliability, the sector currently has hardly any access to insurance or warranties. Other renewable energy sectors, such as solar or wind, do not suffer from such issues. This has resulted in private companies moving in to insure and provide hedging to all sorts of risks (including bad weather insurance to level out revenue generating capabilities). Several interviewees stressed the importance of this barrier to secure secondary financing rounds. Calls have been made to therefore fund more research to tackle, in particular, the operational risks and to provide public support, or direct insurance products[55]

Second, the early start-up, small-scale nature of ocean energy device and component companies is a critical issue and one which uniquely the 'scaling up' tools of, particularly, Enterprise Ireland cannot readily address as section 11 will argue – a new approach is needed. The scaling challenge is one that is unnecessarily complicated by the focus of many entrepreneurs on protecting their intellectual property which in practice may militate against their companies growing or even surviving. It is arguable that the number of instances where intellectual property developed by small Irish companies in

[55] *Study on Lessons for Ocean Energy Development* Draft Final Report, P42. ECORYS and Fraunhofer

any field achieved real value is tiny, certainly compared to businesses where the focus was on competing effectively and on growing to scale. Equally, the question must be asked as to whether many (any?) companies in ocean energy have the financial capacity to defend their patents (including in the Irish courts where the cost of litigation can be robust by any standards!).

Moreover, insurance and scale are linked. It will be impossible for most (all?) device companies to provide warranties and performance guarantees without collaboration with firms blessed with strong balance sheets. The only alternative is for device developers to become site developers as well,

which means that they must 'self-warranty'. In practice, this has proven to be a disaster as the experience of, for example, Aquamarine Power has demonstrated. Small engineering companies do not typically have the money, skills or experience to get successfully into an entirely different field which involves property development…and at the same time undertake the arduous task of developing a device that will successfully and economically generate electricity in the Cruel Sea.

The remaining two topics identified as major obstacles are consenting and health and safety plus operations and maintenance. We have chosen not to address *consenting* in depth in this paper on the grounds that it has already been well-covered (not least by MRIA) elsewhere and major changes in the form of a new legislative framework are pending. *Health and safety* and *operations and maintenance* are closely related topics but are at an early stage of concern insofar as ocean energy is concerned. Nonetheless, it is important to open a dialogue with the relevant authorities and we make recommendations in this regard in the Recommendations set out at 12.

In the 'other' category, *funding* was dealt with in depth in an MRIA report published in 2016; *decommissioning* is potentially a significant issue – the suggestion that small companies in this emerging technology would be required to deposit now the cost of decommissioning their devices in many years' time is unrealistic – and will be taken up by the Association in the context of the forthcoming consenting legislation; the most immediate issue in regard to *vessels* concerns the regulatory regime and this is addressed at 12 below; and, finally, *public engagement* is a critical matter, as many difficult experiences of the wind industry amply demonstrate.

10. Insurance: obstacle and opportunity

10.1 Introduction

There is an evident need (e.g. illustrated by the interviews conducted for this Paper) for bespoke insurance products which adequately match requirements to risk as the wave and tidal energy sector grows and more metal gets 'wet'. This will particularly require both the marine renewables industry and the insurance industry to develop a better understanding of each other and of the issues involved in ocean energy projects.

10.2 Offshore Insurance Requirements

The drivers of the insurance requirements of companies engaged in ocean energy (device and major sub-system developers; site developers) include:

- *Legal* – compulsory insurance such as public or employers liability
- *Contractual* – required by contracts e.g. professional indemnity insurance
- *Financial* – insurance requirements of investors.

It is, therefore, critical to ensure that the right mix of insurance cover is in place with the right party at the right time and that the 'interfaces' are well defined. Project risks need to be clearly quantified and allocated so that there are no gaps in coverage or uncertainty regarding who is liable for what, bearing in mind that the parties involved include not only device and site developers but also constructors, utilities, investors, consultants etc. When a claim occurs, developers need to focus on getting projects back on track and built and operating on time……rather than lose months, perhaps years, tied up in legal proceedings.

> To lender and investors only projects demonstrating convincing returns and a high degree of sophistication regarding the transfer of project risk will secure favourable financing *Poul Hansen, Head of Renewable Energy at JLT Specialty Ltd, the global insurance broker*

Shown below are the typical insurance products that would be consumed throughout the lifetime of a mature UK round 3 offshore wind project, a reasonably close analogue for ocean energy:

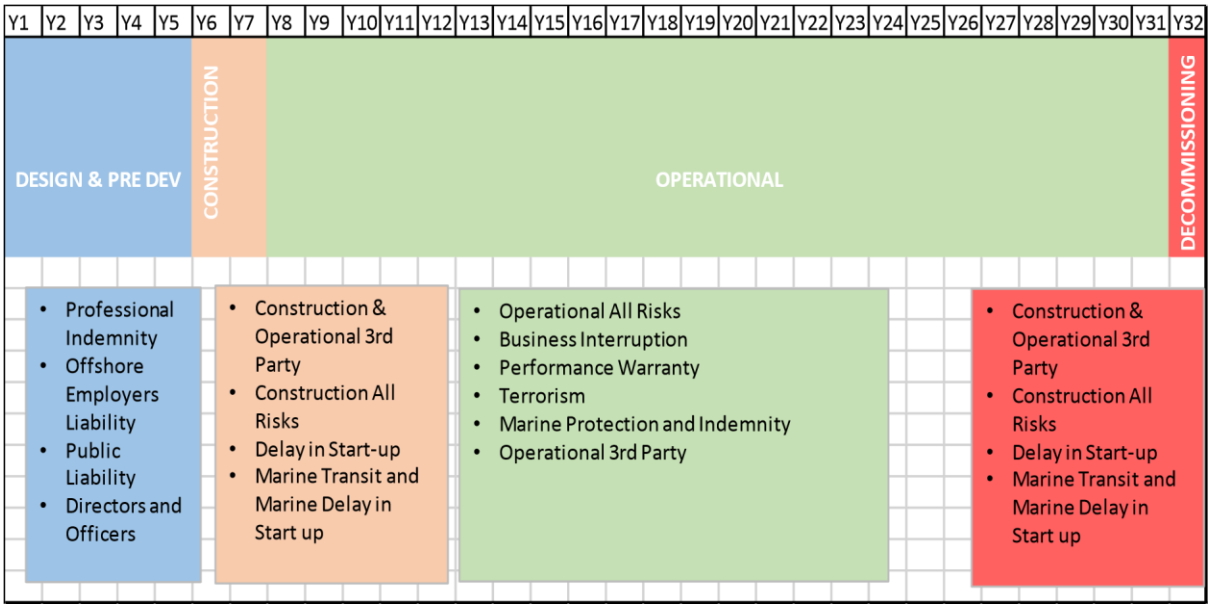


Figure 7: Project Phases and typical insurance products[56]

The Figure above gives a (perhaps) simple overview of a deeply complex insurance system. For example, if a component breaks down at sea, then the project owner/developer (typically, the party involved at 'Operational' in Figure 7) will claim from the insurance company who, given normal processes, will pay out the claim and then, in turn, seek out the 'real culprit' Many projects are delivered under an Engineer, Procure and Construct (EPC) contract - is this where the ultimate liability lies? Or is at the component developer or at the original inventor or laboratory? Or…?

Figure 8 below gives another description of the various types of insurance products required throughout the life of a project, this time in ocean energy:

[56] Derived from *Best Practice Guide to Wave and Tidal Power Insurance – A paper by JLT Speciality Ltd on behalf of RenewableUK's Marine Strategy Group* May 2012

Figure 8. Source: *Ocean Energy Strategic Roadmap Building Ocean Energy for Europe* p.48

Risk	Project Developer & Financiers need	OEM/Supplier obligations	Project Insurance availability	Risk Gap to achieve "bankability"
Construction & Procurement Phase				
Delivery of turbines/ WECs , support structures, etc	Timely commissioning (eg, after 30 days successful running in situ) to initiate revenue generation phase.	Performance Bonds & Liquidated Damages (LDs) often subject to caps, and NB credit risk	Limited to accidental damage in transit or construction and consequent loss of revenue/Business Interruption (BI).	Revenue shortfall protection over and above amount of LDs, etc, in the event of an uninsured delay in acceptance of turbines. (May be more relevant to smaller technology suppliers rather than major OEMs)
Operational Phase (in first, eg, two to five years of demonstration project – ie, until adequate data established)				
Availability of power generation equipment, etc	Plant needs to be available to operate for minimum percentage of each year to achieve revenue targets.	Warranty may include LDs/penalties based on increasing availability over time. LDs capped to % of contract value.	Not normally insured for inefficacy, mechanical breakdown or defect. Some insurer support may become available once "proven"	Loss of revenue over and above the amount provided by any LDs plus excess costs to rectify faults – eg, marine operations, transit, weather delays
Performance against expected power curve	When operating, the plant needs to generate the expected MWh given the wave/ tidal resource.	Warranty may include a static power curve guarantee.	Not insured, although some specialist insurers may offer some support.	Loss of revenue expected given the actual site conditions in excess of any LDs based on static power curve calculations. Method of calculation of any loss will require expert input
Machinery breakdown & defective parts	Protection against costs of repair as well as delay.	Warranty generally covers replacement of parts for limited period. Some may contribute to marine ops costs.	Replacement costs & consequences normally excluded. Cover should widen after, eg, two years of satisfactory operations.	Loss of revenue over and above the amount provided by any LDs plus excess costs to rectify faults – eg, marine operations, transit, weather delays
Decommissioning Phase				
Inadequacy of sinking Fund at termination	Bond-like instrument in lieu of having to fully cash collateralise decommissioning costs at time of financing.	No contractual liability after takeover certificate issued other than through any LDs	Only covered for BI following insured perils during the project.	Build-up of adequate sinking Fund requires several years of successful revenue generation. Sustained uninsured failure of multiple devices would be problematic.
Financiers may also perceive a performance risk on the warranty, availability and power curve obligations (eg, of smaller suppliers) which may need insuring.				

Figure 9: Offshore wind insurance products available from *GCube*

Figure 9 shows the wind insurance cover available from *GCube* who insure 30GW of renewables worldwide, mostly onshore and offshore wind. They appear to have the full suite of insurance products available for that relatively mature industry but note that they do not offer any cover for warranties or performance guarantees.

10.3 INSURANCE AND WAVE AND TIDAL

According to experienced insurance broker JLT Speciality Ltd[57] *'It should be noted that insurers currently find the potential liabilities for wave and tidal difficult to quantify'* and this is reflected in the premiums being sought from early developers and, indeed, the reluctance to insure in some instances. Thus, for example*, 'insurers will not provide Mechanical and/or Electrical Breakdown coverage for wave and tidal during either the testing and commissioning and operational phases, with the core coverage offered being Material Damage and Third Party Liability'*. Insurance availability can vary due to many factors but often it comes down to the track records of the companies and teams involved, what they are doing and where they intend doing it. Insurers will not take on 'trade' risks associated with the research and development of an embryonic industry such as ocean energy

[57] *Best Practice Guide to Wave and Tidal Power Insurance – A paper by JLT Speciality Ltd on behalf of RenewableUK's Marine Strategy Group* May 2012

This latter point notably manifests itself in the performance and technical guarantees area. Throughout the interviews, the MRIA did not find any evidence that the ocean energy was uninsurable during design, construction, and operation or decommissioning. In fact, we found that insurance claims had already been made for total loss and wreck removal! What we also learned, however, was that there were no commercial performance bonds or guarantees available. Small companies and developers are de facto expected to self-underwrite in ocean energy which is not normally credible with customers such as utilities.

After ART's Osprey sank in Australia, Allan Thomson was quoted as saying that "identifying and solving problems was a function of development engineers and added: ''It is at times like this that you realise that your insurance premiums were well spent''. The machine was insured on Lloyd's London Marine Market.

There are solutions to the performance guarantee and warranties issues (see 12) but no financial or other aid will avoid the need for the industry, even very small start-up companies, to adopt vigorous development processes coupled with proper marine warranty, accreditation and certification achievement. Competent and experienced project management will also be a key requirement together with meticulous risk identification, apportionment and control. There are encouraging signs that these points are being adopted e.g. through the processes involved in the Wave Energy Scotland schemes. The MRIA has strongly suggested that the proposed Irish *Pre-Commercial Technology Fund* impose tough engineering standards and practices on <u>all</u> applicants.[58]

However, as with wind, the issue of warranties and guarantees is anticipated to be a problem which may be soluble within the early years of precommercial development. In the wind industry, a new turbine-type can be self-warrantied with around 8,000 hours of successful and properly monitored operation although '…leading insurers have advised that more than 8,000 hours would typically be required for wave and tidal equipment.'[59]

10.4 Offshore wind claims: scale and nature

In offshore wind, insurance claims exceeding €60 million were made in 2015 in relation to incidents surrounding the installation and operation of highvoltage subsea cables i.e. *incidents which on the face of it are independent of the electricity generation technology employed*. The total claimed in 2015 was 25% higher than the 2014 equivalent. The well-known marine

[58] See *Funding the Development of the Ocean Energy Industry in Ireland* www.mria.ie

[59] *Best Practice Guide to Wave and Tidal Power Insurance – A paper by JLT Speciality Ltd* op cit

renewables broker GCube[60] found that since 2008, an average of ten subsea cable failures are declared to insurers every year and that these account for 77% of the losses made by wind projects. The report found that two thirds of all reported cases can be put down to contractor error in the installation phase, which may not be noticed until the project is in operation. This, incidentally, illustrates the importance of ensuring that projects have the right mix of insurance product. One scenario here could be that the operator would want to claim from their insurer under 'business interruption' in order to restart production as quickly as possible and the insurer would then seek to recover the amount involved from the original contractor's insurer.

There have already been a number of claims in the wave and tidal industry, e.g. ART's Osprey wave energy device, but quantitative figures are difficult to come by.

Oceanlinx Wave Energy Wreck at Port Kembla, Australia Photo: Chris Duczynski[71]

10.5 Scale of the renewables industry

In 2015, an estimated 148 GW of renewable power capacity was added to worldwide capacity, the largest annual increase ever. Table 2 shows the breakdown and, also, that US$286Bn was invested, more than all other conventional (i.e. non-nuclear) sources combined. It is noteworthy that Hydropower accounted for the lion's share of the increase.

[60] *Down to the Wire: An Insurance Buyer's Guide to Subsea Cabling Incidents* GCube [71] Illawara Mercury http://www.illawarramercury.com.au/story/3672332/oceanlinx-wavegenerator-delays/

		2014	2015
INVESTMENT			
New investment (annual) in renewable power and fuels[f]	billion USD	273	**285.9**
POWER			
Renewable power capacity (total, not including hydro)	GW	665	**785**
Renewable power capacity (total, including hydro)	GW	1,701	**1,849**
Hydropower capacity[e]	GW	1,036	**1,064**
Bio-power capacity[a]	GW	101	**106**
Bio-power generation (annual)	TWh	429	**464**
Geothermal power capacity	GW	12.9	**13.2**
Solar PV capacity	GW	177	**227**
Concentrating solar thermal power	GW	4.3	**4.8**
Wind power capacity	GW	370	**433**

Table 2– Summary Renewables 2015 [61]

Wind capacity has been steadily growing from a low base over the past decades to a total installed capacity of 433 GW.

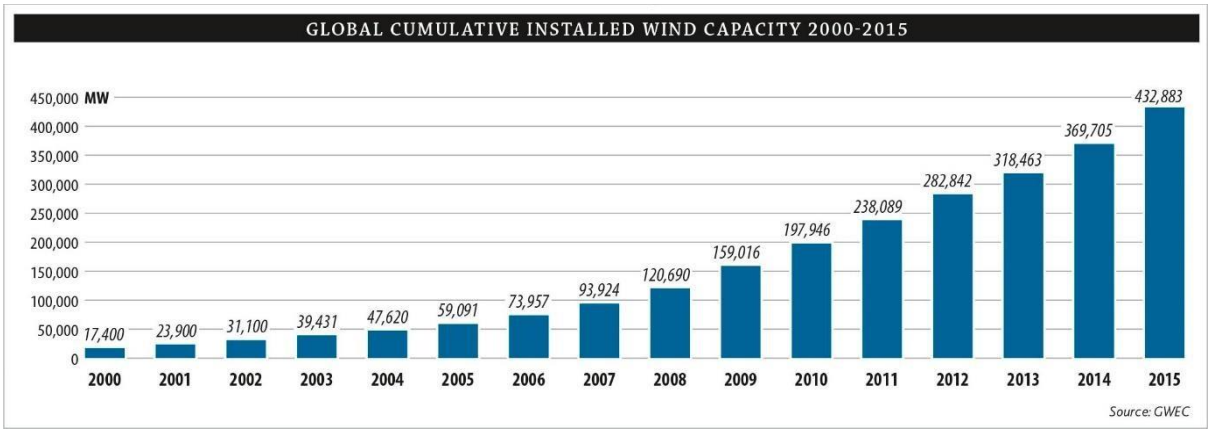


Figure 10- Global Cumulative Wind Installed capacity [62]

A total of over 12 GW of the 433 GW total wind capacity is offshore and almost all of this offshore wind capacity is in Europe…but it is growing elsewhere as onshore sites become more difficult to licence.

Of the 785 GW of total installed renewable capacity reported by REN21, well over 50% is derived from onshore wind and 2% from offshore wind.

10.6 Scale of Renewables Insurance

Mott Macdonald, the global consultancy with an emphasis on engineering, have published a report in which they break down the *levelised-cost-of-*

[61] *REN21 – Renewables 2016 – Global Status Report*

[62] *Global Wind Energy Council 2016*

energy cost of many UK generation types. The figures involved are well referenced, are from real sources and compare well to industry norms at the time. The report states *"Onshore wind has a central cost estimate of £94/MWh. Offshore wind is more expensive, with costs of £157-186/MWh (depending on wind farm location). While offshore is projected to see a large reduction in costs, compared with onshore wind, it will still face much higher costs at £110-125/MWh for projects commissioned from 2020."* [63]

The report breaks out the costs of insurance for the lifetime of projects and shows them on a per-MW and per-year basis. Although it is impossible to tell what insurance products are included and when, the line item breakout does give some idea of cost, scale and relative premiums.

Mott Macdonald have run a number of scenarios, showing immature projects/technology as '*first of a kind*' (FOAK) and then applied a learning rate to get to mature projects (*n^{th} of a kind-NOAK*). They have also taken a spread of figures from low to high based on real feedback. The projects range from small onshore wind to very large UK round 3 offshore wind cases.

The resulting table is shown below:

	First of a Kind (FOAK)				nth of a Kind (NOAK)		
Onshore Wind 100 MW	Low	Medium	High		Low	Medium	High
£/MW/yr	£ 9,350.00	£ 11,550.00	£ 15,400.00		£ 8,500.00	£ 10,500.00	£ 14,000.00
£m/yr	£ 0.90	£ 1.20	£ 1.50		£ 0.90	£ 1.10	£ 1.40
Average		£ 12,100.00				£ 11,000.00	
Offshore Wind 200 MW	Low	Medium	High		Low	Medium	High
£/MW/yr	£ 22,000.00	£ 25,000.00	£ 27,000.00		£ 15,000.00	£ 17,000.00	£ 20,000.00

[63] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65716/71-ukelectricity-generation-costs-update-.pdf

£m/yr	£ 4.40	£ 5.00	£ 5.40		£ 3.00	£ 3.40	£ 4.00
Average		£ 24,666.67				£ 17,333.33	
Offshore Wind Round 3 400 MW	Low	Medium	High		Low	Medium	High
£/MW/yr	£ 30,000.00	£ 35,000.00	£ 40,000.00		£ 20,000.00	£ 25,000.00	£ 30,000.00
£m/yr	£ 12.00	£ 14.00	£ 16.00		£ 8.00	£ 10.00	£ 12.00
Average		£ 35,000.00				£ 25,000.00	

Table 3

Taking the average of these figures and plotting them by technology type shows that the premiums increase as the maturity and risk increase. Onshore wind is cheaper than offshore wind which is cheaper again than offshore wind Round 3 with a factor of 2.5 – 3.

The implication for wave and tidal premiums is that they will undoubtedly be higher still.

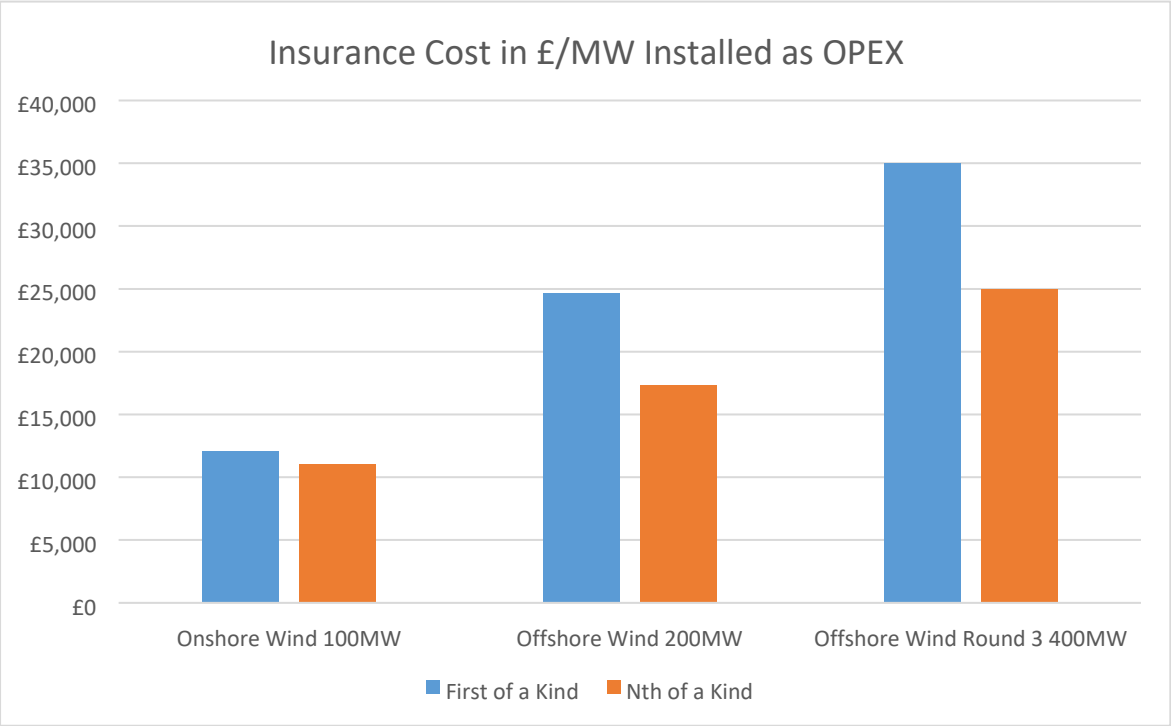


Figure 11– Insurance Cost in £/MW as OPEX

Given that the insurance cost from Mott Macdonald was expressed as an OPEX figure per MW per year, it is possible to estimate the total market size for insurance. It is reasonable to assume that all operational assets will be insured so the cumulative figures from REN21 can be multiplied by the Mott Macdonald costs to get a first estimate. This gives the Figure below:

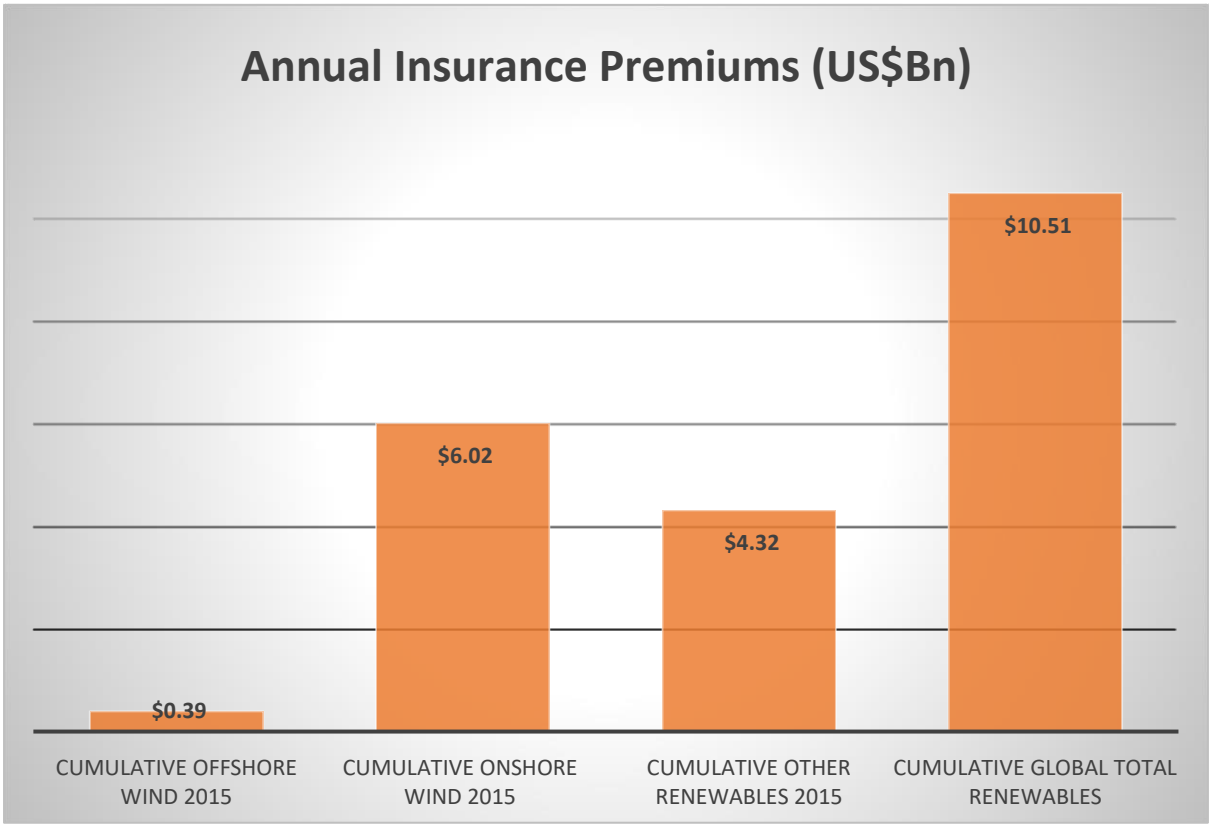


Figure 12: Annual Insurance Premiums

This indicates that the annual insurance premiums for all renewables are over US$10Bn. The immature offshore wind sector figure for premiums amounts to $390m[64] and that for onshore wind is $6bn. In 2015, 77% of all offshore wind claims amounted to £60m which is $75.24m i.e. there is a healthy surplus of premiums over claims.

In short, insurance will be an issue for ocean energy for the next number of years but, based on well documented and relevant precedent, insurance should be a profitable opportunity for the wider Irish ocean energy supply chain.

11. Building Companies of Scale in the Supply Chain

An enduring concern of the Irish industrial development experience is the small scale of most Irish-owned companies. The development agency for Irish-owned manufacturing and internationally trading service firms, Enterprise Ireland, determined in the early 2000s, after considerable analysis, that companies who achieve an annual turnover of about €20m (which became the accepted frontier between 'scale' and 'no scale') were likely to be exporting, profitable, undertaking R&D, growing employment and have the capacity to grow to a significant size e.g. a turnover of €100m+ p.a.[65]

The agency established a select team to help suitable companies to scale-up and to get across the line i.e. get to €20m + annual sales. The team established a reputation for quality work, helping companies with issues as diverse as organisational development all the way to funding and access to export markets etc. It was a time and staff intensive challenge and did not, could not, produce fast results. The approach today, with tight staff resources at the agency, is to make scaling a mainstream activity across all activities and sectors and to '…recognise and respond to different challenges of exporting companies, according to company size and growth stage'[66] but without a specialist team.

An alternative experience is represented by the German *Mittelstand* which refers to a broad category of SME 'Hidden Champions' in private ownership – SME's with an annual turnover of less than €50m and less than 500 employees - account for 99% of all companies and about 70% of all

[64] Although MRIA has anecdotal evidence that the premiums could be as high as €800m+ which only serves to further the point about insurance being an opportunity

[65] The Chairman of MRIA was the Enterprise Ireland Executive Director responsible at the time for the Scaling programme.

[66] *Driving Enterprise Delivering Jobs – Strategy to 2016*, p17 Enterprise Ireland

employment in the private sector [67] . Typically, leading Mittelstand companies are featured by world market leadership (often number 1) in very narrowly defined markets; self-reliance (typically, no alliances or partnerships); family ownership; and strong focus on innovation and R&D.

The latest thinking on scaling is driven by the work of Eric Ries which was first proposed in 2008 and published in 2011[68]. Ries claims that 'start-ups can shorten their product development cycles by adopting a combination of business-hypothesis-driven experimentation, iterative product releases and what he calls validated learning....his overall claim is that if start-ups invest their time into iteratively building products or services to meet the needs of early customers, they can reduce the market risks and sidestep the need for large amounts of initial project funding and expensive product launches and failures… originally developed with high-tech companies in mind, the lean start-up philosophy has since been expanded to include any …company seeking to introduce new products or services into the market'[69]

12. Recommendations

This Paper, as with all MRIA policy documents, recognises that there is a need to mount robust arguments in favour of devoting national resources to our endeavour – developing ocean energy – that has not yet reached maturity anywhere and which is still very much a technology work-inprogress. This is particularly pertinent in light of the social and economic challenges faced by Ireland as it emerges from the Great Recession, the daring required by policy-makers to support an 'industry' that is still at least a decade away from commercial operation by utilities and the policy departure involved in Ireland becoming a technology leader rather than a technology follower – the latter being a course which was profitably followed by Ireland in the past in, for example, software.

MRIA is also always conscious, and makes no apologies for repeating frequently, that ocean energy is a dual opportunity: it would enable Ireland to exploit its rich west coast wave resource and export the resultant electricity to the benefit inter alia of the Exchequer; given our investment in R&D facilities, early companies, the wave resource etc., Ireland is well-placed to become a global supply platform for ocean energy which as section 4 points out could become a huge market. As was pointed out at 3.3, Ireland is

[67] See *The German Miracle Keeps Running: How Germany's Hidden Champions Stay Ahead in the Global Economy* Bernd Venohr and Klaus E Meyer Berlin School of Economics IMB Institute of Management Berlin

[68] *Start Up Lessons Learned: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Different Successful Businesses* Eric Ries, Crown Publishing

[69] *Lean startup* Wikipedia

gradually putting in place the key foundations to support the ambitions outlined above: test sites, policy determinations etc. although there is an urgent need now to progress the long promised consenting legislation while it would be desirable also to advance the Pre-Commercial Technology proposal during the course of 2017.

It is against this backdrop that recommendations in this Paper are made: they are intended to be constructive and to be realistic.

This Paper arose from a general, unquantified but detectable sense of unease in the ocean energy world about the issue of insurance and it was broadened in practice to try and identify other relevant non-financial and non- technical road blocks to the sector's development and growth in Ireland. The nearphobia detected in advance about insurance was well borne out in the interview process with strong concerns being expressed about the availability and cost of 'normal' marine insurance in particular but also about the performance guarantees and warranties which are deemed to be a major threat to the sector. Nonetheless, as the arguments advanced at 10 indicate, insurance could also be an opportunity for 'Ireland Inc.'

Recommendation 1: There is a 'pinch point', a public policy gap, for device and sub system developers in securing insurance (leaving aside performance guarantees etc.). There is a clear need to de-risk this area to the extent possible under legislation etc. for the predominantly small companies involved. *It is recommended that insurance costs should become both an eligible cost (important when reckoning overall grant aid) and, also, eligible for grant aid under the SEAI Prototype Development Fund*.

All of the major firms engaged in the insurance of renewable energy offshore today have a presence in Dublin, notably in the International Financial Services Centre (IFSC). Renewable energy appears to be a profitable, perhaps very profitable, line of business for the international insurance industry[70] and there is an obvious opportunity for Ireland to seek out an 'early mover' position in the ocean energy segment. The potential benefits could include job creation, premium generation (and thus tax revenue to the Exchequer), credibility for the IFSC's ambitions to become a centre of 'green finance' and, finally, add to Ireland's ocean energy reputation and the achievement of our global supply chain ambitions.

Recommendation 2: *Sustainable Nation Ireland* is a blue-chip IFSC based body with the aim inter alia of 'climate finance: mobilise finance and investment into emerging markets using Irish know-how'. *It is recommended*

[70] See 10.6

that a working party be established involving Sustainable Nation Ireland, MRIA, SEAI and other relevant parties to

- *Inform the insurance industry world-wide about the ocean energy opportunity and about Ireland's resources and expertise in the field*
- *Inform the ocean energy industry about the insurance industry's needs*
- *In particular, develop and support insurance product ideas for ocean energy globally thus giving Ireland scope to win global ownership*

It should be noted that the recommendation immediately above is based on ocean energy as an *opportunity* for the local arms of the insurance industry but it should also serve as a credible, and in time perhaps a sympathetic, channel to open up access for early device developers to insurance products.

The Ocean Energy Forum was an initiative by the European Commission and industry to develop a road map for European ocean energy. It is in practice a venture principally involving the Commission and key members of *Ocean Energy Europe* whose secretariat are also involved. Its findings and recommendations – set out in the *Ocean Energy Strategic Roadmap Building Ocean Energy for Europe* published in late 2016 and referenced earlier– are not, at least as yet, Commission policy. Insurance was a key topic on the Forum's agenda. The Forum's insurance working party sought *'the creation of an EU-wide insurance fund…to underwrite risks and fill the gaps in insurance and OEM warranty structures so as to make marine energy demonstration arrays more investable.'*[71]

The Roadmap produced by the Forum recommended the creation of an Insurance and Guarantee Fund to support deployment of the first demonstration and pre-commercial ocean energy 'farms' with an indicative budget of €50m-€70m '*This Fund would not be a permanent construct, and would aim to generate enough knowledge and commercial coverage of risks to make itself obsolete*'.[72] Funding, it is envisaged, will come from both EU and national sources.

The Forum proposal is ambitious in its aims:

'The Fund would insure project revenues in the early years – three to five years at most. Once enough knowledge for a given project or technology is generated, the project developer would be in a position to leverage commercial debt or reinsure his project commercially, thus freeing the Insurance and Guarantee Fund award for the next project, and creating a revolving fund.

[71] *Draft Strategic Roadmap: Design for an insurance fund for first arrays Ocean Energy Forum 12 February 2016* No longer available on line.

[72] *Ocean Energy Strategic Roadmap* op cit. p.48

By focusing on the gaps in existing guarantee/insurance cover from device manufacturer or the insurance market, and for the necessary periods required to bring projects up to commercial project finance standards, a relatively small amount of risk underwriting capital should be able to leverage a considerably larger amount of finance into the projects.

Such a Fund underwriting project risk would cover risks such as availability, output performance, mechanical breakdown and defect. It could also provide long-term decommissioning bonds. It would be subject to suitable acceptance, risk-sharing and criteria……To avoid a free for all approach, a premium would be requested from project developers, though at a reasonable rate to avoid defeating the purpose of the Fund. Limits, self-insurance levels, premium rates and distribution mechanisms all to be agreed upon set up of the Fund'[73]

Very importantly for Ireland, with its population of early stage device developers, the Roadmap proposes a similar approach – but perhaps involving a different insurance product – targeting projects at the early TRL levels

Recommendation 3: *It is recommended that Ireland actively support at Government-to-Commission level, and via the European Transport, Telecommunications and Energy Council, the Ocean Energy Forum initiative on insurance while being cognitive of the likelihood that the initiative will not impact on the bulk of Irish ocean energy enterprises' needs in the short term and that it will also be complementary to Recommendation 1 above. Ireland should also lobby hard to include an instrument designed specifically to support early stage device and sub-system developers in any insurance package determined by the Commission for ocean energy.*

The solution to the various insurance issues dealt with in this Paper are tiedin in many respects to the scale of the companies involved in ocean energy. 'Big' ventures can buy insurance, attract top managers and engineers, and find investors etc a lot more readily than their small counterparts. Companies of scale are needed across the ocean energy spectrum and not just in the areas of device and sub systems development. It is noticeable that this issue arises in some way in every MRIA Paper. For example, in the funding MRIA Paper on funding issues published in 2016, the proposed PreCommercial Development Fund (and the rules suggested for it) is inter alia aimed at helping companies to scale.

It is important to note that Enterprise Ireland is unlikely to undertake, at least at this stage, a specific initiative in the scaling field to support small

[73] *Ocean Energy Strategic Roadmap* op cit P48-49

ocean energy firms – see 11 above for the reasons why this assumption is made. Thus, the scaling solution must be home-grown by the ocean energy industry and related State agencies. The key to growth for most companies in ocean energy is through alliances and partnerships e.g. between complementary small companies; big companies in the energy field and ocean energy start-ups etc. The *OPIN (Ocean Power Innovation Network)* initiative launched on September 1st 2016 is a joint effort to encourage and facilitate such links and is driven by SEAI, ESB, InvestNI, Scottish Enterprise and MRIA in the first instance. The ultimate aim is for industry itself to take ownership of OPIN which would allow the agencies etc. to take a 'back seat'.

Recommendation 4: *The current pioneering founders of OPIN should continue to run the initiative pro tem until an appropriate funding source can be identified and the initiative scaled up to include a full–time secretariat spanning the member jurisdictions.* This recommendation assumes a satisfactory outcome to the review of OPIN scheduled by the original promoters for the spring of this year……all of the indications are that the initiative will continue to be backed.

Recommendation 5: One possible way of helping companies to gain the rigorous engineering standards and general credibility so necessary to attract partners, acquire insurance and to scale is to link up with major consulting companies who can 'partner', albeit on an arms-length basis, promising small device developers. It has been represented to MRIA that current SEAI consultancy fee caps under the Prototype Development Fund are a deterrent to this and should be lifted.

It is recommended that SEAI should review this matter and perhaps run a pilot exercise (with clear measures of success) with a small group of companies to ascertain whether the extra cost involved would be more than offset by measurable positive impacts on companies. Note that the Association is not at this stage actually recommending that the fee caps be raised as it is aware that such developments need to be carefully thought through and proper measures and safeguards put in place.

Recommendation 6: Some of the issues identified during the course of preparing this Paper are of a long term nature insofar as they cannot arise until the core ocean energy technology matures. A typical instance of this is the areas of health and safety and operations and maintenance. The issues raised in these fields during the course of this study are real and will make a big difference in due course. However, it is unrealistic to expect hardpressed agencies and public servants to devote significant time and effort to ocean energy at this stage. But…. there is a curiosity about ocean energy in relevant agencies and it would be wise to tap into this and to open a dialogue in relevant fields, particularly those just mentioned, at this stage.

It is recommended that ocean energy interests open a dialogue with the Marine Survey Office (already agreed in principle by the Department of Transport, Tourism and Sport) and with the Health and Safety Authority. The lead for this can be taken by MRIA and involve other relevant bodies such as SEAI.

Appendix 1: List of Bodies Interviewed

INTERNATIONAL

Black &Veatch

Carnegie Wave Energy

Scottish Enterprise

Nautricity

UK Marine Energy Catapult

Myton Systems Ltd

Lloyds

ECORYS

EMEC

RenewableUK

Swiss Re

Puremarine

Willis Insurance

Ocean Energy Europe

IRELAND

Blue Power Energy

ESB (x 2)

Commissioners of Irish Lights

MaREI

UCC

SmartBay

Doyle Kent Partnership

Oceans Consultancy

NOW Ireland

Benson Engineering

OpenHydro

Seapower

Andrew Parish

Arthur Cox

Technology from Ideas

DP Energy

Enterprise Ireland (x 2)

Ocean Energy Ltd

Department of Transport, Tourism and Sport

Marine Institute

Sustainable Nation Ireland

Appendix 2: Further Opinions of Stakeholders

A. STATE OF THE INDUSTRY

'Wake the market up with an advertised PDF Call'

'We need to put Ireland on the ocean energy 'radar screen'. The best way to do this would be to develop an offshore pilot project. It would help to get over the fragmented nature of our effort which is sub-critical in size'

'Still getting enquiries for support from the wave sector in particular, notably projects at the lower TRL level'

'An important policy point to remember is that there are very few industries that Europe has a leading, the leading, place in. As long as there is private investment interest in ocean energy, Scottish Government will stay involved'

'The previous National Coalition Government was very supportive of ocean energy and we don't have that anymore but the Scottish Government remains just as committed as before. Policy is more positive in Scotland than in Ireland or France. Interestingly, UK Government is very conscious of the cost to consumers of renewable energy support and about energy security…not as interested in carbon reduction agenda. Also, worth noting that economic development is not part of the DECC remit. Scotland, on the other hand, is more interested in community projects, wants to support new projects, open up new opportunities and is open also to small-scale projects'

'New Scottish Government is looking for a new energy strategy and there is a big drive on to get more European funding. A new renewable energy investment fund is about to go through and will be announced soon'

'Marine Scotland is very helpful to ocean energy although there have been some complaints about the cost of EMEC but it gives access to top class standards, certification etc. A very false economy for device developers to undertake testing themselves – need support of a facility like EMEC'

'A UK frustration is that we have no sight beyond 2016 of CfDs. The real issue here is getting sufficient people behind the issue and generating real momentum with policy makers'

'A big issue, particularly given the state of development of the industry, is our inability to provide price guidelines for turbines as the turbines are still at the technical iteration stage and we have no volume production'

'There will be no arrays this side of 2020 greater than a total deployment of 5 MW. As we approach 2025, there will be a build-up. In tidal the commissioned cost per MW at the moment is likely to be €4.5m compared to €3.5m for offshore wind – we need big cost reductions'

'Ocean energy is becoming more difficult (in the UK) with issues such as Contracts for Difference; investor confidence etc. Very hard to 'tie' various pots of money- particularly from different jurisdictions -together to support projects – Canada is the worst offender in that regard'

'Ocean energy technology is in the laboratory and the issue is to get into the water and to last'

'There are huge opportunities in marine technology that will be lost unless resources are put in at this stage'

'Wave is a long way behind tidal but two or three companies are now making moves and have or are about to put kit in the water…WES and US Dept. of Energy calls are seeking innovations'

'The European Commission is not interested in anything other than mainstream electricity generation'

'EU should set measurable stage gates and not focus on TRL levels for ocean energy'

'…the suggested SET Plan targets for LCOE are a concern. We can have a target but we will need to do A, B and C to get there and there need to be measures for these inputs too'

'CfD is the big problem. There is a lack of a coherent UK policy and grand strategy is being dealt with at an EU level and the lower level strategy at the devolved Administration level'

'If you leave MeyGen out of the equation, then the likelihood is we will see 30 MW of ocean energy deployed in coming years against a public figure of 100 MW'

B. INSURANCE

'Galway Bay (Smart Bay) should look after insurance etc. for clients i.e. be a one stop shop. At the very least appoint a specialist insurance broker for all Galway Bay clients'

'Had difficulty in insuring wave rider buoys. Insurance industry in Ireland doesn't understand ocean energy'

'As experience of the (ocean energy) technology goes up, premiums will come down'

'Indications are that insurance costs offshore e.g. for wind turbines are ten times those applying to similar installations ashore'

'ESB will insist on top standards when engaged in ocean energy: we won't compromise our requirements in regard to insurance, guarantees etc.'

'The area of standards and certification needs to be kept under review'

'CIL insures its own buoys and requires customers in instances where they install buoys for third parties to insure their own. Buoys typically comprise of a 'bowl', day mark and sensors'

'CIL self-insures and then joins with Northern Lighthouse Board and Trinity House in regard to vessels. The three authorities have 772 buoys altogether with CIL accounting for 145 of these. They insure against total loss, ship time

(to deal with casualties), general liability up to €230m and professional liability'

'There is a 3 year contract (currently via Willis) with 2 x 1 year extensions possible'

'Look for one year standard guarantees from AIS suppliers which cover electrical faults. We go for standard well known suppliers and not innovators'

'The device reliability required by the ESB under the WestWave project is simply not available at present'

'The cost of insurance is an issue for small developers'

'Concerning warranties and guarantees, manufacturers in offshore wind maintain devices for the 5 year warranty period and then depart. They don't shore the data re failures etc. with the follow on O&M contractors'

'Clients usually want MaREI to certify their output and this is not and cannot be done but, interestingly, SFI has funded MaREI to develop ways of doing more development work in the LiR tanks, for example, and less in the water in order to save costs and to de-risk projects via simulation'

'Insurance is an issue – Seapower have to have insurance for wreck removal, devices, public liability – all unlikely to be a problem. Insurance for cables is, on the other hand, going to be very difficult. We will be better informed when Seapower go out for insurance'

'The problem for small, early stage developers is certification by DMV etc. Advising developers to follow DMV guidelines'

'SmartBay has blanket insurance for any moored wave energy device but next lease application to DECLG [now DHPCLG] will deal with a range of devices'

'An important issue is that major engineering consultants such as B&V and others are independent integrators and this is particularly important for the credibility of device developers with insurance/warranty etc. requirements'

'Had insurance issues (in Australia). Very costly, would be better off self-assuring?'

'There are specific insurance companies who specialise in the sector - the ultimate issue is about risk assessment in an unnatural environment'

'We don't have a fix on insurance'

'Anyone getting to ¼ scale needs advice on how to address issues such as insurance e.g. SmartBay require minimum of €16.5m wreck insurance + public liability insurance - where is that to come from?

'Insurance not an issue yet as we are 'leaning' on DCNS but performance guarantees are a concern'

'Insurance for ocean energy is a problem for deployment projects, not for devices per se. Warranties and guarantees will be a problem for the industry given that devices have to last as much as twenty years. Ocean Energy Europe is looking at the issue of insurance as part of the Ocean Energy Forum exercise, although this is focused on the 'mature' end of the industry'

'*At a high level, the sector is still emerging and it is difficult to talk about insurance issues as the risks are not yet clear or quantified'*

'In technology + site developer scenarios, the promoting company takes all of the risks and all of the rewards'

'Site developers want performance guarantees as the early technology will be seen as posing a high risk'

'Be very careful not to put the cart before the horse in terms of setting standards. In automotive or aviation fields, lots of miles are driven and hours flown before standards are set for new technologies. We may set standards for an elephant where it transpires that a tiger might be better, more efficient! Disagree with EMEC on this point'

'There is a need for open signposting to de-risking. Many projects involve massive leaps of faith on issues such as trenching etc. to get great (theoretical) Levelised Costs of Energy. Many promoters don't know which part of a wave they get their energy from. Need to provide/use a benchmarking service to test projects against prior projects and LCOE plans'

'…the challenge in insurance is to get key insurance companies to take a different view e.g. with respect to the MeyGen project'

'Need to use any insurance fund that may emerge to deal with deployment vessel weather risks'

'Resource certainty is needed for insurance. SMEs could get insurance based on a particular known technology if there is a clear resource. We could get close to that in tidal due to the certainty of any given tidal regime'

'Performance guarantees are going to be important but we are still a long way from needing them. Any investment in ocean energy will not be low risk'

'We are fixated on the CfD problem and so no engagement with the insurance'

'The ratio of component insurance v the cost of the device is important and this goes to the issue of reliability and the risk of single component failure taking out a device'

'There is a need to educate the insurance market on where the risks in ocean energy devices are'

'Insurers won't cover development costs - if devices breakdown, that will be an OEM cost'

'The first thing in regard to performance guarantees is the need to be able to measure performance effectively'

'No insurer will insure a product unless they know and understand the product intimately'

'Started to look at offshore wind insurance in 1991 in Denmark. There were no standards, no view on what is best practice. We started in offshore wind by examining all claims coming in, including from onshore wind and worked with risk engineers and underwriters to figure how to proceed –bear in mind that the early offshore turbines were only c300 kW each'

'SEAI won't grant aid projects that are not insured. Have insurance for total loss and won't do professional indemnity. Haven't enquired so far re warranties and performance guarantees'

'A big issue is that SmartBay require third party vetting of the calculations which lie behind a device. Went on for months. Marine Institute had to go to tender and retained Wood Group Kenny'

'The requirements and standards required by SmartBay need to be codified, bearing in mind that they only deal with ¼ scale projects'

'We do need a third party evaluation of performance and would like to use MaREI but they seem overrun with work'

'The major oil and gas companies mutually self-insure through a pooled insurance scheme called OIL. Members self-insure for the first €150m of a claim'

'Biggest problem in dealing with a new category in insurance is breaking down the silo barriers between risk engineers and underwriters'

'The initial regulatory system i.e. standards for offshore wind was drawn up by the Danish Technical University of Research and dealt with issues such as materials, gearboxes etc. and this led to an A, B and C level of standards – A applied to prototypes etc. This work led to the various international standards today'

'An important issue for the evolution of wave and tidal is that offshore wind in the early days (1992) in pioneering Denmark involved ten turbine manufacturers (not exclusively wind) and today there are just two (Siemens and Vestas) which makes it easier for the insurance industry'

'Swiss Re has only 6 people involved in offshore wind insurance – needs expertise and underwriters must see at least 10 submissions a year'

'…The risks break down into two categories: construction (particularly installation) and operations. The construction area is the much riskier of the two'

*'Insurance: no problem for marine; haven't encountered performance guarantees or warranties yet but intend to pass them back to the turbine (*third -party supplied element of the device) *suppliers'*

C. SCALING

'Need large consultancies (e.g. DMV; B&V) to engage with small developers. WES requires 'Third Party Viewing' on projects'

'Wave Energy Scotland's public procurement approach allows large consultancies to work with small device developers as a sub-contractor at commercial rates. The US Department of Energy schemes allow for similar arrangements'

'The PDF needs a revised formal framework which defines the Fund more clearly, documents their expectations, states the measures of success…..Wave Energy Scotland does this via their 5 stage protocol'

'The main barriers to ocean energy are technology issues. The device developers in Ireland are at an earlier stage (than Scotland?) and they are sensitive to IP issues'

'Small device developers need good teams and these cost money and the route of partnering with a major consultancy is one way of doing so in a possibly affordable manner – Ocean Energy Ltd is a good example of this approach at work'

'Any marine energy project must have a route to market, a positive Government policy, a strategic partner, a support mechanism such as CfD, a schedule of operations and a signed lease offer'

'No one in wave energy today has the resources needed to develop the sector. We need to look at any business model and to be open to partnerships'

'A key to success would the entry of larger companies into the mix and, indeed, picking up 'vibes' about renewed interest from this quarter. In addition, the US is taking a bigger interest in ocean energy than in the past…if this builds up, then watch out!'

'Problem with 'Green Sustainability' funds etc. is that they want the Green but not the risk!'

'Ocean energy is a big challenge for device developers as they have to become expert site developers as well and this requires a different set of skill sets' 'Sensible approach is to first identify a high performance solution at lowest TRL possible and then scale up. A professional systems engineering approach will prevent unintended consequences – e.g. proper analysis and linkage of PTOs, communications, mooring etc.'

'Scaling is an issue and an advantage for Scotland is that the Renewable Energy Investment Fund has the ability, which it inevitably exercises in wave and tidal to put in a non-executive director to companies in which it invests' 'Investors should focus on Unique Selling Points and not on anything else'

'In Japan, there are a number of consortia funded by the State to run with significant technologies but all are led by large companies e.g. Mitsubishi'

'Utilities will get involved with ocean energy at this early stage if they get tax incentives to do so'

'Wave energy needs tidal energy to succeed. Continued funding support is needed across all sectors'

'Ocean energy companies need to use external expertise with practical knowledge and not just desk-based consultants'

'There are silos in the development sector e.g. wind but people are forced to collaborate because of small number of sites. There is huge distrust in ocean energy and the issue is the competition for resources. Not sure what the solution is and there is also the problem of posturing'

'Technology Transfer offices in the Universities are the worst offenders in regard to IP issues'

'It is noteworthy that Wave Energy Scotland worked well to 'save' the IP generated by Pelamis and Aquamarine Power'

'The lack of engineering road mapping is a big barrier to ocean energy development. Wave-systems problems are systems problems. Far too much concentration on TRL at expense of consideration of Technology Performance Level e.g. Levelised Cost of Energy, output v cost'

'If you have money to support a start-up wave or tidal device project, then first identify a real customer need and the system requirements and design will flow on from this'

'Enterprise Ireland's scaling programme allowed the agency to identify the levers necessary to develop an agenda of change for individual companies. The population of potential clients was never large – perhaps 100 companies'

'EI's scaling activity was very intensive for both companies and for the agency'

'We (EI) now have a new engagement model with companies which addresses the challenge of 'how do we take the learnings we have from scaling and diffuse them to a range of companies''

'Features of companies that successfully scale include a clear value proposition, perhaps a capacity to find and execute appropriate acquisitions, have minimally viable products'

D. CONSENTING

'Another issue to watch out for is dealing with the Environmental Protection Agency and e.g. environmental liability assessments and aftercare management plans which could lead to a bond requirement'

'WestWave to generate 5 MW for 15 years. There is no designated SPA or SAC. AMETS SAC designation may cause issues up to the 50m water mark level- some new devices will deploy at 10-20m. The designation concerns the bottlenosed Dolphin.'

'EIA is dealt with on a case by case basis as DECLG are taking a cautious approach and this impacts adversely on everyone'

'Provision of guidance on EA etc. probably held up by need for a public consultation and about governance issues such as which agency issues the guidance'

'SACs are determinative i.e. if adverse findings, then a project cannot go ahead at the location at issue. Making a case is hard and requires lots of scientific evidence. There is no outright ban on activity unless an adverse finding'

'EIA is the baseline but DECLG does the assessment and sets the conditions'

'Interestingly, the aggregates industry pays into a fund each year to address environmental etc. research needs as does the oil and gas industry in Ireland with the funds going to R & D in the universities. Something like this might be appropriate and helpful to marine energy'

'Marine mammals are typically 'make or break' concerns and therefore are well protected'

'90% of the Irish coastline has a designation and ocean energy developers are likely to have to do an AA which is specific to the designation – plant or animal. The impact on the local population is the key issue and to assess this you need to know what the national population is'

'…we need to look at the various EIAs done since the 1980s…. what have we learnt? We need to make policy on an adaptive basis'

'Consenting is potentially a big issue. SmartBay have put in for consent to provide for floating wind turbines and these got a bad press…seeking consent for SB for next 35 years'

'The role for DCCEA in consenting has yet to be sorted out. Generally, the consenting bill needs a push and the general principle of ocean energy projects going to An Bord Pleanála..... (which) apply under the Strategic Infrastructure umbrella will still apply'

'The National Parks and Wildlife Service is not the problem but rather the legal framework (the Habitats Directive) and its interpretation by the European and the Irish courts'

'There is a huge amount of work to be done before a submission e.g. before a consent is sent in and we are not happy with the number of amendments required over trivial things where there is nothing intrinsically wrong about the project. It sends a signal of uncertainty to investors. There is a real need to educate people in the 'system' about ocean energy'

'Our experience in Canada in terms of getting consents is good - we are dealing with a test centre which has blanket approvals'

'Getting good, specific data is a challenge e.g. resource data- our requirements are very specific'

'After funding and technology challenges, the biggest blockage to ocean energy is regulation. We need pilot zones but note that e.g. EMEC won't build the industry - they do the background zoning, invite companies to the zone for one year demonstrations, set milestones etc.'

'There should be one permission where a device is connected from the sea over the foreshore and on to the land beyond and not a separate Foreshore Licence and a Planning Permission. A further issue is that the land beyond the foreshore which will be impacted by ocean energy must be zoned correctly in advance'

'There is a current lack of clarity on what Environmental Assessment is required for full arrays v test instruments for example. There is little accommodation for time limited devices or small scale arrays. It is a moot point as to what happens at test centres- original test centre EA to cover every client who meets its standards? Guidance on this issue may arise from the working party on EA under the OREDP steering group'

'Department of Housing, Planning, Community and Local Government are the custodians of the data and should have data available. But their attitude is that 'you are going to disturb the environment, therefore you should collect the data'. A further underlying issue is that regulators around the world do not get many ocean energy or marine energy applications at present so why should they expend the resources needed to collect data?'

'The 2 year long studies required in guidance documents have no scientific basis…it is actually more useful to study populations on a seasonal basis. One interesting fact is that the population of a particular species in Strangford, Northern Ireland (site of an early tidal device) *was deemed to have fallen over 2 years but this turned out to be in line with a trend which had seen the population fall over the previous 10 years'*

'The process of getting projects in the water everywhere is very chunky and tough. Get the impression that documents are being sent back, particularly in Scotland as part of a 'holding pattern'. Just keep things ticking over seems to be the attitude. In one instance, we received 900 comments – all of a minor nature – from the case worker'

'No problems at our (name supplied to MRIA) *site as long as we adhere to local environment protocols'*

E. HEALTH & SAFETY / OPERATIONS & MAINTENANCE

'Health and Safety standards will be rigorous for ocean energy: we don't allow any of our own staff to go offshore unless they do the relevant survival courses beforehand'

'Everything ultimately comes back to Health and Safety. In Scotland for example developers seeking a lease from the Crown Estate must demonstrate that they have a robust Health and Safety policy, plan etc.'

'*The UK Health and Safety Executive has a lot of stuff developed re offshore wind farms. There are many issues with Health and Safety and marine energy e.g. danger of small boats broaching when butting against a pillar'*

'Lot of conventional Health and Safety is based on a steady environment e.g. working with racking in a warehouse. Offshore, everything is moving and risk assessment needs to take account of this dynamic environment and also of common sense'

'UK guidelines on Health and Safety for offshore wind are gold-plated. The offshore interface involves the Maritime & Coastguard Agency dealing with vessels and the Health and Safety Executive dealing with structures on the seabed'

'Diving regulations will impact on the ocean energy sector. Diving regulations in Ireland are not suited to the ocean energy purpose'

'On the Health and Safety front, we are employing an expert and doing a risk assessment and safety statement'

'There is a great opportunity to test and fine tune both maintenance and Health and Safety using virtual reality and simulation'

'Health and Safety is not an issue for EMEC who have been leaders on the issue and who have been pro-active with the regulators in the UK - failure to interact would have led to problems by this stage. Health and Safety should not be a show stopper if properly handled'

'RenewablesUK is the leading organisation for Health and Safety in offshore renewables etc. and are ISO accredited'

'A big issue for offshore wind in its early days was safety'

'It will be a huge issue if H&S determines that devices have to be unmoored and towed to a port for maintenance. Will impact adversely on the economics of ocean energy'

'There are lots of maintenance support issues specific to wave and tidal e.g. articulated devices are very challenging, corrosion and marine growths will be a big problem'

'We do need to involve the Marine Survey Office and we have no idea about how to go about this'

F. OTHER

F.1 Funding

'Our main problem has been finance. We started in 2006; initially got support from Enterprise Ireland under the Innovation Partnership scheme and then got an innovation voucher before moving into SEAI's schemes. Other issues to hit us en route included Nantes's price was three times greater than anticipated while we had to wait nine months for Plymouth to come on line'

'No point in seeking venture capital until we have a device that is demonstrably viable and so the big issue for us is to get c€0.25m needed at our end to get through ¼ scale testing at SmartBay'

'A progressive build-out is the way to go for device developers e.g. start at ½ MW and then in a second round build, say, 6 MW - this approach allows for debt funding and reduces equity dilution'

'The NER300 model is naïve. The Scottish Government is capitalising part of NER so that they can give money up front to developers'

'LCoE needs to be tied to the time of day when power is available – key for renewables'

'MeyGen is an interesting case study for the industry with all of the external investment coming from the AIM on which parent Atlantis is floated so the investors are watching the share price and not the project per se'

F2. Decommissioning

'Deposit of decommissioning bonds with DECC in UK is a disincentive'

'Decommissioning bonds are part of the cost of testing devices'

'We will seek to cover decommissioning costs out of the cost of the device being scrapped'

F3. Vessels

'The UK Work Boat Association worked with the MCA on regulations for work boats working with marine energy, effectively wind energy but a UK work boat seeking work in Ireland would not be passed by the Marine Survey Office who would see it as a passenger vessel. Marine energy work boats require skippers who are used to working with cargo, for example, in challenging wind conditions'

'It would be a huge boost if the EU were to acquire a vessel which could provide installation and O&M services to early ocean energy deployments'

F4. Public Engagement

'Community engagement is a big issue'

'These marine energy projects are complex and take time – typically around eight years even if policy frameworks etc. are in place'

'Local consultation is a critical issue - Oriel to date has made 390 different submissions and held 90 meetings with local interests'

'There is a need for more knowledge engagement and outreach. As a country, we need public engagement and knowledge of the opportunity around our shores'

'There is awareness of ocean energy in the small (Irish) ocean energy community and in Government Departments engaged in marine renewable energy but there needs to be wider awareness'

'A central vision is needed – a GDP target for our marine resources should be set'

F.5 Miscellaneous

'R and D is undertaken by Trinity House'

'No case for a pool of rentable test instrumentation – not sensible; test instruments tend to get lost and the issue of insurance – how much, who does it – therefore arises. In fact, at Beaufort, clients look for the university to insure everything!'

'The macro issue is that major marine energy deployments off the west coast (of Ireland) will reverse population flows from west to east. The relevant

precedent is the way in which the economic fortunes of the east coast of Scotland were transformed by North Sea Oil and Gas. It provides a chance to develop the local supply chain e.g. ports'

'In the offshore wind industry, the typical position is a 55 year lease (two sets of turbines with a 25 year life each) plus c5 years for decommissioning'

'Responses by SEAI to grant applications are too slow though improving'

'It is very difficult to get numerical modellers at a reasonable price'

'Concerned about the potential cost of access to AMETS'

'We need decent numerical modellers - who are the experts in Ireland? In fact, we need a list, a tender panel to deal with numerical modelling; naval architecture; insurers (if they exist)'

'….other issues: deployment vessels – very expensive; test instrumentation for rent would be helpful; the planned SEAI 'platform' in SmartBay would be desirable but seems to have run into problems; better communications with the industry'

'Other concerns are about the availability of suitable ports, grid access and the issue of 'split consents' i.e. different consents required in the water and on the land for the same project'

'The availability of equipment suitable to ocean energy is an issue e.g. fish sonar. This is the kind of issue OPIN could deal with'

'A big issue for us was the requirement to do survivability tests at 1/15 scale in a tank – it can't be done. We now going to do it at ¼ scale in Smart Bay'

'Next stage for us is AMETS but haven't yet reached the stage where consenting is an issue''

'Biggest problem (Scotland) is grid access where there is little progress'

'The rules and regulations around construction techniques e.g. monopoles are built on onshore energy etc. requirements and this leads to the overengineering of projects. The same thing happened to composites – no regulation codes for composites in marine engineering and this lead to misconception about high costs etc.'

'One issue for academic institutions backing up ocean energy is that the staff are preoccupied with writing funding applications. They need a long term funding pot…. MaREI has that to some degree but more is needed'

'Other issues – grid connections e.g. the grid connection for Fair Head (tidal site) will cost £44m; tariff supports; need for well executed policies e.g. through

instruments such as Marine Scotland; don't underestimate the NIMBY factor e.g. in Orkney'

'An issue to watch out for as developments move over the horizon is the potential for accidental (or otherwise) damage to devices - need for monitoring and security arrangements'

'Who is going to be responsible for security of devices? Who is going to monitor and enforce compliance with conditions set? All are key issues in maritime law'

'Licensing and consenting are a big risk. This risk may even cost us test sites such as Galway Bay or AMETS if it is not addressed. Lack of consenting also has a knock on effect in terms of niche and early markets for wave and tidal technology'

'We could be providing power for aquaculture but the licensing regime for aquaculture is not enabling this market in Ireland'

'MSO and OHS may introduce issues that are inapplicable to ocean energy (e.g. defining a unit as a ship under Irish Flag may introduce need for hand rails, illumination etc.)'

'Hindrances as part of system, lack of process, lack of procedure and lack of legislation

'Clear, transparent well signalled procedures are a must'

'Follow the recommendations of the Our Ocean Wealth development task force and create a Marine Coordination Team and supremo. IDA do this for large FDI projects so the model must exist in government. The supremo must have some powers to coordinate'

'MSFD Directive and the uncertainty of Irish implementation are an issue. Same environmental Directives are applied differently by different Member States. Needs constant monitoring of unintended consequences'

'Lack of committed engagement from large industries & OEMs is an issue'

'Insurance is not really a problem for the projects going into the water in terms of 'wreck plus all-risks'. Warranty is an issue simply because the projects are not commercial and vested interests are promoting them as commercial. Insurers see the warranty risk as too risky at this stage due to technical immaturity'

'Should not have a pooled insurance warranty fund as this is furthering the notion that these projects are commercial as opposed to R&D or pilots. Creating a pool is gambling with tax payers money. Partners can do it from balance sheet as they should see it as part of the project cost. Without this projects will not be financeable'.

'The aspects of Offshore are in two parts really – the construction phase where there can be a multi-billion sum insured for large projects with value of 100's of turbines plus cables plus land-side facilities. This can amount to multimillion euro premiums. Then, in the Operation phase, the premiums are smaller'

'Warranty is for physical loss or damage and doesn't normally extend to loss of business'

'Large companies like SSE tend to self-insure some of the phases, especially performance guarantees'

'Codan in Denmark are large insurer of offshore wind'

'Issue in wave and tidal is the S&P rating of the developer looking for funding. Typically, in offshore (wind) this has been large companies and utilities.

'There is a demand by lenders/insurers to see 5 years of previous financial reports to ensure stability'.

'…the insurance industry is pragmatic and it will watch wave and tidal as it develops'

'Currently there is a trend for the principal in insurance situation to pass risk further down the chain and to squeeze contractors'

'Wave and tidal is in its early days and is not commercial. There is no massive prospect for the insurance industry in the short term but we are interested in developing a long term relationship with sector'

'There will be enhanced premiums in wave and tidal due to risk on the assets. Third party liability is seen as the big item. For example, the Crown Estate requires a minimum coverage of £5m of third party liability'

'Insurers tend to use layering for large risks and this tends to share the risk amongst a number of underwriters'

'…Although asset values in wave and tidal are low (cumulatively compared to other sectors) the deductibles on policies are much higher e.g. £100k on £10m which is a lot for a small company given they have paid a premium too. This is a corporate decision so educating the insurance underwriters would be worthwhile'

'…… several of the key insurance companies in offshore energy are already in Dublin. Allianz, Zurich, RSA, Travellers, Willis. They could be interested in a brief but could develop near term products that would share risk amongst them. Government bond in this area would be an incentive for this'

'One of the issues in Enterprise Ireland's scaling programme is that companies went into it and never came out again!'

'Scaling in Enterprise Ireland was successful with a quite narrow range of companies but there is not a large pipeline of appropriate new entrants. Enterprise Ireland is now re-organising around the stage of growth of companies'

'The common issues in whether or not companies are successful at scaling e.g. to 250+ jobs include: building a management team; an effective middlemanagement team; a robust MIS; a clear strategic focus; most of the issues, in fact, revolve around the management aspect'

'Partnering is important: small companies find it hard to achieve on their own even where the opportunities are obvious.