Non-technical barriers to wave energy development, comparing progress in Ireland and Europe

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http://www.ucc.ie/research/hmrc

Abstract

This paper outlined the non-technical barriers to wave energy development, comparing progress in Ireland and Continental Europe. There have been many reports to date examining the subject from a generic perspective, but few have focused on the progress, or lack of it, in individual countries. The report stemmed from existing work carried out by Waveplam partners in Europe and the International Energy Agency, Ocean Energy Systems (IEA~OES). Waveplam is an EU project supported by Intelligent Energy for Europe (IEE) addressing non-technical barriers that will face the wave energy industry as it moves towards the mass deployment of devices. The framework for discussion comprised three categories of barrier: regulatory, logistical and financial barriers. Each category was assessed with regards its relevance in either the R&D, manufacture or development/production phase of the industry. Results of the analysis showed that most countries had addressed some of the issues. Ireland has made extensive progress with regulatory issues, in particular developing a four phase strategy for product development, as well as specifying targets, but still has not implemented investment grants, a 'one-stop shop' facility for permit applications, easy access to the grid, or suitable construction facilities, skilled workforce, and usable ports. Mainland Europe on the other hand has some natural advantages from a logistical perspective, having larger economies enabling relatively easy industry adaptation to ocean energy construction. Most have population centres located close to the wave energy source, providing better grid infrastructure and construction/port facilities. However the majority of the countries still need to address regulatory issues.

In conclusion, the R&D, manufacturing and development sectors of the wave energy industry present many barriers, with several barriers common to all three. Significant progress has been made by many countries to reduce these barriers. However, there is much inconsistency as to what has been addressed by individual states, with the majority of barriers still remaining to be addressed.

Keywords: Non-technical barriers, wave energy converters

Nomenclature

EIA	=	environment impact assessment
R&D	=	research and development
T&D	=	transmission and distribution
WEC	=	wave energy converter
FIT	=	feed-in tariff
ROC	=	renewable energy obligation credits
MW	=	megawatts
GW	=	gigawatts
SEA	=	strategic environmental assessment

1 Introduction

The European Commission's renewable energy roadmap identifies wave energy as an important element in the EU's future overall energy mix [1]. However there are a number of obstacles that needs to be overcome if wave energy is to fulfil this potential and compete with other more mature technologies.

This report segregates the barriers to wave energy under the following categories[1]:

- Regulatory
- Logistical
- Financial

The wave energy industry was defined under three main sectors:

- Research and development (R&D)
- Manufacturing
- Development/deployment

Europe is at the forefront of wave energy technology as well as supporting policy. This paper discusses how the eight major European countries in the wave energy race (Ireland, UK, Spain, Portugal, Germany, France, Denmark and Sweden) are making progress with fostering their own wave energy industry, and lists their success as well as their failings. Particular emphasis will be made to Ireland, which at present is perhaps at

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[1] Discussion of the environmental barriers was considered outside the scope of this paper.

the forefront in encouraging the industry through policy innovation and addressing the barriers.

2 Regulatory barriers – R&D

Regulatory barriers are perhaps the most important of all barriers to address, and are relevant to all sectors of the industry; R&D, manufacturing and development (Table 1).

Planned strategy

A planned strategy, coupling targets with grant provisions structured over a 15-20 years of development is crucial to get a nascent industry off the ground. Ireland is the only country in Europe as yet who has instigated a comprehensive strategic plan. The programme is structured into four phases. The grants ranged from €21.6M to a high of €34.5M depending on whether the pre-commercial devices are manufactured indigenously or whether the devices would be imported. It was announced in January 2008, that over €26 million of targeted funding would go to the sector over the next three years [2].

R&D grants

As already mentioned, grants form the most important ingredient in stimulating the R&D industry. Most countries in this study have some measure of grants.

For the population size of the country, Ireland has placed sizeable funding for R&D. These include €2 million in grants under the Ocean Energy Prototype Fund and €1 million towards National Ocean Energy facility in University College Cork (UCC) [3]. These programs come under the umbrella of €26M total funds allocated to the Ocean Energy Development Unit (OEDU). Direct sponsorship for academic research is supported by the Charles Parson's fund comprising a total of €20M for all research in the country [4].

The UK has developed a suite of support grant initiatives, which comprise the following:

- Energy Technologies Institute[2] (ETI) is public/private partnership, with the UK Government matching private investments to create a potential £1 billion investment fund for new energy technologies [5].
- Marine Renewables Deployment Fund (MRDF) (total £50M), aimed at the early stage pre-commercial operation and sea trials [6].
- Marine Energy Accelerator (MEA) (£3.5M), organised by the UK Carbon Trust and successor to the Marine Energy Challenge [7].
- Marine Renewable Proving Fund 2009 (MRPF) (£22) [8]. The funds aims to accelerate the leading and most promising marine devices towards the point where they can qualify for the MRDF. The fund is administered by the Carbon Trust and uses new funding provided by the Department of Energy and Climate Change (DECC). Up to £6m is available to successful applicants to help meet the capital costs of building and deploying wave and tidal stream prototypes. The MRPF will provide up to 60% of the eligible project costs.
- Low Carbon Transition Plan 2009 ($38M for ocean energy of a total £60M)[3]. £9.5M for Wave Hub, £10M for a world centre for wave and tidal energy in the South West UK's. £10M for testing facilities at the National Renewable Energy Centre in Northumberland and up to £8m for the European Marine Energy Centre in the Orkneys.
- Scottish based funds including The Scottish Executive Marine Energy Fund, the Scottish Executive fund has £13M [9] and Saltire Prize (£10M)[4].

Other countries which provide research grants are; Denmark (€13M) [10], Spain (€25M) [11] and Portugal (€1.2M) [10].

France, Germany and Italy have no available grants for wave energy at the moment.

Test sites

Test sites are an important infrastructure where pre-commercial designs can be validated. Test sites are usually government funded facilities that ideally would provide at least the following:

- Approved site with existing licensing
- Environment impact assessment waiver (EIA)
- Free cable connection
- Free data collection.
- Adjacent service facilities

There is at present only one operational test site in Europe which is EMEC[5], and has funding of £14M. However, consent for testing requires payment for an EIA for devices over 1MW. A ¼ scale test site also exists in Ireland at Galway bay (non-grid connected) and Denmark, at Nissum Brednin (grid-connected)[6].

There are many other test sites in Europe in the planning phase. Delays in their completion are due to funding difficulties, licensing delays and lack of customers. Government supported test sites planned are:

- Belmullet, Ireland [12]
- WaveHub, UK[7]
- BIMEP, Spain [13]
- SEM-REM, France[8]

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[2] http://www.energytechnologies.co.uk/Home/Technology-Programmes/marine.aspx

[3] http://www.wave-tidal-energy.com/home/news-archive/41-government-regulatory/211-uk-government-to-invest-p60m-in-wave-and-tidal-energy

[4] http://www.scotland.gov.uk/Topics/Business-Industry/Energy/saltire-prize/detail

[5] http://www.emec.org.uk/facilities.asp

[6] http://www.wavedragon.net/index.php?option=com_content&task=view&id=12&Itemid=14

[7] http://www.wavehub.co.uk/

[8] http://www.oreg.ca/docs/2008_Fall_Symposium/Mouslim.pdf

- Pilot Zone, Portugal [14].
- Lysekil , Sweden for Wave Power Project[9]

The final operating conditions at each test centre are not yet published but is likely to be different at each. For instance, the Pilot Zone in Portugal promises to provide the site only. EIA, cabling and connection all have to be paid for or rented by the developer [11].

The only privately funded test site operational at present is for the Pelamis in Agucadoura, Portugal[10]. Other proposed private test sites are:

- South west cork for OE buoy[11].
- Wales for Wavedragon[12].
- North Sea, UK for Trident[13].
- Santona, Spain, for Iberdrola[14].

3 Regulatory barriers – Development

Unless a country is going to create a manufacturing industry, the main avenue for renewable energy industry is in the development and deployment industry. The deployment sector is well established for onshore and offshore wind, as well as solar in some countries. Ingredients necessary for a strong deployment industry are:

- Specified targets which should direct policy to enable those targets to be met.
- Certainty in remuneration and revenue, especially for long-term projects.
- Grants and support for investors.
- Tax concessions.
- Uncomplicated licensing and planning processes.
- Supportive grid networks and connection charges.

Targets

Targets are becoming increasingly recognised as driving engines for policy successes. Some targets, such as atmospheric pollution reduction, are legally binding international commitments. Others are aspirations of national governments to ease the security of electricity supply. The setting of ambitious targets eventually requires proactive policy initiatives to facilitate the target completion. Thus targets are the keystone for successful policy creation and deployment success.

To date, there are only 3 European countries which have set ocean (wave and tidal) energy target goals. Both Ireland and Portugal have proposed 500MW targets for 2020 [6, 15]. Spain has a shorter term target of 5MW by 2010[15].

[9] http://www.el.angstrom.uu.se/forskningsprojekt/WavePower/Lysekilsprojektet_E.html
[10] http://www.pelamiswave.com/content.php?id=149
[11] www.oceanenergy.ie
[12] http://www.wavedragon.co.uk
[13] http://www.tridentenergy.co.uk/index.php
[14] http://www.iberdrolarenovables.es
[15] http://download.southwestrda.org.uk/interes/interest-event---bristol/waveenergy.pdf

Revenue support

In order for targets to be met, and to attract developers, revenue support schemes have been developed and implemented in many European countries. The most popular schemes now fall into two categories:

- Feed-in tariffs (FIT)
- Renewable energy credits (ROCS)

Italy leads with the highest proposed tariff for energy of €0.34/kWh [16]. Portugal follows with perhaps the most developed tariff scheme. The initial tariff of €0.26/kWh is promised for the first five 4MW projects, totalling 20MW. There are a range of reducing FIT as the technology develops and deployment capacity increases, dropping to €0.07/kWh when capacity exceeds 250MW.

Ireland follows with a tariff of €0.22/kWh. This applies to the first 5MW in the proposed Bellmullet test site [17, 18]. There are no announcements as yet of a more extensive tariff scheme for larger developments.

France, Denmark Spain, and Germany also have FIT which are respectively, €0.15/kWh, €0.08/kWh, €0.06/kWh and €0.06/kWh [19].

The UK has approached revenue support with the ROC method. The price of a ROC is approximately £0.045 [10]. From April 2009, the incentives for wave energy in England and Wales will be two ROCs on top of the market price (totalling £0.09/kWh). In Scotland the price incentive will be five ROCs on top of the market price (totalling £0.225/kWh)[10].

Grants

There are currently no grants available in any European country for investors to support deployment projects on a commercial scale.

Planning and permits

A one-stop shop for all planning applications and environmental impact assessments is crucial for encouraging investors to consider participating in wave energy. Without this facility, the combined application process can take years to complete. For example, a wave energy project on the west coast of the United States required 26 federal, state and local permits, in addition to public consultation[16]. The AWS project in Portugal filed permit applications in 10 public departments [20].

The Danish regulatory framework system is based on the “one-stop-shop” principle for off-shore wind and ocean, creating a simplified system for EIA and consent and a much lower degree of uncertainty [21]. In Spain, offshore wind energy developers only need to receive authorisation from the General Direction for Energetic Policy and Mines [22]. The Spanish Royal Decree 1028/2007 established a simple licensing procedure for wave energy installations [10]. “Nevertheless it is still not clear how to apply for the BIMEP test zone”. Portugal has also recently introduced simplified planning application rules, but at present they will only apply to the Pilot zone, and

[16] http://mendocoastcurrent.wordpress.com/2008/04/23/green-wave-to-harvest-wave-power-in-slo-mendocino/

	Tariff	Strategy	Target	Grants	Test site	Grid connection charge	One stop shop planning	SEA[a]
Ireland	€0.22/kWh	4 phase strategy	500MW 2020	€20M Parsons fund €26M OEDU	Belmullet 5MW- €2M	hybrid	planned	planned
Portugal	€0.26/kWh	–	50MW 2010[17] 500MW 2020[18]	€1.2M	25MW	deep	planned	planned
Spain	€0.06/kWh[19]	–	5MW by 2010[20]	PSE-Mar- €25M	BIMEP 20MW- €15M	deep	planned	✓
France	€0.15/kWh[21]	–	–	–	SEM-REV - 2MW - €5M	shallow	–	X
Germany	€0.06/kWh	–	–	–	–	shallow	–	X
Denmark	€0.08/kWh + 0.05/kWh	–	–	RTD - €13M	Nissum Bredning	shallow	yes	X
Italy	€0.34/kWh + 1.8 ROC	–	–	–	–	shallow	–	X
UK	1ROC=0.045 /kWh UK 2 ROC Scotland 5 ROC	–	–	UK: ETI £10 MRDF: £50M Carbon Trust: £3.5M Scotland: SEMEF- £13M €10Saltire Fund	EMEC 20M Wave Hub 20MW	hybrid	UK- planned. Scotland- completed 2009	Completed in Scotland only

Table 1: Regulatory barriers for wave energy
([a] SEA =strategic environmental assessment)

planning applications have to be paid for [23]. Marine Scotland began the development of a one-stop shop for licensing of marine renewables in April 2009, being overseen by the newly formed Marine Scotland[22].

Ireland has yet to implement a one-stop shop. However, it is one of the main tasks of the Ocean Energy Development Unit (OEDU)[23].

Grid connection

There are two major barriers faced with Grid connection:

- Grid connection charges
- Grid capacity

Deep connection charges require the RE developer pay for all costs associated with the connection, including all network reinforcement costs [24]. The countries in the sample where deep connection charges apply are Spain and Portugal [25, 26]. *Shallow connection charges* are costs pertaining to connection to the grid only and all costs related to the grid integration and reinforcement are covered by the end consumers. Countries in the sample with shallow connection charges are Germany, Italy and Denmark. *A hybrid* (sometimes referred to as shallowish) approach can either require the RE generator to pay some fraction of additional grid extension and reinforcement costs or in the case of Ireland and the UK, deep connection charges apply when connecting to the distribution network and shallow when connecting to transmission network[24].

The capacity of the grid T&D system to incorporate large amounts of renewable energy is being increasingly challenged. Countries with upgraded grid systems and interconnectors to adjacent countries are

[17] [6]
[18] http://www.leonardo-energy.org/drupal/taxonomy/term/53
[19] Royal decree 661/2007
[20] http://download.southwestrda.org.uk/interes/interest-event---bristol/waveenergy.pdf
[21] JORF, 2007: Texte N°7 du JORF n°95 du 22 avril 2007. http://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000000794351&dateTexte=
[22] Personal communication from EWTEC reviewer
[23] http://www.sei.ie/Renewables/Ocean_Energy/Ocean_Energy_Development_Unit/
[24] http://www.ofgem.gov.uk/NETWORKS/TRANS/PRICECONTROLS/TPCR4/CONSULTATIONDECISIONSRESPONSES/Documents1/7433-NaREC_9804.pdf

well positioned to accommodate high percentages of renewables. Examples are Denmark, Germany, France and Spain [21, 27].

Countries such as Ireland and UK have traditionally isolated grid networks with no major interconnections. These grid systems will find it particularly difficult to enable increased percentages of renewables, without sizeable investment in grid network upgrading. The Irish government has recently announced the Grid 25 network upgrade scheme with a total investment of €4B [28]. Similarly, the UK are proposing an investment of £4.7B according to a report from the Electricity Networks Strategy Group (ENSG)[25], although this is not yet sanctioned .

Strategic impact assessment (SEA) and 'Hotspot' location studies

There are two main reports required by a developer to determine where best to locate a wave park. These are:

- Strategic Environmental Assessment (SEA): this is a report which identifies all the areas exclusively designated for shipping, oil and gas exploration, cables, military and nature reserves. The remaining area can then be designated for wave parks. The only countries which have completed full SEA studies are the Basque region in Spain and Scotland[26] [29]. The Marine Scotland, formed in 2009, looks after marine spatial planning, EIA guidance, streamlining of consents, guidance on environmental impacts[27]. Ireland is proposing to complete an all-island study under the Marine Institute28.
- The identification of the prime wave resource locations (often called 'hotspots'). The transformation of waves from deep offshore across the continental slope affects both wave height and period as well as the spectral width. When further influenced by interaction with localised bathymetry this can be an energy flux constructive or destructive process [30]. Also included in the assessment are two additional important pieces of information: the proximity to the nearest ports for operation and servicing requirements; the closeness to nearest grid connection. Whilst hotspots may well lead to prime locations for device performance, from the point of view of performance assessment, their avoidance is specifically recommended (Performance Assessment of Wave Energy Devices, EMEC Standard, 2009 - available from EMEC website)[29].

There are two main assessment methods for hotspot evaluation: a) weighted values e.g. Irish test site evaluation [12], b) layered GIS report.

Tax incentives

Tax relief policies to promote renewable energy have only been employed in the United States, Ireland and Denmark.

The US has the widest range of incentives with 17 states offering personal tax incentives, 21 states offering tax incentives, 16 states offering sales tax incentives, and 24 states offering property tax incentives [31].

Ireland has a program of tax relief of corporate investment under Section 62 of the 1998 Finance Act [32]. This scheme was to be terminated in 2004, but has been since extended.

Denmark offers a scheme whereby co-operatively owned wind turbines were exempted from tax, leading to tax expenditures in the order of DKr 70 to 90 million per year [33]. This scheme has been recently terminated.

4 Regulatory barriers – Manufacturing

A successful manufacturing industry requires healthy national R&D as well as a local development industry which will provide a guaranteed home market for its product [21]. However, there are many important policies that need to be in place in order to stimulate a local wave energy manufacturing industry sector.

Grants

The most successful way to provide stimulus to a manufacturing industry is to provide investment grants to the companies. In 1990, the "Danish Wind Turbine Guarantee" act was passed. It guaranteed long-term financing of large wind projects that used Danish made wind turbines, reducing the risk of building larger projects and encouraging local manufacturing [21]. The guarantee had a double benefit of not only providing economical support but also stipulated local production as a prerequisite for eligibility.

There are currently no equivalent grants available in any European country sampled for wave energy manufacturing.

Targets and national strategy plans and standards

Targets have an indirect benefit to the manufacturing industry by providing a guaranteed market for its products.

Even more beneficial are 'national executive' orders, stipulating state funded or public construction of wave energy facilities. Similar orders were instigated by the Danish government to stimulate its offshore wind energy industry [21].

Both Ireland and Scotland have developed standards for ocean energy device development. Irish standards, designed by HMRC [34], developed the 4 stage development approach to device design. Scotland

[25] http://www.energyefficiencynews.com/nuclear/i/1905
[26] http://www.seaenergyscotland.co.uk/
[27] http://news.scotsman.com/scotland/New-body-to-manage-.4962677.jp
[28] http://www.marine.ie/home/Search?qt=bathymetry
[29] Personal communication from EWTEC reviewer.

		Ireland	UK	Portugal	Spain	Denmark	Germany	France
Development	Service ports	X	X	✓	✓	X	✓	✓
	Skilled labour	X	✓	✓	✓	✓	✓	✓
	Population	X	X	✓	✓	✓	✓	✓
	Oil/ gas	X		✓	✓	✓	✓	✓
	Transport	X	X	✓	✓	X	✓	✓
	Weather window	X	X	✓	✓	✓	✓	✓
Manufacturing	Shipyards	dormant	dormant	✓	✓	X	✓	✓
	Supply chain	X	✓	✓	✓	✓	✓	✓

Table 2: Logistical barriers for wave energy (X=poor/limited, ✓=existing or positive advantage)

produced 13 standards outline for the wave and tidal energy industry[30].

Tax incentives

Tax incentives tailor made for start-up wave energy manufacturing industry have not been implemented by European countries as yet.

5 Logistical barriers – Development

Service ports and O/M personnel

Easy access to service ports and availability of skilled service personnel with appropriate equipment are essential ingredients for a development and deployment industry in wave energy (Table 2).

Wave energy farms will need to be serviced regularly via small survey boats launched from local ports. Suitable distances that are economical to travel are about 20-30km [35]. Ireland and UK have very few ports that are within this ideal distance range.

With regards skilled labour force, there are three particular requirements: specialised tug companies to tow or carry the wave energy converters (WECs) to site; experienced underwater divers are required for deployment and maintenance of WEC and moorings, and specialised cable services for laying the electricity connector cable. A local skilled workforce may not be available in the location for construction and deployment, or may be limited.

6 Logistical barriers – Manufacturing

Shipyards and workforce

Initially, WEC devices will probably need to be built in shipyards [36], where existing maritime construction expertise and facilities exist. Over the last two decades most of Europe's existing shipyards have closed down or drastically curtailed operations [37]. Large-scale production of WEC devices in European shipyards may not now be available. Even if the option were available, overseas competing shipyards in Poland, Korea and China, could feasibly outbid local contractors even when factoring in shipping costs, due to lower overseas wages and cost of materials [38]. Ireland has two shipyards that are operating in a very limited capacity. However under the appropriate conditions, both could be revitalised to service the wave energy industry.

Supply chain

A supply chain bottleneck is a phenomenon by which the capacity of an entire system is severely limited by the availability of a single component. The uncertainty of supply chain dynamics is a risk for any technology to overcome. With regard WEC production, at the beginning of the process are the producers of raw materials e.g. steel, followed by the component manufactures, such as ball bearings, hinges and corrosion resistant paint. Finally, are the larger sub-assembly manufactures such as generators, hydraulics, cable and moorings. Delays or interruptions at any of the stages can put an entire project at risk. The availability of a national and international database of suppliers and relevant associations will be of value to elevate, if not remove, this concern. Small countries that have a high dependency on imported products, such as Ireland, are more susceptible to supply bottlenecks than larger economies with a wider industrial base, such as UK, Germany, Spain and Portugal.

In the short term, uncertainty over market volumes can act as a barrier to the investment required to make the transition from a prototype supplier to a commercial supplier [10]. In the medium term, market growth may lead to standardisation of the designs and eventually to manufacturing being relocated to countries with low costs of labour.

Demand bottleneck

Ambitious plans to install GWs of WECs by 2020 could be at risk of being derailed by a critical demand bottleneck. Supply can be met from either local production or imports. A country intending to become a

[30] Communication from EWTEC reviewer.

manufacturer of WECs with no traditional industrial marine base will be challenging. For example, if Ireland is to reach its quota of 500MW of wave energy by 2020[31], it is estimated that approximately one Pelamis will need to be produced every week for the next 10 years [39]. Local construction facilities in Ireland at present do not have this production capacity.

7 Financial barriers – R&D, manufacture and development

Cost evaluation of a project is often left to the last stage of a project evaluation, and the most important factor of these is the cost of materials. Steel, which is currently the main material constituent of a WEC, has had major price fluctuations over the past few years (Figure 1). Recent factors influencing steel price fluctuations were: increasing demand from China for raw materials, which led to a price escalation [40], followed by the credit crunch and global recession in mid 2008, causing steel prices to eventually fall to 2007 prices [41]. The final cost of manufactured steel, typically grade 50 (S355), painted with corrosive protection, can cost anywhere from €5000-7000/ton[32], and this price has not substantially fallen yet, although it is forecast to do so in 2009.

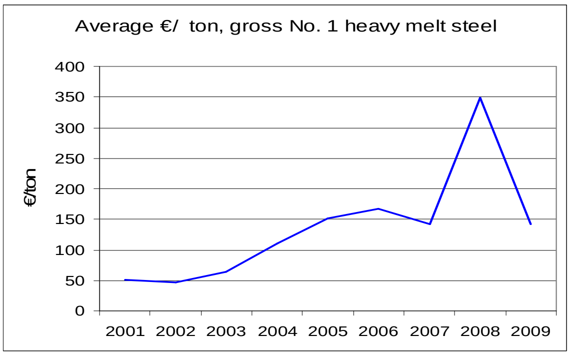

Figure 1: Historical heavy melt steel price, American metal market. 2001-2007 (www.scrapmetalpricesandauctions.com/iron-steel)

The extremely high initial capital costs required for device R&D, manufacture and sale for development is not at present balanced by sufficient revenue return from the product. This has been experienced by almost all pilot projects so far tested, and many may fail due to lack of financial margin in the critical early phase of development [10].

8 Other barriers – conflict of use and environmental impact

The scope of this paper does not allow space to discuss the other possible barriers facing the wave energy industry, such as conflict of use and environmental impacts Detailed discussion can be found in Waveplam reports authored by either Dalton [39] or Neumann [10].

9 Conclusion

This paper examined the many non-technical barriers that face the wave energy industry on its path to becoming a mature industry. The analysis categorised the barriers into regulatory, logistical, financial. Each of these categorises were then examined from the perspective of the three industry sectors; R&D, manufacturing and development/ deployment sectors.

Ireland is the most progressive country with regards policy creation for wave energy. Policies in place are similar to those implemented for its wind energy sector, which focused on stimulating a development industry. Unlike wind, Ireland has provided sizeable funding for R&D. However, there is as yet no targeted funding to stimulate the manufacturing industry. Ireland faces further unique barriers due to its isolation and lack of population, which is moreover centred furthest away from the wave energy source. Small skilled labour force and inadequate port and harbour facilities are all natural or infrastructural barriers that will be difficult and expensive to overcome.

The UK faces similar natural barriers especially in the prime energy locations of Scotland and Cornwall. However, plenty of funding appears to be available for wave energy, especially in Scotland, although much of it is designated for mature projects, with R&D finding it difficult to source funds. Scotland has the only operational test site.

Portugal has ambitious plans to be a market leader in wave energy. A suite of policies and tariffs supports emerged in the early 2000's, but appear to have stalled recently. Natural geographical and demographic advantages give Portugal great opportunity to become a leader in this area.

Spain, more specifically Basque country, also has implemented some policy initiatives that may place Spain at the forefront of the wave energy race. This includes targets, funding, and some innovative R&D companies. Spain also has natural geographical and demographic advantages.

Finally, Sweden, Germany, France and Denmark have the capacity be large players in the emerging industry, however, as yet are minor players due to lack of policy initiatives at present.

[31] http://historical-debates.oireachtas.ie/D/0641/D.0641.200711150017.html
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