Marine Renewables Industry Association

22 December, 2019

Submission to Public Consultation on *Long-Term Strategy on Greenhouse Gas Emissions Reduction*

Introduction

The Marine Renewables Industry Association (MRIA) represents the Marine Renewables Emerging Technologies (MRETs) of wave, tidal and floating wind[1] on the island of Ireland. More details may be found at www.mria.ie while MRIA is located on Twitter at @Marineireland. This Submission deals only with those questions set by the Consultation which are directly relevant to the MRETs and places a particular emphasis on wave energy; tidal energy - for technical reasons dealt with later - is likely to make only a modest contribution to Ireland's future energy needs. Floating wind is an advancing new technology with enormous potential in several spheres e.g. its distance from shore reduces visual impact; there is scope to develop a floating wind manufacturing facility in Ireland with positive implications for jobs and export; and the scope (already being examined by industry) to establish offshore hydrogen plants powered by floating wind[2]

The *Offshore Renewable Energy Development Plan* (OREDP) captured the potential of Irish marine renewable energy perfectly:

> *With one of the best offshore renewable energy (wind, wave and tidal) resources in the world, there is very significant potential in utilising these resources to generate carbon free renewable electricity. The development of*

[1] Wave + tidal energy = ocean energy + floating wind energy = marine renewables experimental technologies + bottom-fixed wind and 'hybrids' of wind and wave = marine renewable energy or marine energy or offshore renewable energy.

[2] The resultant hydrogen would be transported by converted oil tankers and used to power electricity generating stations located at or near to ports. A successful experiment in this area is underway at Orkney in Scotland.

this offshore renewable energy resource is *<u>central to overall energy policy in Ireland</u>*[3].[4]*......*

The case is made here, particularly at 2. below, for a major contribution by wave energy and also floating offshore wind to a move to net-zero emissions by 2020.

Q 2 What advanced technologies, across all sectors, could support a move to net-zero or negative emissions by 2050?

2.1 Resource

The island of Ireland has about one-third of all of the current European Union's total renewable energy resource based on all sources of energy[5]. The offshore resource of wave and wind in Ireland is of remarkable scale.

Table 1: Ireland's marine renewables resource. Source: OREDP[6]

Assessment Area	Total amount of development (MW) that could potentially occur within each assessment area without likely significant adverse effects on the environment (taking into account mitigation).				
	Fixed Wind (MW)	Wave (MW) 10 to 100m Water Depth	Wave (MW) 100m to 200m Water Depth	Tidal* (MW)	Floating Wind** (MW)
1: East Coast (North)	1200 to 1500***	–	–	–	–
2: East Coast (South)	3000 to 3300****	–	–	750 to 1500	–
3: South Coast	1500 to 1800	–	–	–	6000
4: West Coast (South)	600 to 900	500 to 600	3000 to 3500	–	5000 to 6000
5: West Coast	500	5000	6000 to 7000	–	7000
5a: Shannon Estuary	–	–	–	Limited potential	–
6: West Coast (North)	3000 to 4500	7000 to 8000	6000 to 7000	750 to 1500	7000 to 8000
Total Development Potential (MW) (without likely significant adverse effects)	**9800 to 12500**	**12500 to 13600**	**15000 to 17500**	**1500 to 3000**	**25000 to 27000**

[3] <u>Emphasis added</u> by MRIA

[4] *Offshore Renewable Energy Development Plan,* February 2014 Department of Communications, Energy and Natural Resources

[5] Siemen's presentation, attended by MRIA, on file

[6] *Offshore Renewable Energy Development Plan* op cit

2.2 Potential of emerging technologies

Ocean Energy Europe (www.oceanenergy-europe.eu) reports[7] that there is a 14 GW - 26 GW potential of wave and tidal capacity in Europe even if not all technological barriers are overcome and this includes forecasts of 5 GW of wave potential in Portugal; 10 GW of wave and 3 GW of tidal in France etc. Towering over every EU country in terms of potential for wave energy is Ireland with a forecast wave potential capacity of 14-31 GW together with up to 3 GW of tidal energy. The Irish resource is set out in detail in Table 1 above. It should be noted, however, that Northern Ireland has a substantial tidal resource whereas the lower tidal flows in the Republic of Ireland require significant further technological development before cost-effective exploitation can take place.

In addition, Ireland is one of the world's best locations for offshore wind:

- ✓ *High wind speeds*, average 10.2m/s, and > 9.5m/s in many regions
- ✓ *Large potential* >35GW (no likely significant adverse effects on environment.)
- ✓ *High full load hours*: > 40%, floating wind to exceed 50%.
- ✓ *Near shore sites*: Low Installation, O & M costs.
- ✓ *Floating sites*: More potential in cost reduction
- ✓ *Multi-disciplinary capacity*: MaREI, Lir NOTF & industry partners

2.3 Economic Benefits

There are clear, well documented and substantial economic benefits to be derived from exploiting the resource outlined both to meet domestic energy needs, to enable major new exports and to prompt the emergence of a global supply chain base in Ireland.

There is a remarkable confluence of informed opinion regarding the long-term potential of ocean energy (wave and tidal) notwithstanding modest progress to date. *Ocean Energy Europe* has estimated that 100 GW of ocean energy could be installed in Europe by 2050[8]. *The Carbon Trust*[9] has projected that, as a high scenario, a cumulative, undiscounted market, of £460bn in wave and tidal is

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[7] *Industry Vision Paper 2013* Ocean Energy Europe
[8] *Industry Vision Paper 2013* op cit
[9] *Marine Renewables Green Growth Paper* Carbon Trust 2011

possible up to 2050 with the market reaching up to £40bn pa by then. This is based on estimates of 189 GW of wave and 52 GW of tidal energy being installed by 2050. The latest EU, *Ocean Energy Strategic Roadmap*[10], forecasts are similar. The *International Energy Agency*[11] estimates a worldwide potential of up to 200 GW of wave (65%) and tidal energy capacity, again by 2050. The global firm *EY* 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 grow 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'[12].

The most recent study[13] by the British Government sponsored *UK Offshore Renewable Energy Catapult* in mid-2018 forecast 4,000 new jobs in UK tidal energy by 2030 and 14,500 extra jobs by 2040; the equivalent figure for wave energy in 2040 is 8,100 new jobs in the UK alone. This report set a UK target of 1 GW of tidal energy by 2030 and 1 GW of wave energy by 2040.*Regardless of source, expert opinion believes that the ocean energy market will be enormous in 20 years' time.* MRIA believes that, based on reasonably comparable development experiences[14] so far....and the long-term forecasts for ocean energy by creditable sources and institutions.....ocean energy will become a major enterprise opportunity for Ireland, certainly from 2030 or so onwards.

The economic potential of floating wind is also enormous, as is illustrated by Figure 1 - Equinor is Norway's esteemed State energy resource company.

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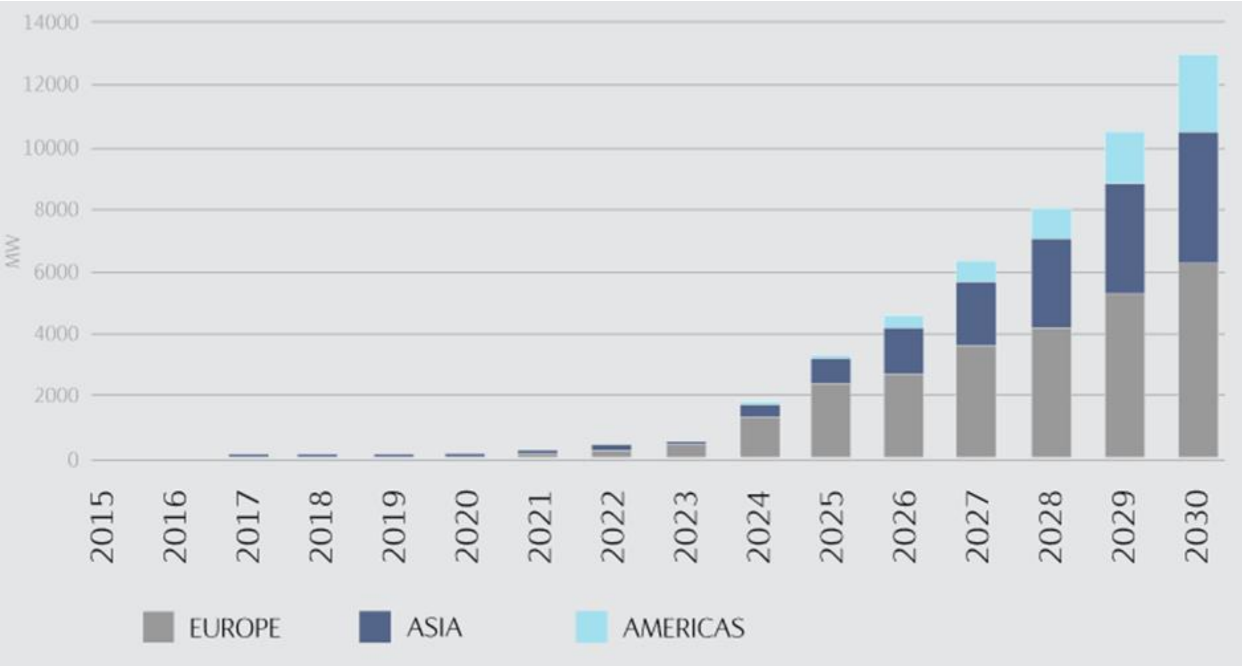
[10] *Ocean Energy Strategic Roadmap Building Ocean Energy for Europe* 2016 Ocean Energy Forum
[11] *Energy Technology Perspectives 2014* International Energy Agency

[12] *Rising Tide – global trends in the emerging ocean energy market* EY 2013
[13] *Tidal Stream and Wave Energy Cost Reduction and Industrial Benefit* May 2018 Catapult Offshore Renewable Energy
[14] The MRIA has examined in detail the development of offshore wind and has drawn well-founded parallels with the ocean energy experience so far and forecasts for its future. See www.mria.ie/publications

Figure 1: Forecast market for floating wind. Source: Equinor



2.4 Technical progress

The journey down the technology and cost 'learning curve' of fixed offshore wind is illustrative[15] of what can happen to an energy technology once it 'industrialises'. This point is well made by recent UK Contract for Differences (in Irish terms, RESS) auctions involving bottom-fixed wind which delivered dramatically lower prices compared to previous auctions e.g. as recently as 2015. The nascent marine renewables emerging technologies - wave, tidal and floating wind - have the potential to reduce costs significantly once their technologies mature and they start to scale.

The research literature[16] suggests that ocean energy is in the 'formative phase', which is characterised as an 'era of ferment' with *'intense technical variation and selection, initiated by technological breakthrough and culminating with the emergence of a dominant design……the number of firms increases while sales remain relatively low'*[17]. This is the stage ocean energy is going through today while floating wind has moved on to the next phase.

The next phase for wave and tidal typically sees a transition from experimentation and pilot products to an upscaling stage which can see big increases in unit size of a technology and a reduction in the number of actors.

[15] See MRIA's *Submission to Department of Communications, Climate Action and Environment* about the *'Mid-term Review of the Offshore Renewable Energy Development Plan (OREDP)' Consultation*. Available at www.mria.ie/publications

[16] Captured particularly well in *Measuring the duration of formative phases for energy technologies* Bento and Wilson published in *Environmental Innovation and Societal Transitions Journal 2016, Vol 21, pp.95-112.*

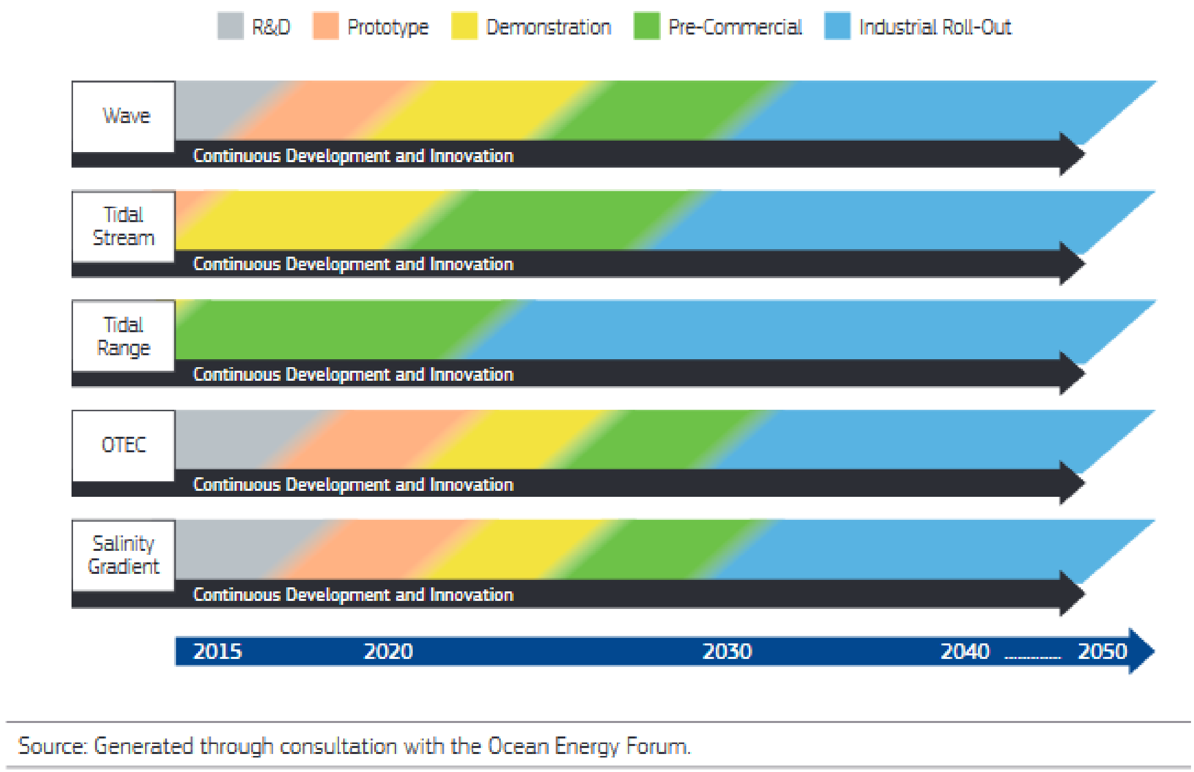
[17]Bento and Wilson op cit

This is the phase which bottom-fixed offshore wind went through from the late 1990's. The first commercial offshore wind farm of just 40 MW, located at Middelgrunden in Denmark, opened for business only in 2000……. Europe now has a total installed offshore wind capacity of at least 18,499 MW! This corresponds to 4,543 grid-connected wind turbines across 11 countries[18].

The offshore wind experience indicates that once the transition from 'formative' to a mature setting takes place, the growth in ocean energy and the creation of jobs and income in first mover nations (Ireland could be one) and those with the feedstock e.g. energy intensive waves (e.g. Ireland) could be of historical importance and impact[19].

Ocean energy is in its formative phase and the current time horizons envisaged i.e. tidal energy being deployed from c2025 and wave energy from c2030, are in line with historic data and trends for *energy technologies as a whole.* Figure 3 shows the consensus European view on deployment timings for ocean energy:

Figure 2: Time horizons for development and deployment of ocean energy. Source: Ocean Energy Forum[20]



[18] *Offshore Wind in Europe Key trends and statistics 2018* WindEurope 2018

[19] See *Collaboration and Innovation Challenges faced by the Ocean Energy Sector and Possible Solutions* available at www.mria.ie/publications

[20] *Ocean Energy Strategic Framework* op cit

Floating wind, as illustrated in Figure 1 earlier, should deploy at scale from 2025.

The Irish Government's renewable energy support model [21]presumes that *energy diversity* is natural as costs fall due to technology development, '......social acceptance challenges and limits to the amount of available land for onshore wind.... (p10)', competitive procurement and an active base of developers. Moreover, the new *Wind Energy Development Guidelines* are likely to have a direct (negative?) impact on the volume of electricity that onshore wind will be able to deliver even though it will be the cheapest form of renewable energy, all of which the Paper recognizes (p11).

Consequently, the early importance of floating wind should not be underestimated. Figure 3 shows the relatively limited availability of Irish 'sea space' with a depth of 50m or less - the parameter within which bottom-fixed offshore wind must operate[22]. This consideration plus the likely impact of restricted areas due to environmental considerations and other factors all suggest that the need for floating offshore wind and wave energy (both normally require a minimum depth of 50m to operate in i.e. the opposite position to bottom-fixed wind) will arise faster than currently anticipated.

[21] *Renewable Electricity Support Scheme (RESS) High Level Design,* 2018 Department of Communications, Climate Action and Environment

[22] There are two known exceptions which go marginally over 50M - SSE's Beatrice farm off Scotland and the possible SSE site at Braymore Point, Dublin

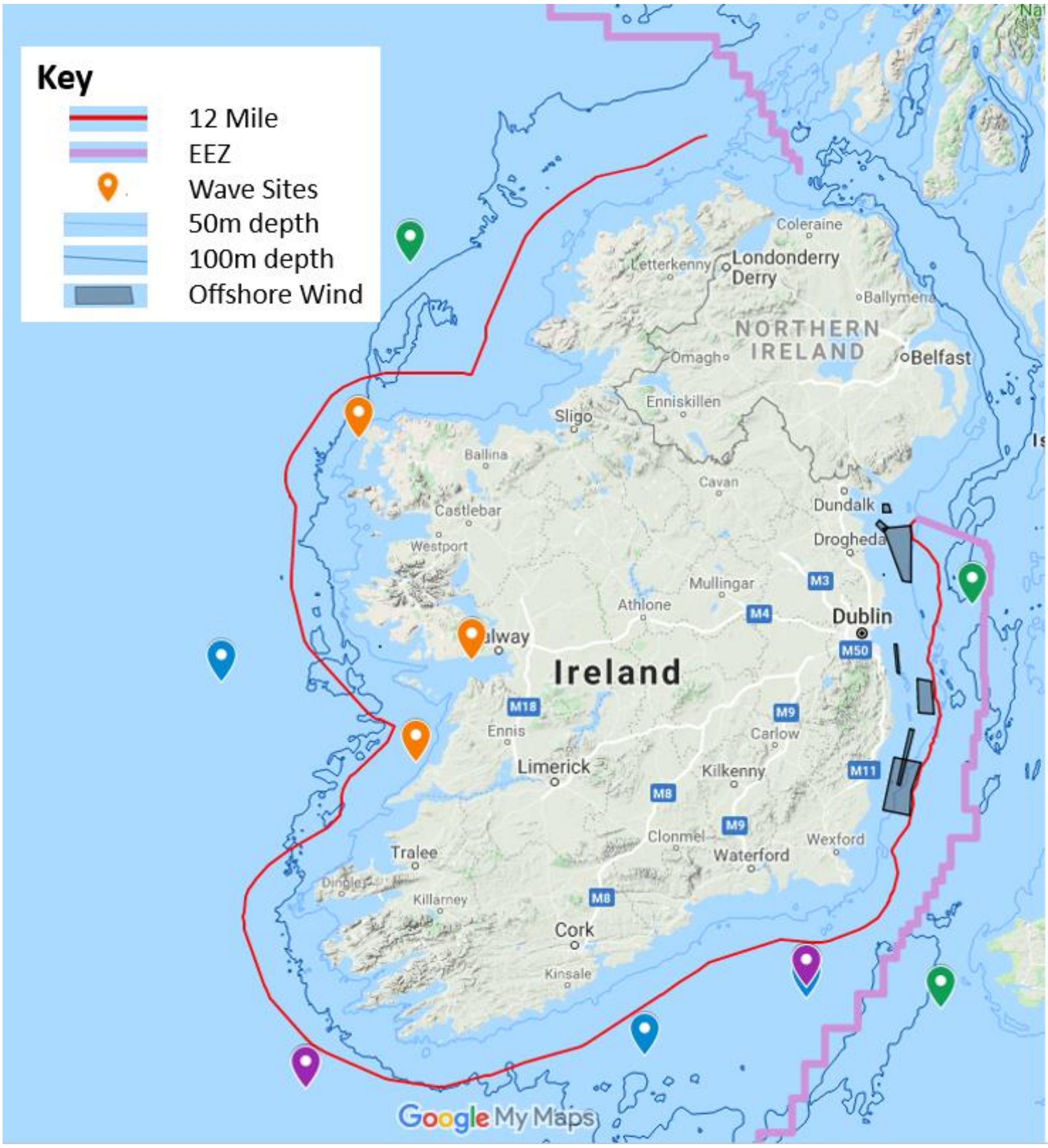


Figure 3: Availability of sea space with depths to suit different marine renewable technologies. Source: MRIA[23]

There is a growing consensus that floating wind will have developed in technology and, therefore, Levelised Cost of Energy terms by the early 2020s although today, the floating wind industry consists largely of Equinor's[24] Hywind 30 MW park off the Scottish coast. Growth to at least 30 GW forecast by 2030 - see Figure 1 - implies a more accelerated rate of growth than was seen for onshore and bottom-fixed offshore wind. The potential for Ireland is obvious: we have Europe's highest offshore wind speeds with a potential of 35-

[23] See *Marine Spatial Planning Needs of Marine Renewable Emerging Technologies 2018*. Available at www.mria.ie/publications

[24] Previously known as Statoil

40GW (of which 25-27 GW is near to shore and thus economical to develop) of floating offshore wind electricity generation potential[25].

2.5. Ocean energy (wave and tidal energy)

The MRIA Council comprises of key figures at all levels of the marine renewables industry both as members and as invited observers. Accordingly, the Association has unrivalled access to expertise and opinion and the suggested forecasts for ocean energy set out in Table 2 reflects the informed opinion of this body of knowledge[26]. Two caveats apply. First, the forecasts extend out only to 2040 as this is deemed the longest creditable forecast timeframe possible in relation to emerging technologies. Second, no forecast is made for floating wind - this is a maturing technology which MRIA suggests will possibly be the single most important offshore energy resource for Ireland by 2050 followed by a substantial contribution by wave energy. We concentrate here on the earlier stage technologies of wave and tidal: ocean energy.

Table 2: MRIA forecast of installed capacity. Source: MRIA

Year	*Tidal capacity MW*	*Wave capacity MW Low Scenario*	*Wave capacity MW Medium Scenario*	*Wave capacity MW High Scenario*
2025	5	5 in 2027/8	5	5
2030	10	20 in 2030 100 in 2035	100	130
2040	15	500+	1000	1400

COMMENTARY ON MRIA FORECAST OF INSTALLED CAPACITY

The forecast for the 2020s for both technologies - wave and tidal - is cautious and reflects a modest amount of installed test devices in the tidal area and some pre-commercial devices too in wave energy.

The 2030 and 2040 forecasts for tidal energy reflect the assumption that various tidal devices are installed, tested for a period and then removed i.e. a regular turnover in the source of mostly experimental, pilot tidal devices. It reflects the constraint of relatively low Republic of Ireland tidal flows i.e. only

[25] Source: see Eirwind project at www.marei.ie
[26] This Table was first published in MRIA's *Submission to Public Consultation on Ireland's Draft National Energy and Climate Plan (NECP) 2021-2030,* 2019 available at www.mria.ie/publications

some tidal devices are suitable even for test in Ireland due to local conditions. This position may change in future as technology develops.

The forecast for wave energy in 2025//2027/8 is based on reasonable assumptions about early devices under test.

The wave energy forecasts for 2030/35 and 2040 are considered under three scenarios: low, medium and high

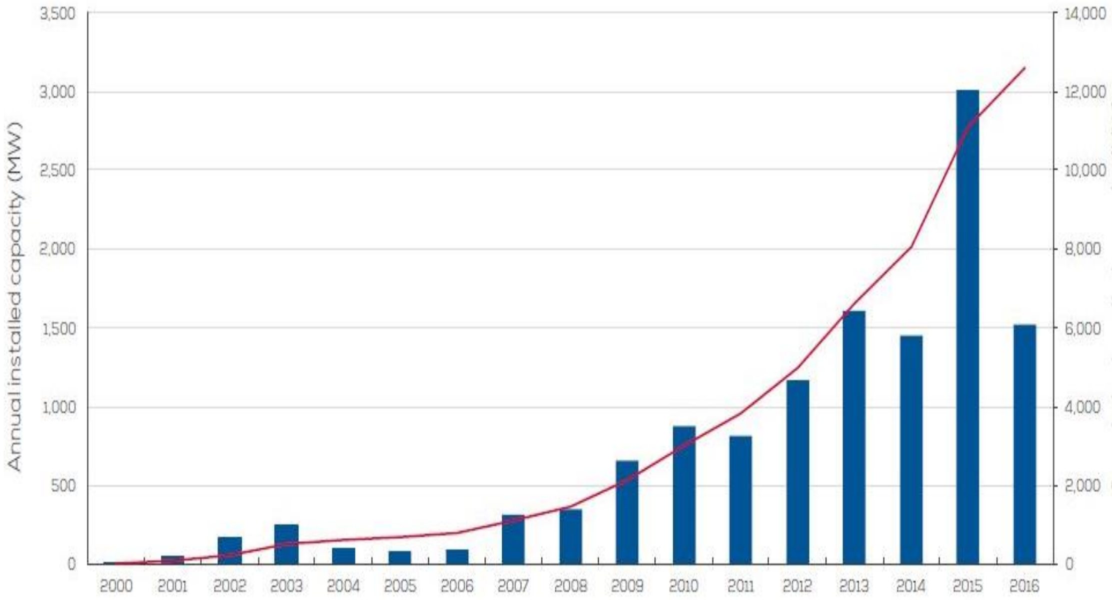
The low wave energy forecast reflects the possibility that a combination of factors, notably the pace of technology development, will see the full deployment of the first devices (perhaps through the ESB led WestWave project?) by no later than 2028.

Learnings from early wave deployments at home and abroad, the impact of the development of floating wind from c2025 (e.g. learnings in areas vital to wave such as moorings), the impact of various national and the EU SET Plan actions etc should then see a growth in deployment to 100 MW by 2035 at least, perhaps in the form of early scale deployments of around 30 MW each. Thereafter, wave energy should deploy at a commercial scale and we forecast a cumulative deployment of 500+ by 2040

The ambitious forecasts for wave energy set out in the medium and high forecasts above are based on the relevant precedent set by bottom-fixed wind and likely to be emulated or exceeded by the more technically challenging floating wind.

The relevant track record of bottom-fixed offshore wind deployment - see Figure 4 below - shows a rate of installation of new offshore turbines which ramped up from minimal level in 2000 to a rate of around 2500 MW annually today. This record represents about 10 countries so an average rate of installation of 250MW pa per country is a reasonable judgement. A similar pattern - see figure 5 earlier - is forecast by the reputable and major Norwegian State energy company, Equinor, in respect of floating wind. The growth of offshore wind over the past c20 years corresponds to the view of expert opinion on the timeframe for the development and deployment of large wave devices (e.g. Ireland's Ocean Energy Ltd device now being installed at a test site in Hawaii).

Figure 4: Cumulative and annual offshore wind installation 2000-2018 Source: WindEurope



Source: WindEurope

Figure 5 below applies the relevant offshore wind trajectory - as illustrated and argued above - and applies it to wave energy and reflects the MRIA's medium wave energy forecast. The graph assumes a start date of c2023 and assumes too a significant rollout after 2030. The forecast, therefore, is for 100 MW installed by 2030 and 1GW by 2040 which is in line with the UK forecast (see 2.3 above).

Figure 5: Forecast for wave energy. Source: Professor Tony Lewis[27]

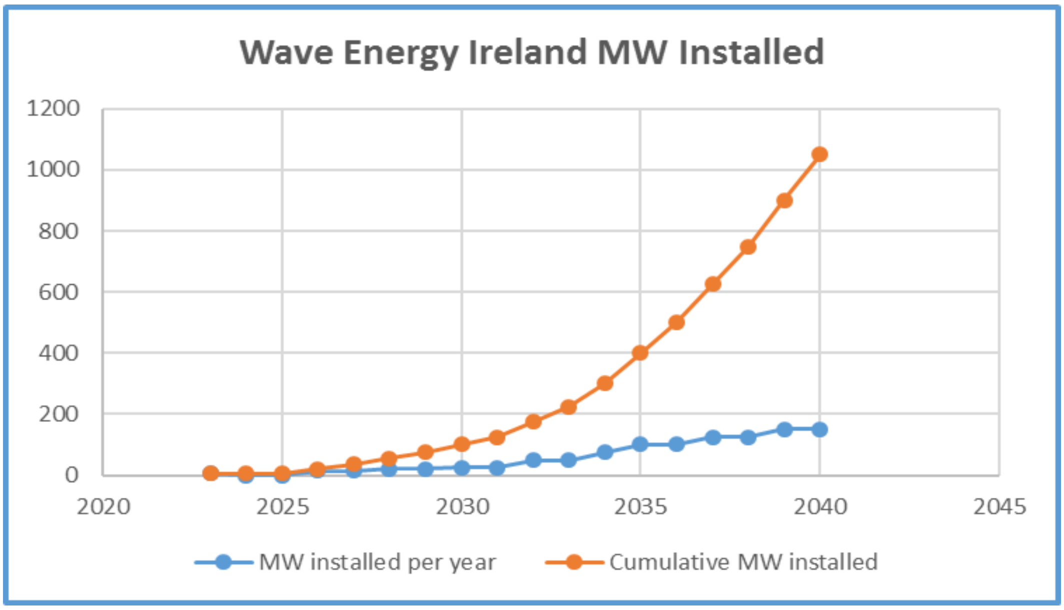
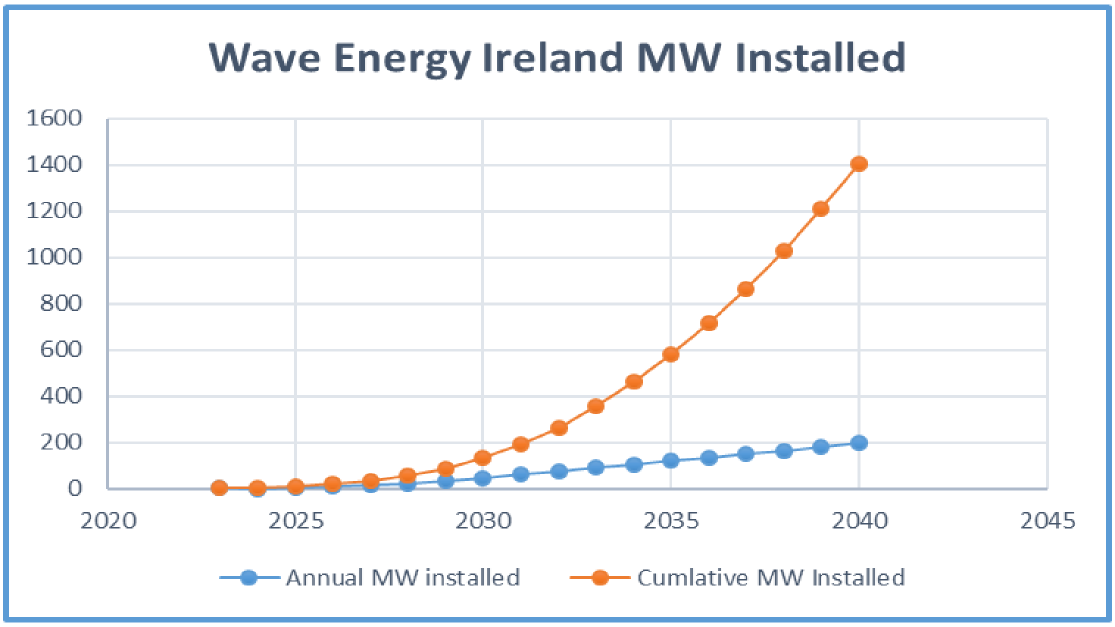


Figure 6: Aggressive forecast for wave energy. Source: Professor Tony Lewis



The second graph above - contained at Figure 6 - takes a more aggressive approach in light of additional drivers of climate change, energy security and large-scale decarbonisation and represents our <u>high wave energy forecast</u>

[27] Professor Lewis is the Chief Technology Officer of Ocean Energy Ltd and a leading researcher at MaREI.

Q5 What resources will help manage intermittency on the grid (e.g. long duration storage, zero-emissions fuel)?

A vital contributor to dealing with intermittency on the grid will arise from the 'integration' of offshore wind farms and wave farms, notably on the south and west coasts.

A key challenge for the grid in a completely carbon free electricity generation system is, of course, the impact on system stability of intermittent contributors (e.g. wind, solar and wave) notwithstanding the contribution (perhaps unquantifiable at this stage) that storage technology such as batteries may make in the future. The variability of the power produced from renewable sources and its uncontrollable nature negatively affects their effectiveness in reducing the requirement for thermal plants and makes them an apparently less attractive and a potentially more expensive alternative.

However, the authoritative study by Fusco, Nolan and Ringwood[28] provides considerable comfort on this issue. Their analysis of the raw wind and wave resource at certain locations around the a of Ireland shows a very low correlation between them on the south and west coasts, where the waves are dominated by the presence of high energy swells generated by remote westerly wind systems. This means that the two resources can appear at different times and their integration in combined farms allows a more reliable, less variable and more predictable electrical power generation system. The reliability is improved thanks to a significant reduction of the periods of null or very low power production which is a problem with standalone wind (or wave) farms. The variability and predictability improvements derive from the smoothing effect due to the integration of poorly correlated diversified sources.

This should allow the achievement of a more reliable, less variable and more predictable electrical power production. The resulting benefits are particularly clear in the case of a relatively small and still quite isolated electrical system such as the Irish one. Here, in fact, high levels of wind penetration strongly increase the requirement of surplus capacity and cause a much lower efficiency for conventional thermal plants

[28] *Variability reduction through optimal combination of wind/wave resources – An Irish case study,* Francis Fusco, Gary Nolan and John V Ringwood in *Energy, Vol 35 Issue 1 2010*

Q20. Where can Ireland show global leadership in GHG-efficiency, e.g. developing 'next horizon' technologies?

Ireland is a leader in the emerging technologies of wave and tidal. There are reckoned to be c280[29] ocean energy companies globally at present and perhaps 10% of that global population is located in Ireland. Supporting these companies (and international clients) are the State test and research facilities at MaREI and LiR NOTF in Cork; SmartBay in Galway; and AMETS in Mayo. Behind these facilities are leading research programmes in ocean energy involving academics and industry and involving all of the universities with UCC in a particular important position through its leadership of the MaREI project. In addition, Irish officials and researchers play an important part in international ocean energy initiatives such as OPIN (managed by the Sustainable Energy Authority of Ireland - SEAI) which promotes EU wide collaboration in ocean energy and MARINERG-i which, under Irish leadership, is working to integrate all of the major European ocean energy test facilities under one corporate roof (and headquartered in Ireland) by 2026.

Ireland is already a global leader in the emerging field of ocean energy (wave and tidal) and also has a growing position in floating wind via companies such as Bluwind, Simply Blue Energy and others. This situation will support Government's 2030 RES-E goals and apparent ambition for a carbon free electricity generation system by 2050. It should also be a key enabler of the development of a global supply chain for ocean energy in Ireland with commensurate major economic and social benefits. However, it requires support via both the future, second, Offshore Renewable Energy Development Plan (see Q26 below) but also through the relaunch, following recent programme reviews, of financial support for ocean energy through SEAI.

Q26. Are there any other comments or observations that you wish to make?

The mid-term review by the Department of Communications, Climate Action and Environment of the Offshore Renewable Energy Development Plan[30] made a number of important recommendations for consideration by Government including the extension of the initial market support tariff for ocean energy to experimental floating offshore wind, an increase in the quantum (MWs) eligible for support and the introduction of a graduated dedicated (to

[29] www.emec.org.uk/marine-energy
[30] https://www.dccae.gov.ie/documents/OREDP%20Interim%20Review%2020180514.pdf

emerging technologies) tariff range i.e. higher support for early projects and lower support as technology reaches maturity.

It is vital that these recommendations are incorporated in the next OREDP, due in 2021, if Ireland is to continue its positive journey to both a carbon free electricity production system by 2050 and a global leadership position on the supply chain for the new offshore renewable technologies - wave, tidal and floating wind.