Position Paper

Towards European industrial leadership in Ocean Energy in 2020

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1. Summary

This Position Paper has been produced by the European Ocean Energy Association, in close collaboration with participants in a newly created Member States Ocean Energy Interest Group.

The following Member States are members of this Ocean Energy Interest Group and support this position paper: Belgium with longer term interests; Denmark; France; Ireland; Netherlands with longer term interests; Norway; Portugal; Spain and the UK. Furthermore, this position paper is supported by the British-Irish Council and its member administrations and the European Ocean Energy Association.

It is the opinion of this Member States Ocean Energy Interest group that there is a significant opportunity for EU-level action. This would bring the key players in the European ocean energy industry together and help to coordinate the development of a leading and highly competitive position in the world market for Ocean Energy technology.

A key weakness or market failure of the current situation is fragmentation, duplication and a lack of focus on the most promising technologies.

The co-ordination effect of providing EU-level support to encourage and facilitate collaboration will be key to seizing the opportunity to create a major new generator of not just energy, but also sustainable jobs and growth. The key potential benefits of accelerating the development of the European ocean energy industry are summarised on page 4 of this position paper.

There is a significant risk that without EU level support, these benefits will not materialise, or the EU's potential competitive advantage will be lost to others. It is clear that this risk could be largely mitigated, by applying order to this developing industry via the conditions that would naturally be applied along with continued and increased central EU budget funding.

We hope that this Paper expresses the appetite that exists for Member State collaboration in this area of technology development. Also, that it encourages an ambitious dialogue and partnership with the European Commission, perhaps by the Commission's active participation in our Interest Group, towards the goal of developing this industry to be ready for commercial deployment.

We therefore look forward to discussions with European Commission colleagues on taking this partnership forward together as quickly as possible.

Our medium term aim is to have ocean energy join other key technologies as a European Industrial Initiative, to be moved decisively towards commercialisation and commercial scale deployment.

Ocean Energy: Summary of key benefits to the European Union

A driver of job creation and economic growth

- A global market for equipment manufacturing and technology development.
- Potentially 26,000 direct EU jobs from ocean energy in 2020; potentially 314,000 direct EU jobs from ocean energy in 2050.
- The creation of new opportunities in European coastal communities.

A route to achieving the EU's renewable energy targets

- The potential to satisfy 15% of EU energy demand in 2050.
- Avoiding 136 MT/MWh of CO_2 emissions in 2050.

Maximising the value and security of renewable energy portfolios

- Ocean energy can diversify and enhance the security of renewable electricity portfolios incorporating large-scale wind energy.
- Ocean energy can maximise the value from developments already in place for the offshore wind industry: infrastructure, supply chain, grid connections and understanding of environmental impacts.

Alignment between EU activity and the IEA's International Vision for Ocean Energy

- A common goal to increase international collaboration to accelerate the development and deployment of ocean energy systems.
- The opportunity for further cooperation to deliver economic growth through ocean energy development.

2. Context

This Paper sets out the steps that countries, planning to deploy ocean energy technologies on a significant scale, are taking to move the sector towards commercial readiness (see examples attached at Annex 1). A key aim of our collaboration is to secure EU-level support for this activity and recognition of the ocean energy sector (wave, tidal, salinity gradient and ocean thermal) as a European strategic technology under the Strategic Energy Technology Plan.

The Member State Ocean Energy Interest Group endorses this Paper and its objectives. It communicates to the European Commission our firm commitment to move the ocean energy sector forward in order to contribute to the 2020 EU Energy Strategy goals.

It is the ambition of the ocean energy industry and the Member State Ocean Energy Interest Group to have reliable technology demonstrated at the industrial and commercial level by 2020 with the potential for significant installed capacity over and above current plans. Our intention is that from 2020 onwards, ocean energy will become a valuable contributor to the EU vision for 2050, which the European Commission is currently defining.

We believe that this development will happen faster and with the greatest benefit to the wider EU, by ensuring maximum co-ordination of public and private activities. EU-level support will ensure that this happens in a structured and efficient way. In the short term, this can be achieved by continued support under Framework Programme 7 Energy and NER300, as well as exploring opportunities for co-operation with the existing Joint Programming Initiative for Healthy and Productive Seas and Oceans (JPI Oceans). At the same time, there is a need to ensure that activities under the SET Plan's European Energy Research Alliance complement this.

3. Recent Progress

Ocean energy[1] has so far been largely absent from the low carbon energy debate, primarily because the development of the ocean energy industry has proved challenging. The challenges associated with device deployment and survivability in the harshest of environments are quite unique. In addition, the capital costs associated with pre-commercial prototypes are disproportionately high in comparison to most other renewable energy sectors. Consequently, it can prove extremely difficult to secure the essential private sector investment for emerging ocean energy technologies, particularly while public sector support also remains so limited in size and scope.

During the past 2-3 years, this situation has started to change, with many positive developments in the sector in Europe but also beyond. One of the factors contributing to growing confidence is the increasing number of devices that are reaching full-scale live testing and proving their reliability over sustained periods. This is helping to drive new investment, utility interest and wider supply chain involvement in the industry. Utility involvement is also driving greater cohesion and collaboration within the sector, including closer links between emerging offshore wind and ocean renewables projects.

However, it is clear that industrial scale-up is wholly contingent on improved competitiveness. This can only be achieved through cost reduction and learning from experience of deployment in open sea conditions. This raises the very real risk that without appropriate funding for the sector in Europe, ocean energy development & deployment activities will expand to a growing extent outside Europe, for example in Canada, the United States or Australia. This would see the potential benefits of ocean energy, for example its value in the context of 2030 targets; its greater predictability alongside more intermittent options such as wind; and the relative accessibility of ocean energy resources in the North Sea and Atlantic compared to alternative large-scale solar energy sources being developed elsewhere.

A number of EU Member States have indicated that part of the renewable energy contribution within their National Renewable Energy Action Plans by 2020 will come from the ocean energy sector (see Figure 1).

[1] Wave, tidal stream, tidal barrage, thermal gradient and salinity gradient technologies.

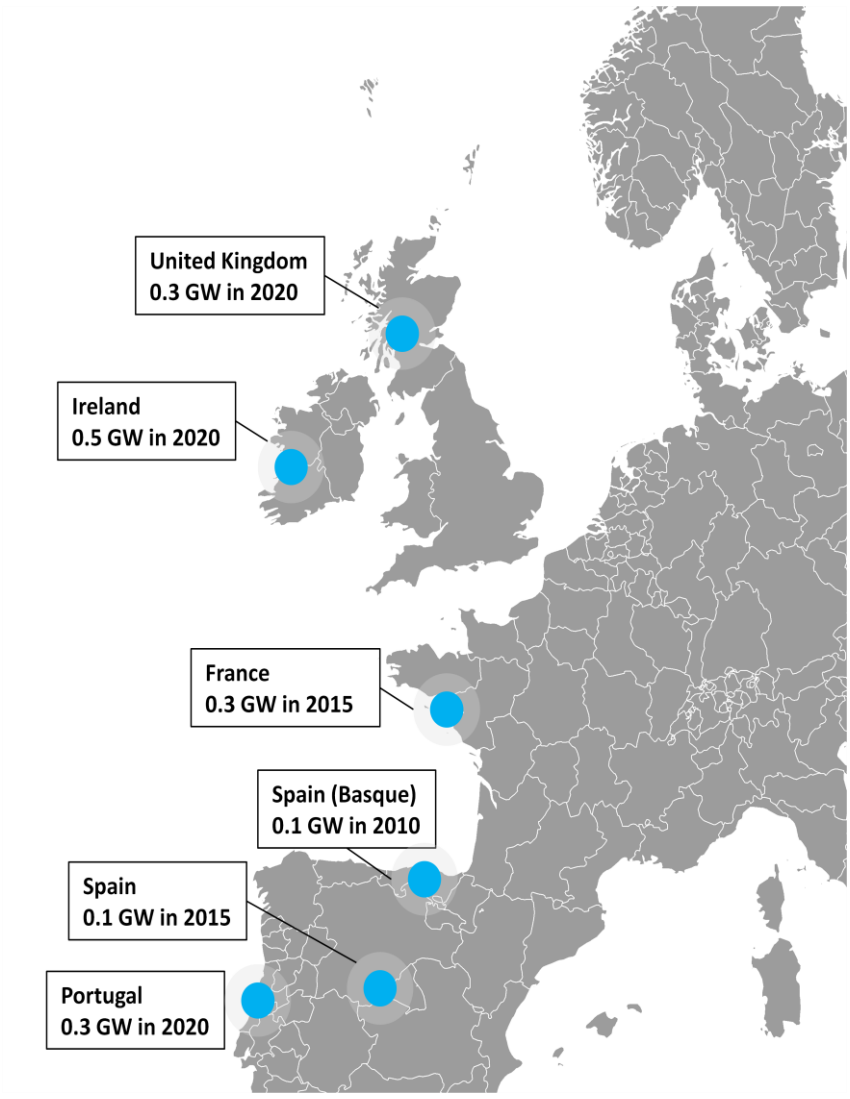


Figure 1 National targets for Ocean Energy in Europe. Source: European Ocean Energy Association

In addition, several EU Member States have also put in place attractive financial incentives and developed world class testing facilities for ocean energy. For example, the UK's Renewables Roadmap estimates that up to 300 MW (producing approximately 0.9 TWh) could be deployed in the UK by 2020, with much larger-scale deployment anticipated in the period beyond 2020. Relative to overall population, countries including Ireland, Portugal and Denmark have set very high ocean energy targets, potentially involving a significant proportion of the overall budgets available to support renewable energy.

Other Associated Member States are also extremely proactive in the development and exploitation of the available ocean energy resource. Examples include the States of Jersey and Guernsey and the Isle of Man, all of which are represented on the Marine Energy Group of the British Irish Council.

Despite these clear and encouraging signs of support, public spending across Europe is under severe pressure. It is therefore possible that this support for ocean

energy could be quickly overturned in favour of more developed options. Ocean energy needs long-term support.

4. EU Added Value

The development of the ocean energy sector is currently focussed within Europe. The majority of the ocean energy sector therefore views Europe as a likely centre for pre-commercial and early commercial deployment. All elements are in place; political support, industrial interest and energy needs.

However, the sector is still at a relatively early phase of development. It is now reaching the critical point where, over the coming decade, it will move into large-scale development and become commercially viable. There are currently a large number of commercial-scale prototypes undergoing testing and plans are underway for the development of pre-commercial array deployments in the period from 2012-2014. This will include those likely to be supported under Framework Programme 7 Energy and possibly NER300.

The first commercial leasing round for ocean energy has already taken place in the UK, with long-term leases for more than 1.6GW of deployment awarded, mostly for development by large energy utilities. On the industrial side, energy utilities such as EDF, E.ON, Iberdrola, RWE, Scottish and Southern Energy, ScottishPower and Vattenfall; and large manufacturers such as ABB, Voith Hydro, Bosch Rexroth, and Rolls Royce are participating in the development of ocean energy technologies. Furthermore, a number of large industrial concerns are already making significant investments in ocean energy companies.

Many Member States will be moving to an energy mix in the coming decade which will be high in intermittent renewables such as wind. Ocean energy offers additional benefits when compared with other offshore renewables, such as good predictability; reduced visual impact; and potentially higher load factors. Research is already suggesting that incorporating wave and tidal energy within a large-scale renewable electricity portfolio could reduce problems with grid balancing and reduce grid operating costs[2].

Whilst the resource and application potential for ocean energy obviously benefits the Member States and Associated States with a coastline, there is also a global market for equipment manufacturing and technology development, which could benefit many other Member States. As the sector continues its development from the pre-commercial stage, it will be able to take advantage of clear synergies with developments offered by the offshore wind industry, namely infrastructure, supply chain, grid connection and understanding of the environmental impacts.

[2] http://www.bwea.com/pdf/marine/Redpoint_Report.pdf

These opportunities for Member States also bring risks. Without close co-ordination between Member States, industry and other stakeholders, our current competitive advantage over global competitors could quickly disappear. We firmly believe that there is a strong strategic case for EU-level action now, to bring the sector together and accelerate its development to ensure that our competitive advantage is realised.

EU-level action would provide the industry with greater certainty. It would facilitate the exchange of best practice; avoid duplication; develop the necessary technology and industrial supply chain capacity; and facilitate project completion by providing simpler planning and consenting processes.

Cooperation and collaboration will be vital to unlocking the potential of ocean energy. We should seek to build on other existing areas of collaboration and look for synergies, for example with the EU's Joint Programming Initiative for Healthy and Productive Seas and Oceans (JPI Oceans). These, along with the European Commission's initiatives such as the Atlantic strategy and the Commission's forthcoming "Blue Growth" jobs strategy, offer excellent opportunities to co-operate, strategically together, to build and maintain strong EU ocean industries. We should also take advantage of the existing work under FP7 Energy as well as the developing activity under the European Energy Research Alliance, and its links to the ocean energy work of the International Energy Agency.

The recently published 'Oceans of Energy: European Ocean Energy Roadmap 2010-2050' estimates the industrial and socio-economic benefits for the European Union to be substantial, as can be seen in Table 1.

Installed Capacity (GW)	**Direct Jobs[3]**	**Total Jobs (Direct & Indirect)[4]**	**CO_2 avoided (Mt/year)[5]**	**Investment (€m)[6]**
3.6 (in 2020)	26,000	40,000	2.61	8,544
188 (in 2050)	314,213	471,320	136.3	451,104

Table 1 Estimated benefits of developing a world-leading European Ocean Energy Industry

[3] FREDS Marine Energy Group, Roadmap, 2009

[4] FREDS Marine Energy Group, Roadmap, 2009

[5] Fakta om Vindenergi, Faktablad M2, Januar 2007, www.dkvind.dk

[6] FREDS Marine Energy Group, Roadmap, 2009

With a projected installed capacity of 188 GW and the creation of over 470 000 jobs, the EU has compelling reasons for setting up an enabling framework to support the full development of the ocean energy sector.

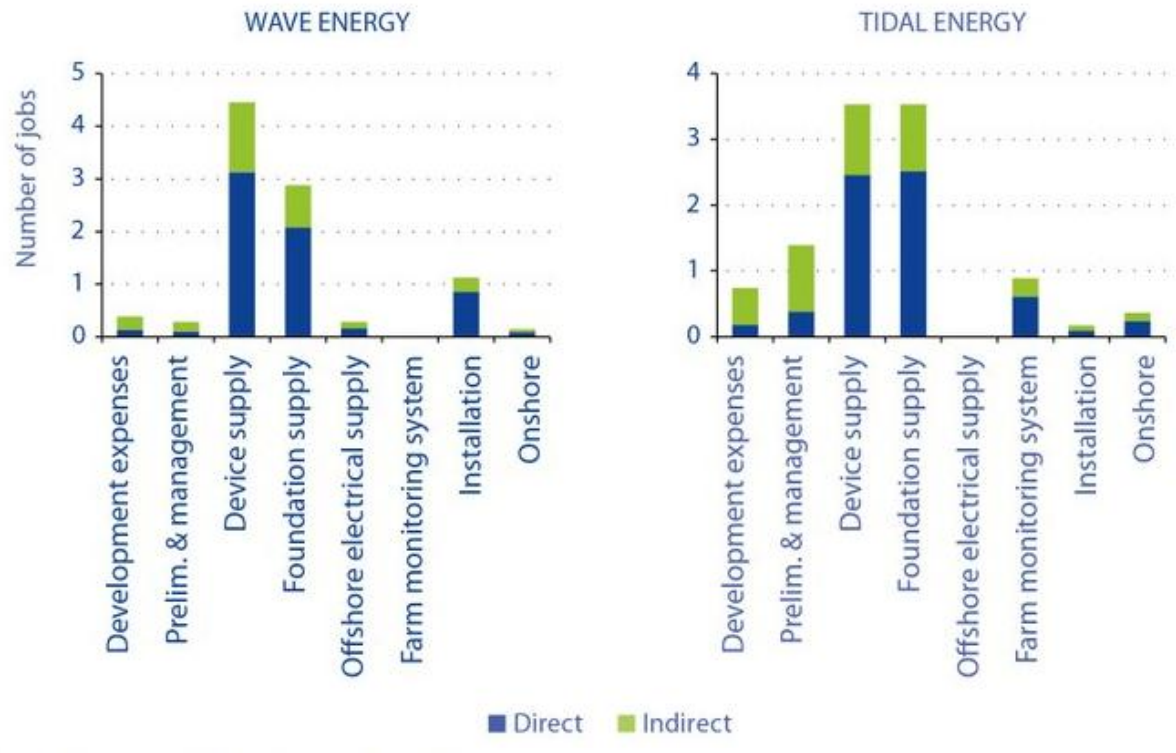


Figure 2 Job creation per MW of ocean energy installed capacity. Source: European Ocean Energy Association

5. Succeeding Together

All of the major European electricity utilities are currently engaged in the ocean energy industry, either through investments in technologies or projects, or by committing resources to draw up strategies to support further development of the ocean energy industry. Those utilities recognise that, as the ultimate end customers of ocean energy technology, they have a major role to play in early stage development. Major manufacturers are also making significant investment in technology development.

At the time of writing, eight ocean energy projects have been submitted to Member States with a view to securing funding under the NER 300 process, which will fund at least one demonstration project in each of the open ocean energy categories (wave, tidal and OTEC). The FP7 2012 call will also be targeted at demonstrating technologies at scale and interested Member States will be working on ambitious projects to bid into this process. Meanwhile the progression of work under the European Energy Research Alliance is focussing on generic underpinning technologies (e.g. moorings, power take off systems and environmental impacts) which will be critical to developing the sector at scale.

Major efforts are being made to move the sector forward. However, to realise its potential and effectively build a European industry on existing activity (following the trajectory for wind), the industry must overcome a number of challenges. A new generation of full-scale ocean energy conversion devices will have to be installed in real operating conditions in the next few years. FP7 Energy already envisages supporting the deployment of 2 arrays of at least 3 MW. Manufacturing processes need to be developed, automated and optimised with knowledge transfer from, and industrial cooperation with, other sectors, primarily offshore wind and offshore oil and gas. Electricity network connections will also have to be planned to enable major ocean energy power delivery.

Risk reduction will be required to leverage the necessary scale of private investment into the ocean energy industry; this can be achieved by appropriate fiscal policies (grant support and market pull). Revenue incentives are important; however, they are currently insufficient and will not work in isolation from capital support measures in the early stages of industry growth. It is anticipated that costs will not reach mature levels until a number of commercial scale developments utilising technologies of similar generic design have been installed.

The Member States supporting this Position Paper are keen to see ocean energy recognised as a strategic technology within the EU with a strong role to play in diversifying the future energy mix. Recent instabilities globally and the consequent impact on oil prices make this issue particularly pressing. A joint private / public effort, such as the establishment of a European Industrial Initiative (EII) in the medium term, would signal a major step forward and show of confidence for the development of the European ocean energy industry. This development could focus not only on deployment of the devices themselves, but also the development of a supply chain, with the consequent benefits for economic growth and employment.

Working together with the European Commission in a structured way such as this would provide a strong stimulus to bring together the necessary critical mass of private / public resources to advance the industry to full commercialisation. With this goal in mind, the inclusion of ocean energy within the forthcoming FP7 Energy and Intelligent Energy Europe 2 Work Programmes, and as supported projects, will be essential stepping stones in leveraging private investment, accelerating development and achieving the associated benefits of a thriving Ocean Energy industry for Europe.

6. Conclusion

It is the opinion of the European Ocean Energy Association, the British-Irish Council and the EU Member States supporting this position paper, that a strategic collaboration between industry, member states and the European Commission to develop our European competitive advantage in the developing ocean energy industry, offers significant added value for the EU.

Without coherent and consistent support, there is a significant risk that this competitive advantage and the potential opportunities for European growth and jobs, as well as synergies with other marine energy technologies, will be lost.

We hope that we can look forward to discussions with European Commission colleagues soon, on taking this partnership forward together as quickly as possible.

7. Annexes

7.1 Annex 1: Member State test facilities

MW-scale prototype devices have been deployed within Member State territorial waters. A number of Member States have put in place attractive financial incentives in terms of both revenue support and capital grants, with the aim of achieving the 2020 ocean energy targets set out in the Member States' National Renewable Energy Action Plans (see Figure 1).

To support this, EU Member States have also developed world-class testing facilities for ocean energy, as can be seen from Figure 3.

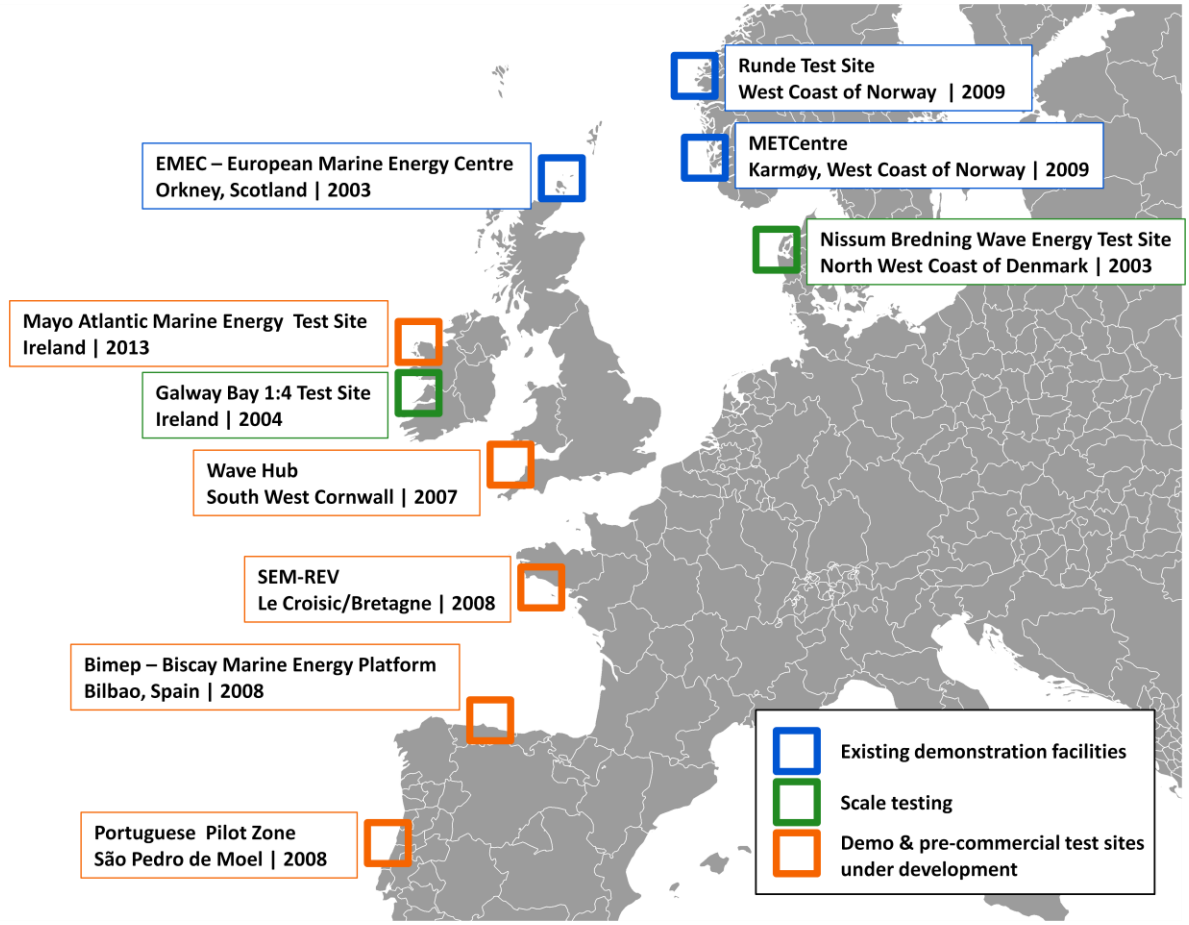


Figure 3 Overview of European Ocean Energy testing facilities. Source: WaveEnergy Centre

7.2 Annex 2: Specific Member State Activities

7.2.1 Denmark

Picture or map

Key Facts

- **Ocean Energy Potential**

Exploitable Wave Resource:
Exploitable Tidal Resource:

- **Ocean Energy Targets**

Installed Capacity by 2012:
Installed Capacity by 2050:

- **Current Installed Capacity**

Wave Energy:
Tidal Energy:

- **Ocean Energy Support Schemes**

Feed in Tariff:
Grant Funding Schemes:

- **Test Centres**

Department of Civil Engineering, Aalborg University, Denmark

Current and Planned Projects

Technology	Capacity	Location	Developer	Type	Year
Wave Dragon wave converter	Full scale prototype	n/a	Wave Dragon	Wave	2010
Advanced wave converter	Prototype	n/a	Leancon Wave Energy	Wave	2010
Crestwing, Flat Interconnected floats	Prototype	Aalborg University	Wave Energy Fyn	Wave	2011
Wave converter	500KW Demonstrator	North Sea	Wave Star Energy	Wave	2011
Dexia 1:5 wave converter	5KW prototype	Aalborg University	Dexa Wave Energy	Wave	2013

Ocean Energy Deployment

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Installed Capacity (MW)											
Produced Power(GWh)											

Progress

The Danish Council for Strategic Research's Programme Commission on Sustainable Energy and Environment has decided to allocate just under DKK 20 million to a strategic research alliance aimed at bringing wave power closer to the market, a project to be managed by the Department of Civil Engineering-AAU. The project centres on one of the biggest technological challenges facing the industry: developing a joint design basis for wave power facilities that will make the facilities more reliable as well as lower the price of the energy produced to a more competitive level. The tools being developed during the project must enable AAU and the individual technology developers to simulate the actual resistance of the new and upscaled wave power concepts to wave loads, so new, expensive damage in

the North Sea and at Nissum Bredning can be prevented. The coming research will also make it possible to improve the economy of future projects because simulations can identify the optimum economic balance between safety level and construction costs. Technology developers must also be able to assess the impact of extreme loads and ongoing wave loads on the coming structures.

In recent years, EDDP and Energinet.dk have provided project funding for several wave power concepts at various stages of development. Wave Star has received EDDP funding for upscaling and demonstrating its 500 kW wave power unit. First, Wave Star installed a lighter version with a 110 kW capacity in the autumn of 2009, in which the floats have the same dimensions as the full scale unit. If the test operation at Roshage Mole in Hanstholm goes according to schedule, the next phase will be a test of the full-scale unit in the same location. Long term, the idea is to move the unit into commercial operation off the offshore wind farm Horns Rev II, where it can make use of the existing landing cable. As upscaling proceeds, Wave Star has produced fine results with greater production compared to previously measured efficiency. A mathematical model tested at AAU with the support of ForskEL lies behind the success. Wave Star has also patented its control system for individual float control. However, the technology has been much more expensive to develop than expected, and the company went through a highly conflict-ridden restructuring that delayed project completion. ForskVE has granted operations support for electricity generation from both the lighter version and the full-scale unit.

Further new concepts to come
Wave Dragon, another of the more established wave power concepts, has been plagued by accidents, earlier with damage at Nissum Bredning and most recently a total loss sustained in March due to ice packing. LEANCON Wave Energy has successfully completed testing a very simple OWC concept on a scale of 1:40 in AAU's wave tank and, with renewed ForskEL funding, has started upscaling to a scale of 1:10 at Nissum Bredning. Following similar successful testing in the wave tank, Waveenergyfyn's crest wing has received ForskEL funding for building a prototype. DEXA Wave Energy has been working determinedly on its concept's Power-Take-Off (PTO) and has now received ForskEL funding for a unit on a scale of 1:5. *Wave Stars' simplified full-scale version containing 2 x 2 floats was commissioned in the rough North Sea waves at Roshage Mole in the autumn of 2009.*

Like several others under way, these concepts will stand stronger as the industry through the AAU research alliance initiatives becomes able to devise a more long-term strategy for future technology development. In addition to the new research alliance, technology developers in the wave power industry may apply for funding from the newly established commercial fund Danish Wave Energy Center, which is to coordinate the industry's practical development work in the area near Hanstholm and the work for a stronger public understanding of wave power potential.

Policy Framework and Government Bodies

Energinet Technology Support Organisation, Denmark

Energinet.dk supports the development of Wave Energy through the ForskEL programme, with a budgetary framework of DKK 130 million (about 17 million euro). Calls are therefore made each year for applications within research, development and demonstration projects which aim to develop and integrate environmentally

friendly power generation technologies. On average, the support of wave energy is relatively limited, about 1,5 million euro per year, but in some cases up to 2,5 million. This is not much in terms of full scale projects, but on the other hand we do not want to support full scale projects until the devices are ready. We believe in gradually scaling up the devices, and not proceeding hastily. So we are waiting for reliable electricity production on a small scale, but we strongly believe we will get there. But we will probably not get there without extended cooperation, both nationally and internationally, and we therefore appreciate that cooperation and support through EU programmes is needed.

Right now we are focused on initiating cooperation between the Danish ocean energy concepts though a newly formed partnership, but this is just to start with in our own backyard. Actually, I think the Danish concepts have more cooperation with partners in the EU than with each other.

Market Incentives

Permitting and Licensing

Test Centres

Department of Civil Engineering, Aalborg University, Denmark

Research and Development

For this year's Forskel Call, the strategy is to support the following:

Operational reliability, useful life and reduced kWh price

Developing efficient, reliable devices as well as achieving adequate useful lives are the major challenges in respect of wave power. The Danish Commission on Climate Change Policy deems the production price per kWh to be a barrier to more widespread use of wave power in Denmark. Consequently, the development should be based on the factors which have the greatest impact on the price per kWh generated, and the development should therefore be based on a general analysis of wave power devices relative to efficiency, production costs and maintenance.

Cooperation

One of the primary activities in the newly established partnership for wave power is to identify common interests and challenges and boost the sector through the systematic exchange of experience and the initiation of joint development projects. Energinet.dk wishes to promote the cooperation and in particular grant funding for joint projects specialising in areas playing a special role in reducing the price per kWh. The projects must as far as possible be based on experience and competencies from other sectors in order to make it possible to customise the efforts to the unique, technical challenges posed by wave power.

New concepts

Funding may still be granted for the development of new concepts, provided that the focus is on the unique properties of the plant vis-à-vis comparable plants and that these properties have a favourable effect on the price per kWh. To the extent feasible, the development must be based on already developed components and existing experience, both in respect of the development of the device and the calculation of the price per kWh.

Grid-connected plants will primarily be eligible for funding through ForskVE, and, in this context, it is expected that the grant payments will be made dependent on the performance of the device relative to the wave climate.

Focus on core components	Technology development of components with special impact on the achieved production price per kWh. Collaboration with specialised enterprises and/or other players in the sector.
New concepts	New principles for harnessing wave energy. Utilising existing components wherever possible.
International	Collaboration with other European countries on developing wave power, e.g. through EU-funded projects.

Industry

Utility	Involvement

7.2.2 France

Key Facts

- **Ocean Energy Potential**

Exploitable Wave Resource:
Exploitable Tidal Resource:

- **Ocean Energy Targets**

Installed Capacity by 2012: 256MW
Installed Capacity by 2020: 380MW

- **Current Installed Capacity**

Wave Energy:
Tidal Energy:

- **Ocean Energy Support Schemes**

Feed in Tariff: 260-76 €/kWh
Grant Funding Schemes:

- **Test Centres**

Current and Planned Projects

Technology	Capacity	Location	Developer	Type	Year
Open Centre Turbine	500kW	Paimpol	OpenHydro, EDF	Tidal	2011
3 x Open Centre Turbine (16m)	1.5MW	Paimpol	OpenHydro, EDF	Tidal	2011

Ocean Energy Deployment

FRANCE OCEAN ENERGY DEPLOYMENT SCENARIO TO 2020											
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Installed Capacity (MW)	240	240	256	271	287	302	318	333	349	364	380
Produced Power(GWh)	500	500	572	644	717	789	861	933	1006	1078	1150

Progress

France has the first and largest tidal energy plant in the world at La Rance, with an installed capacity of 240MW. It produced 534 GWh in 2009.

For marine currents, the potential is estimated as 400MW produced for 3,500 hours of annual operation, and an eighth of this potential by 2020. The main constraint is reported to be the lack of suitable sites and the main resource location, the North-Western coast of France.

Tidal energy is considered as having a resource of 500MW production for 2500 hours per year, but none of this can be harnessed before 2020. For wave energy, the government estimates a resource of 200MW produced per year with 4,000 hours operation. As for salinity gradient, the French administration estimates the technological and ecological barriers as still too high to enable the development of industrial size projects by 2020.[i]

Policy Framework and Government Bodies

In 2004 the French Agency for the Environment and Energy Management (ADEME) produced a document mapping out the different types of ocean energy technologies and estimating present and future costs.

The French Government has developed a Multi-Annual Investment Plan (PPI) 2009 to identify the resources required to develop renewable energy sources, including ocean energy. In 2010, through the implementation of the binding provisions in the RES Directive 2009/28/EC, the French government produced an ambitious National Renewable Energy Action Plan (NREAP) that reaffirms its involvement and commitment in the sector.

Market Incentives

Permitting and Licensing

Test Centres

Research and Development

Industry

Utility	Involvement

7.2.3 Ireland

Key Facts

- **Ocean Energy Potential**

Exploitable Wave Resource: 21TWh
Exploitable Tidal Resource: 915GWh

- **Ocean Energy Targets**

National Renewable Energy Action Plan (NREAP) Modelled Electricity scenario for 2020: 75MW
NREAP Non-Modelled Export Scenario for 2020: 500MW

- **Current Installed Capacity**

- **Ocean Energy Support Schemes**

Feed in Tariff: €220/MWh (subject to state aid approval)
Grant Funding Schemes: Prototype Development Fund (ongoing)

- **Test Centres**

Galway Bay, Scale prototype test site (to be grid connected in 2011)
AMETS, Belmullet, Co Mayo Full scale grid connected wave energy test site (under development)

Current and Planned Projects

Technology	Capacity	Location	Developer	Type	Year
Wavebob, Oyster, Ocean Energy Buoy or Pelamis	5MW – 15MW	W. Coast Ireland	ESBI lead developer	Wave	2015

Ocean Energy Deployment

Ireland ocean energy deployment scenarios to 2020:

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Installed Capacity (MW)	0	0	0	0	0	5	0	13	25	38	75
Produced Power(GWh)	0	0	0	0	0	0	0	42	81	124	230

Table 2 NREAP Modelled Scenario

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Installed Capacity (MW)	0	0	0	0	0	5	0	125	225	325	500
Produced Power(GWh)	0	0	0	0	0	0	0	383	690	996	1533

Table 3 NREAP Non Modelled Scenario

Progress

The Republic of Ireland, with over 5,631 km of coastline, and its northern location on the Atlantic Arc, has one of the most significant Ocean Energy resources in Europe.

Policy Framework and Government Bodies

In 2008 the Irish Government set up the Ocean Energy Development Unit (OEDU), as part of the Sustainable Energy Authority of Ireland (SEAI), to take forward the sector, implement the ocean energy strategy, administer the Prototype Development Fund to industry, support the Hydraulics and Maritime Research Centre (HMRC), develop a grid connected wave test site, manage the conduct of an SEA for Wave, Tidal and Offshore Wind and stimulate supply chain mobilisation .

In its 2010 National Renewable Energy Action Plan, the Irish government affirmed its significant commitments in the field of ocean energy

The Department of Communications, Energy & Natural Resources has recently published its draft Offshore Renewable Energy Development Plan (OREDP) and the consultation on the draft Plan, its Strategic Environmental Assessment Environmental Report and the Natura Impact Statement closed on 6 May 2011. Ireland's draft OREDP describes the current state of play in Ireland on offshore wind, wave and tidal energy. It describes some of the factors that are likely to affect policy as

it develops. The final OREDP (which will include the appropriate assessment decision) will be published following a Government Decision expected to be in July or September 2011, along with a Ministerial SEA statement which will indicate how environmental considerations and the Natura Impact Statement were taken into account in the final version of the Plan and how the public consultation was considered.

Market Incentives

The Irish government has financed or is financing a total of 15 Irish companies, for the most part through the Prototype Development Fund administered by SEAI.

Permitting and Licensing

Responsibility for developments on the foreshore transferred to the Minister for the Environment, Heritage and Local Government in 2010. Since that date, work on the streamlining and modernising of the consent process for foreshore developments, with particular emphasis on renewable energy projects has been underway. Improvements are being introduced as follows:

1. In the short term, the consent system for offshore energy development is being integrated within the wider regulatory and strategic environment. Interested parties are welcome to apply for Foreshore Investigation Licensing. This permission is designed to facilitate the testing of devices and /or site conditions. No entitlement to a lease for the area attaches to this permission.
2. For current applicants for a foreshore lease, the following approach applies: Where a positive environmental assessment has been made, but before a lease will be offered, the promoter must satisfy the Minister that the requisite regulatory permissions, financial, managerial, technical and legal expertise and crucially, connection to the electricity grid have been secured. In taking this approach (Conditions Precedent), the Minister has brought improved clarity to the consenting process for existing applicants.
3. In addition, by ensuring that all future evaluations of environmental impact statements are undertaken within the context of the finalised OREDP and its SEA report, the Minister can deliver more transparent and sustainable foreshore consent decisions.
4. In the area of legislative reform, the Minister has committed to an overhaul of the current consent process in order to align the regulatory aspect of the system more closely with existing land planning. The Department is preparing a General Scheme of the necessary Bill. It is intended that the Bill would, inter alia, integrate the foreshore consent processes for major infrastructure projects within the strategic consent process operated by An Bord Pleanála

(the Planning Board), while the foreshore consent process for non-strategic infrastructure projects would be integrated within the planning consent process operated by the local authorities.

It is intended that the reforms will deliver a plan-led policy framework for the approval of activities and developments in the marine environment, a single consent process for project approval as well as greater certainty of timeframes. Mandatory pre-application consultations, transparent assessment of environmental impacts and full public participation are also planned.

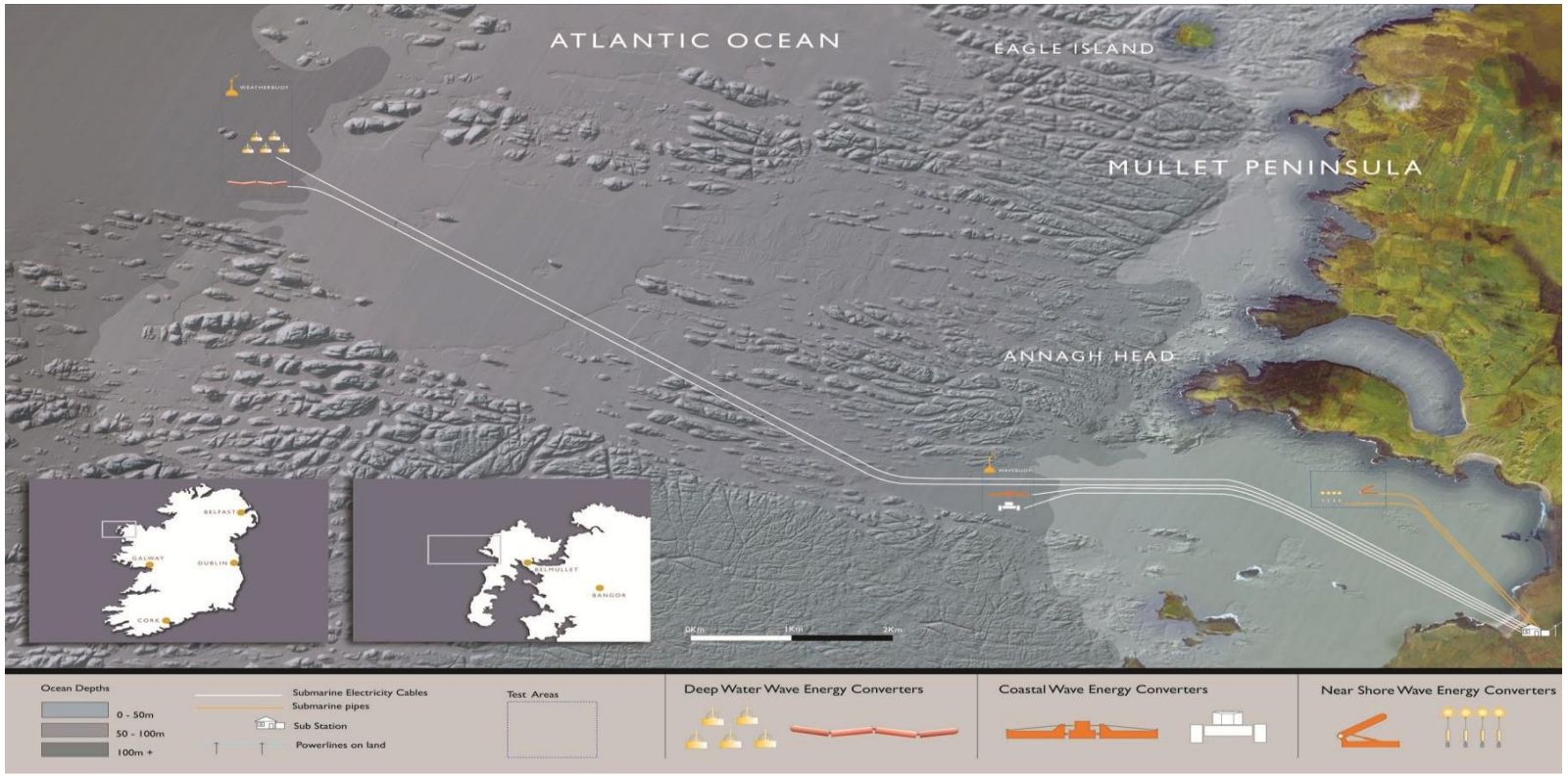
Pending the introduction of this framework, the OREDP will provide important assistance to the Department's approach to foreshore consent applications.

5. Over the medium term, the Department will also be working with other relevant Departments and agencies towards the development of a marine spatial planning framework, providing for the strategic development of the foreshore while managing competing and often conflicting sectoral demands.
6. The Department of the Environment, Community and Local Government is supportive of awarding offshore renewable energy rights through a system of future competitive leasing rounds. The Department is of the view that optimal use can be made of the renewable resource only through targeted development opportunities identified and agreed by the various stakeholders involved in energy policy, grid connection and regulation of the marine and coastal zones.

Test Centres

In 2006 SEAI and the Marine Institute created a scale prototype test site on the north side of Galway Bay 1 mile east of An Spideal .This site is 37 hectares in area and 21-24 metres deep. Two devices have been in the water at the site: Ocean Energy Ltd.'s *Seilean* oscillating water column (OWC) device, and the Wavebob device, a prototype of which was first installed in 2006..[ii]The site forms part of a wider research infrastructure – SmartBay – supporting innovation in the field of marine ICT – sensing, data management and communications

To complement this existing test site, a full scale grid connected wave energy test facility is being developed in County Mayo, west of Belmullet, off Annagh Head. The Atlantic Marine Energy Test Site will enable assessment of performances of wave energy devices under open sea conditions in terms of electricity generation and survivability. The image below shows the proposed test site and the different depths.



Research and Development

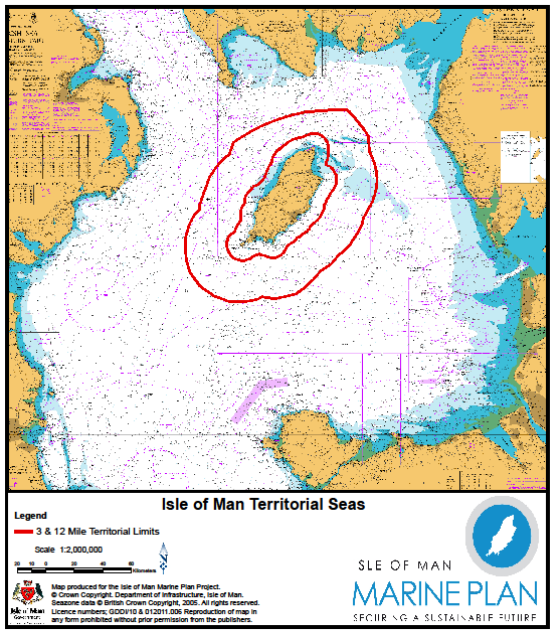
Industry

- In 2009, the OEDU and the consultancy company RPS produced a report about the engineering and specialist support requirements for the Ocean Energy sector, which pointed out the many economic opportunities in terms of labour market and supply chain development. SEAI has also commissioned other studies on the economics of ocean energy, assessment of ports and shipping requirements, assessment of the industrial potential for offshore wind in Ireland, and engineering and specialist Support requirements of the Ocean Energy sector - an assessment of Irish companies' capability to supply products and services to the Marine Energy sector.

It is intended to commission a study on a cost-benefit analysis of whether Ireland should engage in the co-operation mechanisms under the Directive for renewable energy export.

There are several Irish companies that have invested significantly in the ocean energy sector. These include ESB International, Bord Gais Eireann, Wavebob, Open Hydro, and Ocean Energy Ltd. Under the Prototype Development Fund in SEAI and other grant programmes from the national Enterprise agency, some 15 Irish ocean energy companies have received funding support.

7.2.4 Isle of Man



Key Facts

- **Ocean Energy Potential**

In the Irish Sea wave energy densities tend to be less than 10kW/m.
Exploitable Wave Resource: 24 – 34 GWh/y

The spring peak current speed is 2 - 3 m/s.
Exploitable Tidal Resource: 18 – 380 GWh/y

- **Ocean Energy Targets**
- **Current Installed Capacity**
- **Ocean Energy Support Schemes**

Grant Funding Schemes: Financial Assistance Scheme to encourage sustainable economic growth in the Island.

- **Test Centres**

Current and Planned Projects

Ocean Energy Deployment

Progress

The Isle of Man owns its own territorial seas up to 12 miles from the shoreline and the seabed therefore consists of 87% of the Island's territory. This extensive ownership of the territorial seas represents significant opportunities for future marine renewable energy generation.

Policy Framework and Government Bodies

The Isle of Man Government requested the UK ratify the Kyoto Protocol on our behalf, which was achieved. The requirements on the Isle of Man are to develop plans and policies to reduce our CO_2 emissions. To contribute towards this, a target of 15% of electricity generated from Renewable Sources by 2015 was agreed by the Isle of Man Parliament, Tynwald in March 2010. The Isle of Man Government will consider the installation of marine renewable energy devices within our territorial waters when the appropriate framework for consenting and development is confirmed.

A marine spatial planning officer was appointed in July 2010 to co-ordinate the interests of all stakeholders involved in both the preparation of a marine spatial plan for the island and to develop a strictly controlled consenting regime.

A number of Regional Environmental Assessments have been consulted to better understand the benefits of undertaking one for the Isle of Man as Strategic Environmental Assessments are not applicable here. It is anticipated a decision will be taken as to how best approach the process of REAs in the near future and determine whether it is feasible for one to be undertaken here. Any REA undertaken will not negate the need for EIAs to be undertaken for future marine developments should this be determined as part of the consenting process (currently being reviewed).

Market Incentives

Permitting and Licensing

The Isle of Man owns its seabed out to 12 nautical miles which means there is no requirement for issuing a licence under the Food and Environmental Protection Act 1985 (FEPA). The current consenting process for the Isle of Man requires that permission be sought from the owner of the seabed (currently the Department of Infrastructure) who will then consider the request. A number of other consenting regimes have been consulted, and work is currently progressing on determining the best process which can be used to issue consent for marine developments.

Test Centres

Research and Development

Industry

7.2.5 Portugal

Key Facts

- **Ocean Energy Potential**

Exploitable Wave Resource: 14TWh
Exploitable Tidal Resource: Low / Not evaluated yet

- **Ocean Energy Targets**

Installed Capacity by 2012: 5MW
Installed Capacity by 2050: 250MW

- **Current Installed Capacity**

Wave Energy: 400kW

- **Ocean Energy Support Schemes**

Feed in Tariff: 260-76 €/kWh
Grant Funding Schemes: PRIME, €3M SURGE FP7 Project

- **Test Centres**

Pico Wave Energy Plant
Agucadoura wave energy demonstration centre
The Pilot Zone

Current and Planned Projects

Technology	Capacity	Location	Developer	Type	Year
Pico OWC	400kW	Pico, Azores	WavEC	Wave	1999

Waveroller	300kW	Peniche	AW Energy, Bosch Rexroth, Eneolica	Wave	2011
BlueWAVE	2.5MW	Pilot Zone	Oceanlinx	Wave	2012
Wavebob	250kW	Pilot Zone	Standpoint consortium (Wavebob, Vattenfall)	Wave	2012

Table 1

Ocean Energy Deployment

PORTUGAL OCEAN ENERGY DEPLOYMENT SCENARIO TO 2020

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Installed Capacity (MW)	5	5	5	10	35	60	75	100	125	175	250
Produced Power(GWh)	1	2	3	9	35	75	112	159	206	297	437

Table 2

Progress

Offshore renewable energy activity in Portugal was initiated in 1978 with R&D in wave energy, which started at the Instituto Superior Técnico (IST). This led to the construction of the 400kW European Pilot plant at Pico in the Azores in 1999 under the responsibility of IST. The plant cost approximately €4M, half of which was supported by Electricidade de Portugal (EDP) and Electricidade dos Açores (EDA) and the other half by the European Commission under a Joule project and the Portuguese government under an ”Energia” project.

In 2005 under the umbrella of WavEC and its associates the plant was refurbished and operation was resumed in 2007. In 2010 the plant operated for 1300 hours over the year, delivering 45MWh to the island’s grid.

Policy Framework and Government Bodies

The Portuguese National Renewable Energy Action Plan (NREAP) sets out very ambitious targets (see Table 2).

Market Incentives

The pilot zone is managed by the Portuguese TSO – Rede Energética National (REN) which is licensing the different wave farms to different project developers and end-users. So far the pilot zone is devoted only to wave energy, but it is expected that it will be expanded also to floating and deep offshore wind. Stakeholders expect that the feed-in tariff for wave energy presented in Table 3 will be assumed also for floating and deep offshore wind.

Initial FIT (€/kWh)	Min	Max
Demostration	0,258	0,258
Pre-comercial	0,163	0,209
Commercial1	0,102	0,163
Commercial2	0,086	0,117
Commercial3	0,076	0,076

Table 3: Feed-in tariff for wave energy

Permitting and Licensing

REN has the concession to operate the pilot area for the production of electricity from the sea. This concession also includes the authorisation for deployment of grid infrastructure connection, use of public water resources, checking the use by others of water needed to produce electricity from wave energy, as well as competence for the award of license for establishment and operation of the business of power generation and its review.

Test Centres

Three relevant support infrastructures for offshore renewable energy exist or are planned in Portugal: Pico wave energy plant, the Aguçadoura site, and the Pilot Zone.

Pico wave energy plant project was briefly described above. It is owned and managed by the Wave Energy Centre, a private not-for-profit organisation. Pico plant will be part of the European network of R&D infrastructures on ocean energy under the MARINET project. Under this project European researchers may be funded to develop R&D activities at Pico plant.

The Aguçadoura is the open ocean test site where the AWS prototype in 2004 and the Pelamis farm in 2008 were tested. It consists of a land station with electric power equipment to deliver energy to the grid and data acquisition equipment, a 4MW underwater electrical cable and three grid connected berths at 45m water depth, which will be used to deploy the 2.3MW Windfloat floating offshore wind prototype in 2011.

The Pilot Zone is a large area off the west coast (about 400km^2) being developed for wave energy. The access to this phase is expected to be on a first-come first-served basis. Special feed-in tariffs will be applied under this regime. The pre-commercial phase applies between 4MW and 20MW per technology with a total of 100MW at national level. The total installed capacity in the commercial phase will reach 250MW.

Research and Development

Portugal is participating in several R&D activities and projects through the Wave Energy Centre (WavEC), Instituto Superior Técnico (IST) and Laboratório Nacional de Engenharia e Tecnologia (LNEG). About 25 full-time researchers are active in these three R&D centres. Other smaller research groups are also active.

The R&D activity in Portugal has been developed under nationally funded projects and EC funded projects. The main projects are listed below.

Framework Programme projects:

- Equitable testing and evaluation of marine energy extraction devices in terms of performance, cost and environmental impact (EQUIMAR), FP7-Energy
- Components for ocean renewable energy systems (CORES), FP7-Energy
- Marine renewable integrated application platform (MARINA Platform), FP7-Energy
- Full scale demonstration prototype tidal stream generator (Pulse Stream 1200), FP7-Energy
- Demonstration & Deployment of a Commerical Scale Wave Energy Converter with an innovative Real Time Wave by Wave Tuning System (WavePort), FP7-Energy
- Standardisation of Point Absorber Wave Energy Convertors by Demonstration (Standpoint), FP7-Energy
- Simple underwater generation of renewable energy (SURGE), FP7-Energy
- Off-shore Renewable Energy Conversion platforms - Coordination Action (ORECCA), FP7-Energy
- Development and validation of technical and economic feasibility of a multi MW Wave Dragon offshore wave energy converter (Wave Dragon MW), FP6-SUSTDEV
- Nereida MOWC: OWC integration in the new mutriku breakwater, FP6- SUSTDEV
- High-efficient, low-weight, pile-supported 500-kW wave energy converter (WAVESTAR), FP6- SUSTDEV
- Sustainable Economically Efficient Wave Energy Converter (SEEWEC), FP6- SUSTDEV

- Full-scale demonstration of robust and high-efficiency wave energy converter (WAVE SSG), FP6- SUSTDEV
- Demonstration plant of a tunnelled wave energy converter (ALDA), FP6- SUSTDEV
- Co-ordinated Action on Ocean Energy (CA-OE), FP6- SUSTDEV
- European Ocean Energy Association (EU-OEA), FP6- SUSTDEV
- Prediction Of Waves, Wakes and Offshore Wind (POW'WOW), FP6- SUSTDEV
- Marine Renewables Infrastructure Network for Emerging Energy Technologies (Marinet), FP7-Infrastructures
- Wavetrain 1 and 2, FP7-People

Other European projects:

- KIC INNOENERGY, EIT
- The Future of the Atlantic Marine Environment project (FAME), INTERREG IV - Atlantic Area Programme
- Aquatic Renewable Energy Technologies (Aqua-Ret 1 and 2), Leonardo da Vinci Programme
- Wave Energy Planning and Marketing (WavePlam), Inteligent Energy Europe
- Streamlining of Ocean Wave Farms Impact Assessment (SOWFIA), Inteligent Energy Europe

National projects:

- Methodologies for Design, Monitor and Update Strategic Roadmaps: Application to Marine Energies Development in Portugal (Roadmapping Offshore Renewables in Portugal)
- Technology Observatory for Offshore Energy (OTEO)
- Wave Energy Acoustic Monitoring (WEAM)

Industry

Utility	Involvement
EDP	Technology demonstration and project

	development

Developers

AW Energy, the Finish company that, in association with the Portuguese Eneólica, is developing a Waveroller 300kW project in Peniche, Portugal, under the €3 million funded SURGE FP7 project.

The Portuguese Kymaner has secured a national €1.2 million from QREN to develop components for oscillating water columns.

7.2.6 Spain

Key Facts

- **Ocean Energy Potential**

Exploitable Wave Resource: TWh
Exploitable Tidal Resource: GWh

- **Ocean Energy Targets**

Installed Capacity by 2016: 10MW
Installed Capacity by 2050: 100MW

- **Current Installed Capacity**

300 kW – Mutriku Wave Power Plant

- **Ocean Energy Support Schemes**

Feed in Tariff: 74.4€/kWh
Grant Funding Schemes:

- **Test Centres**

Test Field of Santona
Test Field of Ubiarco
Bimep – Biscay Marine Energy Platform

Current and Planned projects

Technology	Capacity	Location	Developer	Type	Year
Voith Wavegen	296kW	Mutriku, Spain	Ente Vasco de la Energia	Wave	2011
Project welcomE	100kW	Canary Islands, Las Palmas	PIPO Systems	Wave	2010

Ocean Energy Deployment

	2015		2016		2017		2018		2019		2020	
	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh
Ocean Energy Development	0	0	10	22	30	66	50	110	75	165	100	220

Progress

The most important ocean energy resource in Spain comes from waves, with a medium-high potential (between 20 and 60 kW/m) along the Atlantic and Cantabrian coastlines. In 2010 a nationwide wave resource survey was undertaken, and national targets of installed power were fixed. There is a significant R&D programme, with the development of several technologies of wave energy converters but without any full-scale devices tested at sea to date.

Policy Framework and Government Bodies

The Spanish Government's "Renewable Energy Action Plan 2011-2020"[iii] aims to have 10MW of installed capacity of ocean energy by 2016 and 100MW by 2020.

Regional Governments of several areas (the Basque Country, Cantabria, Asturias, Galicia and the Canary Islands) are, in addition, promoting the installation of test facilities and demonstration projects. Two of them have set targets on Ocean Energy so far: the Basque Country plans 5 MW of installed power by 2010, and the Canary Islands considers 50 MW by 2015.

Market Incentives

Permitting and Licensing

Current Spanish legislation regards ocean energy in two Royal Decrees from 2007[iv]; one establishes the "o*ne stop shop*" administrative procedure to apply for an authorization for electricity generation installations at sea, and the other one sets the feed-in tariff price, so that the specific tariff is negotiated for every individual project, depending on the investment cost.

Test Centres

In Cantabria there are two relevant test projects:

- **Santoña Test centre:** The regional Government of Cantabria has the objective of developing a test site for prototypes of Wave Energy Converters. The Testing Field Area would accommodate up to 10 WEC devices with a maximum combined power of 1.5MW.

- **Ubiarco Test Centre:** The objective of this project is to develop a testing site for prototypes of WECs and Floating Wind Turbines (FWT). The Testing Field Area will allocate up to four Floating Substations, up to 4MW each, which will provide connection to a maximum of four devices. These two test facilities will be supported by "The Great Maritime Engineering Tank" that is being built in the Scientific and Technological Industrial Park of Cantabria which will integrate experimental management, a system of physical modelling and a system of numerical modelling.

In the Basque Country, the Basque Government is developing through EVE, its energy agency, a test facility, **bimep – Biscay Marine Energy Platform,** which will allow full-scale prototype testing and demonstration of renewable marine energy converters up to 20MW. The environmental permit is granted, and the industrial permit and the concession as maritime terrestrial public domain are submitted. The underwater and land cables are contracted and the sub-station to transmit the energy is tendered and will be awarded before the end of 2011. *bimep* is integrated in MaRINET, an EU funded programme that brings together an infrastructure network with 42 facilities from 28 partners spread across 11 EU countries.

Research and Development

Spain is participating in several international initiatives on promoting ocean energy, including WAVEPLAM (www.waveplam.eu). This project, led by EVE (the Basque Energy Agency), aims at developing tools, establishing methods and standards, and creating conditions to speed up introduction of Ocean Energy into the European renewable energy market.

At national level, PSE-MAR is a strategic research project funded by the Ministry of Science and Innovation (MICINN) aimed at developing three different wave energy converting technologies, a test and demonstration site and guidance on non-technical issues. This project, coordinated by TECNALIA, is formed by three developers (HIDROFLOT, PIPO Systems and OCEANTEC), industrial companies, R&D centres and universities.

In the Canary Islands, a general marine research infrastructure - the Canary Islands Oceanic Platform (PLOCAN) - is under development, which could host ocean energy projects.

In 2009 the Ministry of Science and Innovation commenced the OceanLider programme. Led by Iberdrola Ingeniería y Construcción, it includes several marine energy R&D activities including resource assessment, site selection, operation and maintenance, technology development, grid connection and environmental aspects.

R&D activities are well coordinated with other European partners by means of the participation of TECNALIA in several European projects funded by the European Commission within the seventh framework programme, such as EquiMar (www.equimar.eu), CORES (http://hmrc.ucc.ie/FP7/ cores.html) or Wavetrain2 (www.wavetrain2.eu).

Regarding standardisation issues, AENOR, the Spanish standardisation board, launched a national mirror group for the international committee IEC/TC 114 in June 2008. This group will work on the establishment of standards concerning marine energy, mainly for wave and water currents devices.

Industry

Utility	Involvement
IBERDROLA	R&D, Technology demonstration and project development

Mutriku, Basque Country: Mutriku Wave Power Plant (see photo)**.** Nereida Project in Mutriku (Basque Country), promoted by EVE, is an Oscillating Water Column (OWC) integrated in a breakwater and involves a €5.7M investment, €4M for civil work and the rest for electro-mechanic work and grid connection. The plant

consists of 16 turbines, 18.5kW each, with an estimated overall power of 296kW. The plant started operations in July 2011.

Santoña, Cantabria: IBERDROLA Energías Marinas de Cantabria S.A installed at sea, in September 2008, the first OPT's Powerbuoy of 40kW in Santoña (Cantabria). This buoy was removed from the water to incorporate some technical improvements.

7.2.7 United Kingdom

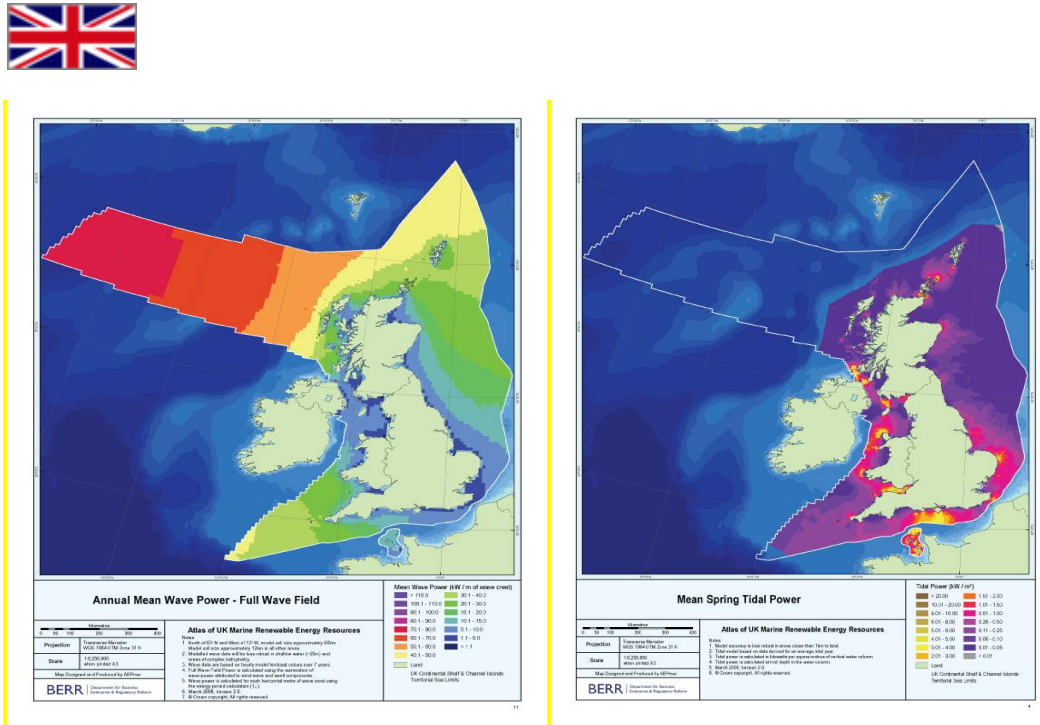


Figure 4 UK Atlas of Offshore Renewable Energy

Key Facts

- **Ocean Energy Potential**

Exploitable Wave Resource: 50 TWh/y
Exploitable Tidal Resource: 18TWh/y

- **Ocean Energy Targets**

Installed Capacity by 2012: The UK has no set target. However, marine energy is expected to contribute significantly to the UK's 2050 renewable energy and carbon reduction targets.

Installed Capacity by 2050: DECC 2050 Pathways analysis suggests that deployment could range from a negligible level (in a worst case scenario) up to, at the higher end of the range, around 27 GW by 2050.[7]

- **Current Installed Capacity**

Wave: 2.6MW

Tidal: 3.4MW

- **Ocean Energy Support Schemes**

Renewables Obligation: Wave - 5 ROCS (Scotland only)
2 ROCs (Rest of UK)
Tidal – 3 ROCs (Scotland only)
2 ROCs (Rest of UK)

The UK Government launched its public "Consultation on proposals for the level of banded support under the Renewables Obligation for the period 2013-17" for England and Wales on 20 October 2011. The Government is proposing to introduce 5 ROCs for wave and tidal stream energy up to a 30MW project cap for deployment in the period to 2017. The new bands will come into effect on 1 April 2013. This RO banding review is specifically set for the deployment from 2013 to 2017. Beyond 2017, it is the intention that marine technologies will continue to be supported via the proposed feed-in tariff (FiT) with Contract for Difference support mechanism which the UK is introducing under its Electricity Market Reform, which should provide greater clarity and long-term vision for investors. The closing date for responding to the public consultation is 12 January 2012.

The Scottish Government launched its public consultation on the Review of ROC bands on 21 October 2011; the closing date for responses is 13 January 2012. The Scottish Government is proposing a support level of 5 ROCs for wave and tidal stream and is seeking views on the introduction of a project cap to accompany this higher band.

Grant Funding Schemes: The UK Government recently announced the £20 million Marine Energy Array Demonstrator to help support the demonstration of arrays of wave and tidal devices. The Scottish Government also announced an £18 million fund to support marine energy commercialisation that will support the deployment of the first commercial marine energy arrays and the scaling-up of the devices currently undergoing testing in Scottish waters.
Details of other funding support from the Technology Strategy Board and the other Devolved Administrations are still to be confirmed.

[7] 2050 Pathways Analysis, DECC, July 2010, URN10D/764

- **Test Centres**

European Marine Energy Centre (EMEC), Orkney, Scotland – Full scale and part scale testing
NAREC, Blyth, North East England – Land based testing
WAVEHUB, Cornwall, South West England – Array testing

Current and Planned Projects

Technology	Capacity	Location	Developer	Type	Year
Marine Current Turbines	1.2MW	Northern Ireland, Strangford Lough	MCT	Tidal	2008
Oyster 1	315kW	Scotland, EMEC	Aquamarine Power	Wave	2009
Pelamis	750kW	Scotland, EMEC	PWP, E.On	Wave	2010
TGL	500kW	Scotland, EMEC	Rolls Royce TGL	Tidal	2010
Oyster 800	2.4MW	Scotland, EMEC	Aquamarine Power	Wave	2011 (first phase)
Ak-1000 Mk 1	1MW	Scotland, EMEC	Atlantis Resources	Tidal	2011
HS-1000	1MW	Scotland, EMEC	Hammerfest Strom, Scottish Power	Tidal	2011

			Renewables		
Neptune Proteus	500kW	England Humber Estuary	Neptune Renewable Energy	Tidal	2011
Pelamis P2	750kW	Scotland, EMEC	Pelamis, Scottish Power Renewables	Wave	2011
SR250	250kW	Scotland, EMEC	Scotrenewables	Tidal	2011
AWS-III single cell	½ of 2.5MW	Scotland, EMEC	AWS Ocean Energy	Wave	2012
PS1200	1.2MW	Scotland, Kyle Rhea	Pulse Tidal	Tidal	2012
TGL (ReDAPT)	1MW	Scotland, EMEC	Rolls Royce TGL	Tidal	2012
Voith Wavegen 100kV	4MW	Scotland, Siadar	RWE npower Renewables	Wave	2012
DeltaStream	1.2MW	Wales, Ramsey Sound	Tidal Energy Ltd, Eco2	Tidal	2012
Voith Siemens Hydro Tidal	1MW	Scotland, EMEC	Voith Hydro	Tidal	2012

Ocean Energy Deployment

UK WAVE & TIDAL STREAM DEPLOYMENT BY YEAR: 2007-2011

	2007	2008	2009	2010	2011
Cumulative UK wave energy deployment (MW)	0.25	0.25	0.55	1.3	1.8-2.3
Cumulative UK tidal energy deployment (MW)	0.3	1.6	1.6	3.1	4.6
Total (MW)	0.55	1.85	2.15	4.4	6.4-6.9

Progress

Many of the leading wave and tidal energy device developers are based in the UK, with many more looking to deploy their technologies there, thanks to the potential resource and the support which has been available for both technology development and deployment.

The success of the £22 million Marine Renewable Proving Fund has helped accelerate the development of six leading technologies resulting in full scale devices being deployed for testing in real sea conditions at EMEC with more to follow in 2012.

The UK Government announced last June it is investing up to £20 million to help support the demonstration of arrays of wave and tidal devices, building on the success of the Marine Renewable Proving Fund and other government support. The Marine Energy Array Demonstrator scheme is expected to open in spring 2012 and, subject to a value for money assessment, will support two projects to test prototypes in array formations – the final development stage in generating large scale electricity from marine power prior to commercial roll out.

The UK Government has completed the process of the UK Offshore Energy Strategic Environmental Assesment 2. The process concluded that there are no overriding environmental considerations to prevent the leasing of wave and tidal energy devices, provided appropriate measures are implemented that prevent, reduce and offset significant adverse impacts on the environment and other users of the sea. The OESEA2 paves the way for future leasing rounds for marine (wave and tidal) energy.

Policy Framework and Government Bodies

The UK Government has established a new UK Marine Energy Programme, that is focusing on enhancing the UK marine energy sector's ability to develop and deploy wave and tidal energy devices at a commercial scale.

Through the Programme the Government will put in place a coherent programme of policies across Government, to enable the UK Marine Energy sector to move from prototype testing to commercial deployment over the coming 5 years;

The Marine Energy Programme Board, which draws together key stakeholders from across the marine energy sector, will play a central role in advising what actions the Programme should address to advance the industry.

The Marine Energy Programme Board comprises representatives from across industry including utilities, industrials, technology developers, financiers and the Devolved Administrations.

The Marine Energy Programme Board, established three Working Groups to take the work of the Programme forward. These will cover broadly:.

- Support needed for small scale arrays and early commercial deployment
- Planning and consenting issues
- Knowledge sharing though a Marine Intelligence Network

Working Groups will report their progress back to the Programme Board.

In addition to this, the Government has set out a real vision for marine energy in the UK to encourage the clustering of activities through marine energy parks, that aims to bring together manufacturing, expertise and other activities to drive the marine sector forward to commercialisation.

The Scottish Government ensures that the development of the wave, tidal and offshore wind energy sectors is achieved in a sustainable manner in the seas around Scotland. To address the various issues and challenges associated with developing marine renewables, a number of projects have been initiated to provide solutions and support to partner organisations and industry. In particular, Marine Scotland, within the Scottish Government, is leading a research programme to improve knowledge on the potential environmental impacts of marine renewables. Marine Scotland is also taking forward a wave and tidal energy marine plan to determine the areas most suitable for development.

Market Incentives

The UK has a long history of supporting marine renewables and most of the leading devices have received substantial levels of grant support from both the UK Government and from devolved administrations. Support for research and development has been available through the Research Council, Technology Strategy Board, the Carbon Trust, the Energy Technologies Institute and the Scottish Government.

In addition to grant support, the UK also provides revenue support to the deployment of wave and tidal technologies through the Renewables Obligation (RO). Currently in England, Wales and Northern Ireland wave and tidal generation receive two ROCs (Renewable Obligation Certificates) per MWh while in Scotland, tidal energy receives three ROC and wave energy five ROCs. The UK and Scottish Governments have launched public consultations on proposals for 5 ROCs for wave and tidal stream energy – subject to a 30MW project cap in England & Wales (see above "Ocean Energy Support Schemes" heading for further details). The new bands will come into effect on 1 April 2013.
The Scottish Government launched the Saltire Prize[v] in 2008 which will provide a £10 million prize for the production of commercial quantities of marine energy.

The Scottish Marine Renewables Road Map[vi], published in June 2009, sets out a development path for the sector in Scotland and estimates that between 1 and 2 GW of power could be harvested in Scottish Waters by 2020, creating at minimum around 2,600 jobs.

The Welsh Assembly Government have developed a Marine Renewable Energy Strategic Framework and published a Ministerial Statement setting out their ambitions for deploying wave and tidal energy[vii].

During 2010, the Department of Enterprise, Trade and Investment published a draft offshore renewable energy strategic action plan 2009-2020 for Northern Ireland waters. The plan proposed a target of at least 300 MW of tidal stream by 2020.

The Energy Technologies Institute (ETI), in association with the UK Renewable Energy Centre (UKERC) have published a prioritisation roadmap which considers the key technical barriers to be overcome by the sector and the ETI's role in addressing these[viii].

Permitting and Licensing

In 2010 The Crown Estate announced the results of the world's first commercial leasing round for wave and tidal technologies – in the waters around the Orkney Islands and the Pentland Firth. The Crown Estate awarded 11 leases to developers with a total potential capacity of 1,600 MW. The 11 sites (5 wave and 6 tidal) are depicted below[8].

[8] Further information on the leasing round, and on the nature and location of the individual awards themselves, can be found at http://www.thecrownestate.co.uk/newscontent/92-pentland-firth-developers.htm

Marine Scotland, within the Scottish Government, is responsible for planning and licensing offshore renewable activities in Scottish waters. In March 2011, the Scottish Government provided consent to the Sound of Islay tidal stream array, the largest commercial tidal array in the world.

Further leasing rounds by The Crown Estate across the UK for marine energy are ongoing on a six-monthly basis.

In preparation to offer development rights for tidal energy projects in Northern Irish waters, The Crown Estate launched a 'design discussion' on 1 April 2011. This will help shape the leasing and development process for commercial projects, which is planned to start later this year. Development rights could be awarded as early as spring 2012.

Test Centres

European Marine Energy Centre (EMEC) in Orkney – the world's first accredited and grid-connected marine energy test facility, offering full-scale and scaled testing facilities;

Wave Hub in Cornwall, South West England – Wave energy array test site;

National Renewable Energy Centre (NaREC) in Blyth, North East England.

Research and Development

The SuperGen Marine Energy Research Consortium undertakes collaborative research with the intention of achieving a step change in the development of generic marine energy technologies. The overall aim, while still generic, has evolved and is now directed towards increasing understanding of the device-sea interactions of energy converters from model-scale in the laboratory to full size in the open sea. Supergen Marine recently launched the third phase of its research programme.

Industry

Utility	**Involvement**
E.On	Technology demonstration & project development
ScottishPower	Technology demonstration & project development
SSE Renewables	Technology demonstration & project development

RWE npower	Project development
EDF	Project development
International Power	Project development
ESB International	Technology demonstration & project development

7.2.8 United Kingdom – Crown Dependencies in the Channel Islands

Key Facts

The Channel Island (CI) Crown Dependencies (CDs) comprise the Bailiwicks of Jersey and Guernsey in the English Channel. The Bailiwick of Guernsey includes the Islands of Sark and Alderney both of which have autonomy in respect of the exploitation of ocean energy potential.

Special terms were negotiated for the CDs on the UK's accession to the EEC in 1973. These are contained in Protocol 3 to the Treaty of Accession. The effect of the protocol is that the CI CDs are within the Common Customs Area and the Common External Tariff. Other Community rules do not apply to the CI CDs.

Guernsey and Jersey are signatories to the United Nations Framework Convention on Climate Change and have been included in the UK ratification of the Kyoto Protocol. They are not independently bound to the Kyoto targets, rather their emissions inventory is added to that of the UK's. The CI CDs are committed to significant carbon reduction assisted in the long term by the exploitation of the ocean energy in their jurisdictional waters.

- **Ocean Energy Potential**

Although detailed feasibility studies are ongoing, initial estimations (Robert Gordon University assessment 2005) estimate that across the CI region there is a usable tidal resource of 1.5-2.5 TWh/yr. Combined with a significant offshore wind resource in accessible waters across the region of up to 3.0 TWh/yr there is good potential for the CI to become a net exporter of renewable energy. Existing sub-sea interconnectors from Guernsey and Jersey to France are already in place with further links planned over the next decade.

- **Ocean Energy Targets**

Final targets for the extraction of this resource are under development.

- **Current Installed Capacity**

There is currently no installed capacity, although Alderney is progressing a specific project (see table below).

- **Ocean Energy Support Schemes**

Currently no jurisdictional support schemes are in place although discussions are underway to assess how these could evolve, particularly if renewably generated energy could be exported to the UK or EU renewable energy market.

- **Test Centres**

Currently there are no active test centres in Jersey or Guernsey, although Alderney is progressing a specific project (see table below).

Current and planned projects

Technology	Capacity	Location	Developer	Type	Year
OpenHydro	3 X 0.9 MW	Alderney	Alderney Renewable Energy	Tidal and Pumped Storage Hydroelectric	Estimated 2012 (first phase)

Ocean Energy Deployment

Currently there is no installed ocean energy capacity in the CI.

Progress

Despite their small area, the CI represent attractive conditions for inward investment. Weather conditions are more favourable than the North Sea and the Islands represent a well regulated historically favourable commercial environment both for early and ongoing scale deployment and investment

Policy Framework and Government Bodies

Both Jersey and Guernsey have recognised the role of renewable energy in their respective energy policies and have in place roadmaps for their long-term development which include developing the regulatory, statutory and fiscal frameworks to incentivise inward investment. The objectives are to increase on-island energy security of supply as well as decreasing greenhouse gas emissions and diversifying local economies.

Market Incentives

Currently none of the Channel Islands offer market incentives.

Permitting and Licensing

Alderney has already developed a block-based leasing and permitting system administered by the Alderney Commission for Renewable Energy. In 2008 a licence was issued which provided the developer with access to 50% of the island's territorial waters (3 nautical miles from the coast) and will serve the Channel Island region's first test site.

Both Jersey and Guernsey (with Sark) are currently evolving their consenting and permitting regimes that reflect best practice whilst aiming to provide a joined up process that gives investor certainty. All the Channel Islands benefit from an accessible, business-focussed, independent government.

Research and Development and Industry

Currently there is no research and development based in the Channel Islands or renewable energy industry and the CDs are likely to work with larger Partners either in Mainland Europe or the UK. The Alderney Project will be leading the way with deployment from 2012.

7.3 Annex 3: Overview of Ongoing and Planned Prototypes and Farms

Acronym and Name of project	Location	Investment (€)	Funding entity	capacity	Partners involved	Status
Limpet	Limpet, Scotland			0.5 MW	Wavegen	Running
Oyster 1	EMEC, Scotland			0.25 MW	Aquamarine Power	Running
Open Hydro	EMEC, Scotland			0.25 MW	Open Hydro / Scottish Government	Running
AK-1000	EMEC, Scotland			1 MW	Atlantis Resources Corporation / Scottish Government	Running
Oyster 800	EMEC, Scotland			3 x 0.8 MW	Aquamarine Power / Carbon Trust / Scottish Government	Planned 2011
P2	EMEC, Scotland			2 x 0.75 MW	Pelamis Wave Power / Scottish Power Renewables / Carbon Trust / Scottish Enterprise	Planned 2011
PowerBuoy	EMEC, Scotland			0.15 MW	Ocean Power Technology / Scottish Government	Planned 2011
Wello Oy	EMEC, Scotland			0.5 MW	Wello	Planned 2011
ScotRenewables	EMEC,			0.25 MW	ScotRenewables / Scottish Government	Planned

	Scotland					2011
TGL	EMEC, Scotland			0.50 MW	Tidal Generation Ltd – Rolls Royce	Planned 2011
Hammerfest Strom	EMEC, Scotland			1 MW	Hammerfest Strom UK Ltd / Scottish Power / Carbon Trust	Planned 2011
Pico	Azores, Portugal			0.4 MW	WavEC, EFACEC, Kymaner, IST	Running
WaveRoller	Peniche, Portugal			0.5 MW	AWEnergy Oy, Bosch-Rexroth, ENP, Eneólica WavEC, IH, Câmara Municipal de Peniche	Planned 2011
OE Buoy	Galway Bay Test Site, Ireland			0.02MW	Ocean Energy Ltd	Running
OWC Pico Power Plant	Island of Pico, Azores, Portugal			0.4MW	Wave Energy Centre, et al.	Running
Hidroflot	Asturias, Spain			50MW	Hidroflot Technologies	Proposed
Oceantec WEC	Basque Country, Spain			0.5MW	EVE, Technalia, Oceantec Energias Marinas	Planned 2011+
PB40, PB150	Santoña			1.39MW	OPT, Iberdrola	Running

7.4 Annex 4: Past and Ongoing EC Funded Projects

Acronym	Start date	EC budget contribution	Programme	Status
WaveNet	1/4/2000		FP5-Energy, Environment, and Sustainable Development (EESD)	Finished-31/3/2003
CA-OE	27/9/2004	1 500 00€	FP6 – DG RTD	Finished-26/12/2007
Wavetrain I	1/6/2004	1 820 000€	Marie Curie actions-Intra-European Fellowships	Finished-29/2/2008
AquaRet I		297 383€	Leonardo Programme	Finished
EU-OEA Dissemination activities	1/10/2004	1 593 000€	FP6 – DG ENER	Finished-31/12/2007
CORES	1/4/2008	3 449 587€	FP7 – DG RTD	Running till 31/3/2011
WAVEPLAM	1/11/2007	526 988€	Intelligent Energy Europe	Finished-31/10/2010
EquiMar	15/4/2008	3 990 024€	FP7 – DG RTD	Running till 14/4/2011
Wavetrain II	1/10/2008	3 579 635€	FP7 -	Running till 30/6/2012
AquaRet II		293 778€	Leonardo programme	Running
ORECCA	1/3/2010	1 599 032€	FP7 – DG RTD	Running till 31/08/2011
MARINET		8 999 997€	FP7 – DG RTD	Running
SOWFIA	1/10/2010	1 442 345,25€	Intelligent Energy Europe	Running till 30/9/2013
SEEWEC	1/10/2005	2 299 754€	FP6 – DG RTD	Finished-31/03/2009
WaveSSG	1/12/2005	10 000 000€	FP6 – DG RTD	Finished-31/05/2008

Pulse Stream 1200	1/11/2009	8 008 935€	FP7 – DG ENER	Running till 31/10/2013
Waveport	1/2/2010	4 591 850€	FP7 – DG ENER	Running till 31/01/2014
Standpoint	16/11/2009	5 096 653€	FP7 – DG ENER	Running till 15/11/2012
Surge	5/10/2009	2 997 000€	FP7 – DG ENER	Running till 04/10/2012
Offshore Test Station		2 M€	KIC InnoEnergy - ETI	Running
Fame		3.4 M€	Interreg IV	Running

7.5 Annex 5: Overview of Member State Support Schemes

Country	Main System	Duration	Hydro (small)	Solar	Wind	Geothermal	Biomasses	**Wave/Tide**	Biogas	Sewage and landfil gas	MSW	RDF
Austria	FIT	10+ years	31.5-62.5	300-460	75.5	73	111-156.5		113-169,5	40,5-59,5		
Belgium	Quota/TGC and FIT (minimum tariffs)							**50**				
Bulgaria	FIT		41-44	367-400	61-80		83-110					
Croatia	FIT	12	60-90	290-470	90	170			140-170	50		
Cyprus	FIT	15	63	204/337-386	48-92		63					
Czech Republic	FIT + Premium	15	60-85	229-481	88-114	161	84-121		81-108			
Denmark	Fixed and Premium tariff Bonus payment	10+10		80-50	44-47	69	50	**80-50**	80			
Estonia	All RES bought at fix price (74,2 fixed - 54,2 premium)											
Finland	Tax Exemption 4- 7,3 €/MWh											
FYROM	No											
France	FIT	20	60,7 +	300-400 ++	82-130	120+	49 +	**150**	75-90 ++	45-57,2	45-50 +	
Germany	FIT	20-30	66,5-96,7	457-624	51,5-91	71,6-150	80,3-109,9	**76.5-126.7**		66.5-96.7		
Greece	FIT	12	73-84,6	400-500/230-270 for thermal	73-90	73-84,6	73-84,6					
Hungary	FIT	Lifetime of plant	42,90-117,30	34,24-105	34,24-105		42,90-117,30/39,60-110		42,90-117,30			
Ireland	FIT	15	72		57-59 140		70-72	**220**				
Italy	Quota/TGC 130€/MWh in 2007 option FIT for small plants < 1MW	15	220	Separate FIT 36-49 * 20 years	220	200	220-300	**340**	180			
Latvia	FIT (2007)	10	110-141		126-130		130-167		130-167			
Lithuania	FIT (2002-present)	10	57,9		63,7		63,7-69,5					
Luxembourg		10	77,6	280-560	77,6		102,6		102,6	102,6		
Malta	Under construction (Grants and or fixed purchase price)											
Netherlands	FIT Since august 2006 the premium tariffs were put at 0	10							97 (exception)			
Poland	Quota obligation											
Portugal	FIT	15	75-77	PV 310-470/Therm 267-273	74-75		102-109	**260-76**	115-117		53-54	74-76
Romania	Quota/TGC mandatory quota for electricity suppliers											
Slovak Republic	Tax relief, FIT		60-84	251	51-88	110	79-129		65-79			
Slovenia	FIT (Fixed and premium)		26-62	31-374	25-61	25-59	34-70		49-121			
Spain	FIT or premium price	No limit but decreasing	70-78	PV 184-440/Therm 215-269	61-73	65-69	81-159	**69,8-65,1 38,4-30,6**	65-80		23 (premium)	
Sweden	Quota / TGC: Currently certificates are trading for around 29-31 €/MWh											
UK	ROCs							**3 – 5**				

7.6 Annex 6: Offshore Testing Infrastructure

Intelligent Energy Europe

Waveplam

	Country	Location	Name	Est'd	Seabed Area	Water Depth	Energy Flux	Shoreline Distance	Port/Harbour Distance	Phase	Grid Connection	Facilities	Devices
A	Scotland	Orkney Island	EMEC	2003	5 km^2	35m – 75m	40 kW/m	2 km	Edinburgh, 430 km Invarness, 200 km Stromness, 8 km	4	4 Berths 11kV Grid Con.	Monitoring Station, Wave Buoys	Pelamis Waveroller Oyster
B	Portugal	Pico Is. Azores	Pico Test Plant	1999	--	7m	30 kW/m	--	Peniche, 1600 km Horta, 16km	3/4	15kV Grid Con.	1 Substation	Air Turbines
C	Portugal	Figueira da Foz	Portuguese Pilot Zone	2007	320 km^2	30m – 100m	40 kW/m	4 km	Leixoes, 148 km Peniche, 63 km Fig. da Foz, 37 km	4	2 Berths		Floating
D	Portugal	Agucadoura (Commerical)	(AWS) Pelamis Array	(2002) 2007	km^2	40m	40 kW/m	5 km	Peniche, 240 km Leixoes, 32 km Monserrate, 25 km	5	3 Berths	Wave Buoys Substation	Pelamis
E	Denmark	Nissum Bredning	Danish Benign Test Site	1990	km^2	6m	<1 kW/m	200m	Thyboron, 7.5 km	3		Pier, Monitoring Station	Wave Dragon Wavestar
F	Denmark	Roshage Pier, Hanstholm	Danish Exposed Test Site	1988	km^2	12m	7-11 kW/m	200m	Hanstholm, 1.5 km	3/4		Pier	Waveplane Wavestar
G	Ireland	Galway Bay		2005	0.37 km^2	20m -25m	3 kW/m	1 km	Killybegs, 300 km Foynes, 150 km Galway City, 15 km	3	--	Wave Buoys	OE Buoy Wavebob
H	England	St. Ives Bay, Cornwall	Wavehub	2010	8 km^2	50m – 65m		11 km	Plymouth, 160 km Falmouth, 100 km St. Ives, 9 km	4/5	4 Berths Max. 20MW 33kV Grid Con.	2-4 Wave Buoys	Orecon OPT, Pelamis Fred Olsen
I	Ireland	Frenchport, Co. Mayo	Irish Open Ocean Test Site	2009	21 km^2	40m – 120m	50 kW/m	7 km	Galway City, 190km Killybegs, 125 km	4/5	2 Berths		Wavebob OE Buoy
J	Spain	Armintza, Basque Country	BIMEP	2010	8 km^2	50m – 90m	21 kW/m	750 m	Bilbao, 24 km	4/5	4 Berths with 13 kV Line, 30kV line	Wave Buoys	
K	Spain	Mutriku, Basque Country	Mutriku Breakwater	2009	273 m^2	7m	7 kW/m	--	Bilbao, 64 km San Sebastian, 32 km	4/5			16 x 18.5 kW OWC
L	Spain	Santona, Basque Country	Iberdrola, Santona	2008	1 km^2	50m	27 kW/m	4 km	Bilbao, 32 km Santona, 4km	4/5			1 x 40 kW PowerBuoy 9 x 150 kW
M	France	Pays de la Loire		2010					St. Nazaire, 30km Nantes, 75km	4/5		Wave Buoys	Searev

Table 5.1 European Test Sites

[i] République Française, Ministère de l'Environnement, du Développement Durable, des Transports et du Logement, « National action plan for the promotion of renewable energies », pp.94-95
http://ec.europa.eu/energy/renewables/transparency_platform/doc/national_renewable_energy_action_plan_france_en.pdf

[ii] http://www.marine.ie/home/aboutus/organisationstaff/researchfacilities/Ocean+Energy+Test+Site.htm

[iii] Available at
http://www.idae.es/index.php/mod.documentos/mem.descarga?file=/documentos_20100630_PANER_Espana_version_final_%5B1%5D_cdb842de.pdf

[iv] Royal Decree 661/2007 (May 25th), which regulates the electricity production in special regime (it includes feed-in tariffs for renewable energy), and Royal Decree 1028/2007 (July 20th), which establishes the administrative procedure to apply for an authorization for electricity generation installations at sea.

[v] http://www.scotland.gov.uk/Topics/Business-Industry/Energy/Action/leading/saltire-prize

[vi] Available at http://www.scotland.gov.uk/Publications/2009/08/14094700/0

[vii] http://wales.gov.uk/topics/environmentcountryside/energy/renewable/marine/marineenergy/?lang=en
http://wales.gov.uk/topics/environmentcountryside/energy/renewable/marine/framework/?lang=en

[viii]http://www.energytechnologies.co.uk/Libraries/Related_Documents/ETI_UKERC_Roadmap.sflb?download=true